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Mandatory reporting of certain emissions of contaminants into the atmosphere — Amendment

Notice is hereby given, in accordance with sections 10 and 11 of the Regulations Act (R.S.Q., c. R-18.1) and sections 2.2 and 46.2 of the Environment Quality Act (R.S.Q., c. Q-2), that the draft Regulation to amend the Regulation respecting mandatory reporting of certain emissions of contaminants into the atmosphere, appearing below, may be made by the Minister of Sustainable Development, Environment and Parks on the expiry of 60 days following this publication.

The object of the draft Regulation concerns the mandatory reporting of greenhouse gas emissions. It introduces amendments to the content of the emissions report, the verification of the report and the persons required to send such a report. It amends the methods used to calculate greenhouse gas emissions already provided for in certain sectors or industrial activities, and adds new methods for other sectors or activities.

Further information may be obtained by contacting Vicky Leblond, Direction des politiques de la qualité de l'atmosphère, Ministère du Développement durable, de l'Environnement et des Parcs; telephone: 418 521-3813, extension 4386; email: vicky.leblond@mddep.gouv.qc.ca; fax: 418 646-0001.

Any person wishing to comment on the draft Regulation is requested to submit written comments within the 60-day period to Michel Goulet, Director, Direction des politiques de la qualité de l'atmosphère, Ministère du Développement durable, de l'Environnement et des Parcs, édifice Marie-Guyart, 675, boulevard René-Lévesque Est, 5e étage, boîte 30, Québec (Québec) G1R 5V7; email michel.goulet@mddep.gouv.qc.ca; fax: 418 646-0001.

PIERRE ARCAND,
Minister of Sustainable Development,
Environment and Parks

Regulation to amend the Regulation respecting mandatory reporting of certain emissions of contaminants into the atmosphere

Environment Quality Act
(R.S.Q., c. Q-2, ss. 2.2, 46.1 and 46.2)

1. The Regulation respecting mandatory reporting of certain emissions of contaminants into the atmosphere (c. Q-2, r. 15) is amended in section 3

(1) by inserting "or liquid manure" after "manure" in paragraph 0.2;

(2) by adding the following after the first paragraph:

"For the application of Division II.1,

(1) "CO_2 emissions attributable to fixed processes" means the CO_2 emissions resulting form a fixed chemical process reaction producing CO_2 from carbon in a chemical bond in the raw material and carbon used to withdraw an unwanted component of the raw material where there is no substitutable raw material;

(2) "greenhouse gas emissions attributable to combustion" means greenhouse gas emissions related to an exothermic reaction of a fuel;

(3) ""other" category greenhouse gas emissions" means greenhouse gas emissions other than emissions attributable to fixed processes and emissions attributable to combustion.

2. Section 4 is amended

(1) by striking out "an enterprise, facility or" in the first paragraph;

(2) by replacing "the facility, establishment or enterprise" in the first paragraph by "the establishment";

(3) by replacing " if an enterprise has several establishments, a separate report must be made for each establishment that exceeds the reporting threshold. If an" in the fifth paragraph by "if an";

(4) by striking out "enterprise, a" and "enterprise" in the sixth paragraph.

3. Section 5 is amended

(1) by striking out "enterprise," in the first paragraph;

(2) by replacing "the enterprise, facility or" in the first paragraph by "the facitility or";

(3) by replacing "the enterprise, facility or" in the third paragraph by "the facitility or".

4. Section 6 is amended

(1) by striking out "enterprise" in the first paragraph;

(2) by inserting the following after subparagraph 4 of the second paragraph:

"(4.1) a model for the estimation of emissions;".

5. Section 6.1 is replaced by the following:

"**6.1.** Every person or municipality operating an establishment that, during a calendar year, emits into the atmosphere greenhouse gases mentioned in Schedule A.1 in a quantity equal to or greater than 10,000 metric tons CO_2 equivalent must report those emissions to the Minister in accordance with this Division until such time as the emissions have been below the reporting threshold for 4 consecutive years.

Where an establishment has more than 1 facility, the data pertaining to each facility must be identified separately.

In the case of a person or municipality that operates an enterprise that purchases electricity produced outside Québec for its own consumption or for sale in Québec, or that exports, transports or distributes electricity, an enterprise that transports or distributes natural gas, or an enterprise that carries on gas or oil exploration or development, the threshold reporting provided for in the first paragraph applies to the enterprise, which is considered as an establishment for the purposes of this Division.

In addition, when an enterprise, a facility or an establishment changes operator during a year, the declaration must be made by the new operator. The previous operator must provide the new operator with all the data required for the report for the period of the year for which the enterprise, facility or establishment was under his or her responsibility.

When an emitter referred to in the first or third paragraph closes an establishment for which the greenhouse gas emissions reached or exceeded the reporting threshold during the preceding calendar year, it must, within 6 months of closing the establishment, send to the Minister an emissions report for the period during which the establishment was operating but was not covered by such a report. ".

6. Section 6.2 is amended

(1) by adding the following after subparagraph 4 of the first paragraph:

"(4.1) the total quantity of CO_2 emissions attributable to fermentation of biomass and biofuels;";

(2) by inserting "and their origin or method of determination" in subparagraph 7 of the first paragraph after "used";

(3) by adding the following after subparagraph 7 of the first paragraph:

"(8) the total greenhouse gas emissions of each type, excluding CO_2 emissions attributable to the combustion of fermentation of biomass and biofuels and greenhouse gas emissions attributable to the mobile equipment referred to in QC.27 in Schedule A.2, namely:

(a) the annual fixed process emissions, in metric tons CO_2 equivalent;

(b) the annual combustion emissions, in metric tons CO_2 equivalent;

(c) the annual "other" category emissions, in metric tons CO_2 equivalent;

(9) in the case of an emitter required to cover greenhouse gas emissions pursuant to section 46.6 of the Environment Quality Act, the annual quantity of benchmark units relating to the emitter's activities. ".

7. Section 6.6 is amended

(1) by replacing "excluding CO_2 emissions attributable to the combustion of biomass and biofuels, must, not later than 1 September" in the first paragraph by "excluding CO_2 emissions attributable to the combustion or fermentation of biomass and biofuels and the greenhouse gas emissions attributable to the mobile equipment referred to in QC.27 in Schedule A.2, must, not later than 1 June";

(2) by adding "accredited to ISO-17011" at the end of the first paragraph;

(3) by replacing ", unless at least 3 years have elapsed since the last verification" in subparagraph 2 of the second paragraph by "since the 2012 emissions report";

(4) by adding the following after subparagraph 2 of the second paragraph:

> "(3) where the emitter wishes to have the verification of the annual report done by a verifying organization other than the organization that verified the report the preceding year but that verified a report for previous years, the organization must not have carried out a verification for the emitter in the 3 previous years; "

(5) by replacing "3 consecutive years" in the third paragraph by "4 consecutive years";

(6) by striking out the fourth paragraph.

8. Schedule A is amended by replacing the line" - formaldehyde;55-00-0" in the section concerning contaminants that cause toxic pollution in Part II by the following:

> "- formaldehyde; 50-000-0".

9. Schedule A.1 is amended by replacing the line "HFC-152A (CH_3CHF_2) | 75-37-6 | 43" in the section concerning hydrofluorocarbons (HFCs) by the following:

> "HFC-152a (CH_3CHF_2) | 75-37-6 | 140".

10. Schedule A.2 is amended

(1) in QC.1:

> *(a)* by striking out "or, when fossil fuels and biomass fuels are used in the same stationary unit, the CO_2 emissions for all the fossil fuels and for all the biomass fuels" in subparagraph *a* of paragraph 1 of QC.1.2;
>
> *(b)* by adding the following at the end of QC.1.3:
>
>> "In addition, when a fuel is not specified in one of Tables 1-1 to 1-8 of QC.1.7, the CO_2 emissions attributable to that fuel do not need to be calculated provided they do not exceed 0.5% of the total emissions of the establishment. ";
>
> *(c)* by replacing "equation 1-1" in the part preceding subparagraph 1 of the first paragraph of QC.1.3.1 by "equation 1-1 or 1-1.1";

(d) by adding ", with the exception of an emitter using a stationary unit with a design rated heat input capacity that is greater than 264 GJ/h and that operated for more than 1000 hours during at least one of the three preceding years" at the end of subparagraph 2 of the first paragraph of QC.1.3.1;

(e) by adding the following after subparagraph 4 of the first paragraph of QC.1.3.1:

"(5) for a biomass fuel specified in Table 1-3 except if it is targeted by another calculation method specified in this Schedule.";

(f) by adding the following equation after equation 1-1 in QC.1.3.1:

"**Equation 1-1.1**

$$CO_2 = Fuel \times OEF \times 0.001$$

Where:

CO_2 = Annual CO_2 emissions attributable to the combustion of each type of fuel, in metric tons;

Fuel = Mass or volume of the fuel combusted during the year, expressed

- as a mass in kilograms, for solid fuels;
- as a volume in cubic metres at standard conditions, for gaseous fuels;
- as a volume in litres, for liquid fuels;

OEF = Overall CO_2 emission factor for the fuel, as specified in Table 1-3, 1-4 or 1-5, expressed

- in kilograms of CO_2 per kilogram, for solid fuels;
- in kilograms of CO_2 per cubic metre at standard conditions, for gaseous fuels;
- in kilograms of CO_2 per litre, for liquid fuels;

0.001 = Conversion factor, kilograms to metric tons.";

(g) by striking out "or 250 mmBtu/h" in the part preceding paragraph 1 of QC1.3.3;

(*h*) by adding "or, when a mass flowmeter is used to measure the flow in kilograms per unit of time, replace $\left\lfloor \frac{MW}{MVC} \right\rfloor$ by 1" at the end of the definition of factor MW in equation 1-7, in paragraph 4 of QC.1.3.3;

(i) by striking out the fourth paragraph of QC.1.3.4;

(*j*) by adding the following at the end of QC.1.4:

"However, when a fuel is not specified in one of Tables 1-1 to 1-8 of QC.1.7, the CH_4 and N_2O emissions attributable to that fuel do not need to be calculated. ";

(k) by adding the following after paragraph 2 of QC.1.4.1:

"(3) of a fuel specified in Table 1-2 or of a biomass fuel.";

(l) by inserting ", or emission factor specified in the document "AP-42, Compilation of Air Pollutant Emission Factors" published by the U.S. Environmental Protection Agency (USEPA)" after "or 1-7" in the definition of the factor EF in equation 1-10, in QC.1.4.1;

(m) by replacing "or emission factor for the fuel specified in Table 1-3 or 1-7 in QC.1.7" in the definition of the factor EF in equation 1-12 in QC.1.4.2 by ", emission factor for the fuel specified in Table 1-3 or 1-7 in QC.1.7, or emission factor specified in the document "AP-42, Compilation of Air Pollutant Emission Factors" published by the U.S. Environmental Protection Agency (USEPA)";

(*n*) by striking out "high heat value" in the definition of factor "n" in equation 1-13 in QC.1.4.2;

(o) by replacing "equation 1-4" in paragraph 1 of QC.1.5.1, by "equations 1-2 and 1-4";

(p) by inserting "and waste-derived fuels" after "coal" in paragraph 4 of QC.1.5.1;

(q) by replacing "an enterprise, facility" in the part preceding subparagraph 1 of the first paragraph of QC.1.5.2 by "a facility";

(*r*) by inserting "le" before "fournisseur" in the French text of subparagraph 2 of the first paragraph of QC.1.5.2;

(*s*) by replacing "magajoule" in paragraph 1 of QC.1.5.3 by "gigajoule";

(*t*) by replacing "or ASTM D1946-90 (2006) "Standard Practice for Analysis of Reformed Gas by Gas Chromatography"" in subparagraph 3 of the second paragraph of QC.1.5.5 by ", ASTM D1946-90 (2006) "Standard Practice for Analysis of Reformed Gas by Gas Chromatography" or ASTM D2163-07 "Standard Test Method for Determination of Hydrocarbons in Liquefied Petroleum (LP) Gases and Propane/Propene Mixtures by Gas Chromatography"";

(*u*) by inserting the following lines in Table 1-1 of QC.1.7 after the line "Petroleum Coke – Upgrader Use":

"

Ethanol (100%)	21.04
Biodiesel (100%)	32.06
Rendered Animal Fat	31.05
Vegetable Oil	30.05

";

(*v*) by inserting the following lines in Table 1-1 of QC.1.7 after the line "Municipal solid waste":

"

Tires	31.18
Agricultural By-products	8.60
Biomass By-products	26.93

";

(*w*) by adding the following line in Table 1-1 of QC.1.7 after the line "Landfill Gas (captured methane)":

"

Biogas (captured methane)	0.02810

";

(*x*) by inserting the following lines in Table 1-3 of QC.1.7 after the line "Spent Pulping Liquor":

"

Agricultural By-products	N/A	112	N/A	N/A	N/A	N/A
Biomass By-products	N/A	100	N/A	N/A	N/A	N/A
Biogas (captured methane)	N/A	49.4	N/A	N/A	N/A	N/A
Ethanol (100%)	N/A	64.9	N/A	N/A	N/A	N/A
Biodiesel (100%)	N/A	70	N/A	N/A	N/A	N/A
Rendered Animal Fat	N/A	67.4	N/A	N/A	N/A	N/A
Vegetable Oil	N/A	77.3	N/A	N/A	N/A	N/A

“;

(*y*) by replacing the line "**Gaseous fuels**" in Table 1-3 of QC.1.7 by the following:

"

Gaseous fuels	**CO_2 (kg/m^3)**	**CO_2 (kg/GJ)**	**CH_4 (g/m^3)**	**CH_4 (g/GJ)**	**N_2O (g/m^3)**	**N_2O (g/GJ)**

";

(2) in QC.2:

(a) by striking out subparagraph 4 of the first paragraph of QC.2.2;

(b) by replacing "daily molecular weight of refinery fuel gas and flexigas" in subparagraph 5 of the first paragraph of QC.2.2 by "average molecular weight of each gaseous fuel";

(c) by adding the following after subparagraph 5 of the first paragraph of QC.2.2:

"(6) the number of times that the methods for estimating missing data provided for in QC.2.5 were used.";

(*d*) by replacing ", 4 and 5" in the second paragraph of QC.2.2 by "and 4";

(e) by replacing QC.2.3.2 by the following:

"QC.2.3.2. Calculation of CO_2 emissions for each supply system for refinery fuel gas and flexigas

The annual CO_2 emissions for each supply system for refinery fuel gas and flexigas must be calculated based on the carbon content and molecular weight of the refinery fuel gas or flexigas, using equation 2-1:

Equation 2-1

$$CO_2 = \sum_{i=1}^{n} \sum_{j=1}^{m} \left(Fuel_{ij} \times CC_{ij} \times \frac{MW_{ij}}{MVC} \right) \times 3.664 \times 0.001$$

Where:

CO_2 = Annual CO_2 emissions attributable to the combustion of refinery fuel gas or flexigas, in metric tons;

n = Number of days of operation in the year;

i = Day;

m = Number of supply systems;

j = Supply system;

$Fuel_{ij}$ = Consumption of refinery fuel gas or flexigas in supply system *j* for day *i*, in cubic metres at standard conditions;

CC_{ij} = Carbon content of the sample of refinery fuel gas or flexigas in supply system *j* for day *i*, measured in accordance with QC.2.4.2, in kilograms of carbon per kilogram of fuel;

MW_{ij} = Molecular weight of the sample of refinery fuel gas or flexigas in supply system *j* for day *i*, in kilograms per kilomole;

MVC = Molar volume conversion factor of 24.06 m^3 per kilomole at standard conditions;

3.664 = Ratio of molecular weights, CO_2 to carbon;

0.001 = Conversion factor, kilograms to metric tons.";

(f) by striking out "and the high heat value" in paragraph 2 of QC.2.3.4;

(g) by replacing "low heat content gas" in subparagraph *a* of paragraph 3 of QC.2.3.4 by "natural gas";

(h) by replacing "and refinery fuel gas" in subparagraph *b* of paragraph 3 of QC.2.3.4 by ", refinery fuel gas and low heat content gas";

(i) by replacing QC.2.4.2 by the following:

"QC.2.4.2. Carbon content and molecular weight of gaseous fuels

The carbon content and molecular weight of gaseous fuels must be measured daily using one of the following methods:

(1) in accordance with QC.1.5.5;

(2) using the chromatographic analysis of gaseous fuels, provided that the gas chromatograph is maintained and calibrated according to the manufacturer's instructions.";

(j) by striking out QC.2.4.3 and QC.2.4.4;

(*k*) by adding the following at the end of QC.2.4:

"**QC.2.5. Methods for estimating missing data**

When sampling or measurement data required by this Regulation for the calculation of emissions is missing, the emitter must use replacement data determined in accordance with QC.1.6.";

(3) in QC.3:

(a) by replacing "monthly aluminum production", in subparagraph 7 of the first paragraph of QC.3.2 by "monthly and annual liquid aluminum production";

(b) by replacing "aluminum" wherever it occurs in subparagraph *a* of paragraph 8, subparagraphs *a*, *b* and *i* of subparagraph 9 and subparagraphs *a* and *d* of subparagraph 12 of the first paragraph of QC.3.2 by "liquid aluminum";

(c) by striking out subparagraph *d* of subparagraph 8 of the first paragraph of QC.3.2;

(d) by inserting "and annual" after "monthly" in subparagraph *b* of subparagraph 10 of the first paragraph of QC.3.2;

(e) by striking out subparagraph *e* of subparagraph 10 of the first paragraph of QC.3.2;

(f) by inserting "and annual" after "monthly" in subparagraph *f* of subparagraph 11 of the first paragraph of QC.3.2;

(g) by striking out "attributable to anode effects" in the part preceding subparagraph *a* of subparagraph 12 of the first paragraph of QC.3.2;

(h) by replacing subparagraphs *a* and *b* of subparagraph 12 of the first paragraph of QC.3.2 by the following:

> "*(a)* the slope determined in accordance with the method in QC.3.6.1, in metric tons of CF4 per metric ton of aluminum, per anode effect minute, per pot and per day for each series of pots, and the date on which the slope is determined for each series of pots;
>
> *(b)* the anode effect frequency, in anode effect minutes per pot and per day, calculated monthly for each series of pots;";

(i) by striking out subparagraphs *c*, *d* and *e* of subparagraph 12 of the first paragraph of QC.3.2;

(j) by replacing "or C_2F_6 per metric ton of aluminum, per millivolt" in subparagraph *f* of subparagraph 12 of the first paragraph of QC.3.2 by "per metric ton of aluminum";

(k) by replacing subparagraphs *g* and *h* of subparagraph 12 of the first paragraph of QC.3.2 by the following:

> "*(g)* the date on which the overvoltage coefficient is determined for each series of pots;
>
> *(h)* the C_2F_6/CF_4 weight fraction, in kilograms of C_2F_6 per kilogram of CF_4, for each series of pots;";

(l) by adding the following after subparagraph 13 of the first paragraph of QC.3.2:

"(14) the number of times that the methods for estimating missing data provided for in QC.3.7 were used;

(15) the total greenhouse gas emissions for each type of emissions, namely:

(a) the annual fixed process emissions corresponding to the total of the emissions referred to in subparagraphs 1, 2 and 4, in metric tons CO_2 equivalent;

(b) the annual combustion emissions corresponding to the emissions referred to in subparagraph 6, in metric tons CO_2 equivalent;

(c) the annual "other" category emissions corresponding to the total of the emissions referred to in subparagraphs 3 and 5, in metric tons CO_2 equivalent;

(16) the annual quantity of aluminum hydrate produced, in metric tons.";

(m) by replacing equation 3-1 of QC.3.3.1 by the following:

"**Equation 3-1**

$$CO_2 = \sum_{i=1}^{12} [NAC \times MP \times \frac{(100 - S_a - Ash_a)}{100} \times 3.664]_i$$

Where:

CO_2 = Annual CO_2 emissions attributable to the consumption of prebaked anodes, in metric tons;

i = Month;

NAC = Net anode consumption for liquid aluminum production for month *i*, in metric tons of anodes per metric ton of liquid aluminum;

MP = Production of liquid aluminum for month *i*, in metric tons;

S_a = Sulphur content in the prebaked anodes for month *i*, in kilograms of sulphur per kilogram of prebaked anodes;

Ash_a = Ash content in the prebaked anodes for month *i*, in kilograms of ash per kilogram of prebaked anodes;

3.664 = Ratio of molecular weights, CO_2 to carbon.";

(*n)* by replacing "aluminum" wherever it occurs in equation 3-2 in QC.3.3.2 by "liquid aluminum";

(*o)* by replacing equation 3-4 of QC.3.3.3 by the following:

"**Equation 3-4**

$$CO_{2\ PM} = \sum_{i=1}^{12} \left(CPM \times BAC \times \frac{100 - Ash_{pm} - S_{pm}}{100} \right)_i \times 3.664$$

Where:

$CO_{2\ PM}$ = Annual CO_2 emissions attributable to packing material, in metric tons;

i = Month;

CPM = Consumption of packing material for month *i*, in metric tons of packing material per metric ton of baked anodes or cathodes;

BAC = Production of baked anodes or cathodes for month *i*, in metric tons;

Ash_{pm} = Ash content of packing material for month *i*, in kilograms of ash per kilogram of packing material;

S_{pm} = Sulphur content of packing material for month *i*, in kilograms of sulphur per kilogram of packing material;

3.664 = Ratio of molecular weights, CO_2 to carbon;";

(*p)* by replacing QC.3.4 by the following:

“**QC.3.4. Calculation method for CF_4 and C_2F_6 emissions**

Annual CF_4 and C_2F_6 emissions must be calculated using one of the calculation methods in QC.3.4.1 and QC.3.4.2.";

(*q)* by replacing QC.3.4.2 and QC.3.4.3 by the following:

"QC.3.4.2. Annual CF_4 and C_2F_6 emissions

The annual CF_4 and C_2F_6 emissions must be calculated for each series of pots using the following methods:

(1) for CF_4 emissions, using equation 3-7 or equation 3-8:

Equation 3-7

$$E_{CF4} = \sum_{i=1}^{12} \left[slope_{CF4} \times AEF \times MP \right]_i$$

Where:

E_{CF4} = Annual CF_4 emissions, in metric tons;

i = Month;

$slope_{CF4}$ = Slope for series of pots *j,* determined in accordance with the method in QC.3.6.1, in metric tons of CF_4 per metric ton of liquid aluminum, per anode effect minute, per pot and per day, for month *i*;

AEF = Anode effect frequency, in anode effect minutes per pot and per day, calculated for month *i*;

MP = Monthly production of liquid aluminum, in metric tons;

Equation 3-8

$$E_{CF4} = \sum_{i=1}^{12} \left[OC_{CF4} \times MP \right]_i$$

Where:

E_{CF4} = Annual CF_4 emissions attributable to anode effects, in metric tons;

i = Month;

OC_{CF4} = Overvoltage coefficient of series of pots *j* determined in accordance with the method in QC.3.6.1, in metric tons of CF_4 per metric ton of liquid aluminum, for month *i*;

MP = Monthly production of liquid aluminum, in metric tons;

(2) for C_2F_6 emissions, using equation 3-8.1:

Equation 3-8.1

$$E_{C2F6} = \sum_{i=1}^{12} \left[E_{CF4} \times F \right]_i$$

Where:

E_{C2F6} = Annual C_2F_6 emissions, in metric tons;

i = Month;

E_{CF4} = Monthly CF_4 emissions, in metric tons, for month *i*;

F = C_2F_6/CF_4 weight fraction, determined by the emitter or selected from Table 3-1 in QC.3.8, in kilograms of C_2F_6 per kilogram of CF_4.";

(*r*) by replacing "$SS_{Shipped}$" in the definition of factors in equation 3-9 in QC.3.5.1 by "$S_{Shipped}$";

(*s*) by replacing "an enterprise, facility" in the part of QC.3.6 preceding QC.3.6.1 by "a facility";

(*t*) by replacing "specified in QC.3.4.2 or the Péchiney method specified in QC.3.4.3" in the second paragraph of QC.3.6.1 by "or the Péchiney method specified in QC.3.4.2";

(*u*) by adding the following after QC.3.6.2:

"QC.3.7. Methods for estimating missing data

When sampling or measurement data required by this Regulation for the calculation of emissions is missing, the emitter must use replacement data determined as follows:

(1) when emissions are calculated using a continuous emission monitoring and recording system, the method in paragraph 2 of QC.1.6 must be used;

(2) for each parameter needed to calculate greenhouse gas emissions, except data on aluminum production or feedstock consumption, the missing data must be replaced by the arithmetic average of the data sampled or measured immediately preceding and following the missing data period. If no data are available prior to the missing data period, the emitter must use the first data obtained after the missing data period;

(3) for data on aluminum production or feedstock consumption, the missing data must be estimated using all the data relating to the processes used.

QC.3.8. Table

Table 3-1. C_2F_6/CF_4 weight fractions based on the technology used

(QC.3.4.2)

Technology used	**Weight fraction** **(kg C_2F_6 / kg CF_4)**
Centre-worked prebaked anodes (CWPB)	0.121
Side-worked prebaked anodes (SWPB)	0.252
Vertical stud Söderberg (VSS)	0.053
Horizontal stud Söderberg (HSS)	0.085

";

(4) in QC.4:

(a) by inserting the following after subparagraph *d* of subparagraph 3 of the first paragraph of QC.4.2:

"(*d.1)* the monthly content of non-calcined calcium oxide in the clinker, in metric tons of non-calcined calcium oxide per metric ton of clinker;

(d.2) the monthly content of non-calcined magnesium oxide in the clinker, in metric tons of non-calcined magnesium oxide per metric ton of clinker;";

(b) by striking out subparagraphs *f* and *g* of subparagraph 3 of the first paragraph of QC.4.2;

(c) by replacing "monthly" in subparagraphs *h* and *i* of subparagraph 3 of the first paragraph of QC.4.2 by "quarterly";

(d) by striking out subparagraph 4 of the first paragraph of QC.4.2;

(e) by adding the following after subparagraph 8 of the first paragraph of QC.4.2:

"(9) the number of times that the methods for estimating missing data in QC.4.5 were used;";

(10) the total greenhouse gas emissions for each type of emissions, namely:

(a) the annual fixed process emissions corresponding to the total of the emissions referred to in subparagraphs 2 and 4, in metric tons CO_2 equivalent;

(b) the annual combustion emissions corresponding to the total of the emissions referred to in subparagraphs 6 and 7, in metric tons CO_2 equivalent;

(11) the annual quantity of mixed clinker, gypsum and limestone produced, in metric tons.";

(f) by striking out the second paragraph of QC.4.2;

(g) by adding the following at the end of QC.4.3.1:

"In addition, the CO_2 emissions attributable to the combustion of fuels in all cement kilns must be calculated in accordance with paragraph 2 of QC.4.3.2.";

(h) by replacing "cement kilns" in the part preceding subparagraph *a* of paragraph 1 of QC.4.3.2 by "each cement kiln";

(i) by replacing "4-4" in subparagraph *a* of paragraph 1 of QC.4.3.2 by "4-3";

(j) by replacing equations 4-1 to 4-4 in QC.4.3.2 by the following:

"Equation 4-1

$$CO_{2-C} = \sum_{i=1}^{12} \left[Cli \times EF_{Cli} \right]_i + \sum_{j=1}^{4} \left[Q_{CKD} \times EF_{CKD} \right]_j$$

Where:

CO_{2-C} = CO_2 emissions attributable to calcination, in metric tons;

i = Month;

Cli = Production of clinker, in metric tons;

EF_{Cli} = Monthly CO_2 emission factor for the clinker, established using equation 4-2, in metric tons of CO_2 per metric ton of clinker;

j = Quarter;

Q_{CKD} = Quarterly quantity of dust discarded that is not recycled to the cement kiln, in metric tons;

EF_{CKD} = Quarterly CO_2 emission factor for the dust discarded that is not recycled to the cement kiln, established using equation 4-3, in metric tons of CO_2 per metric ton of dust;

Equation 4-2

$$EF_{Cli} = \left(CaO_{Cli} - CaO_{NCRM} \right) \times 0.785 + \left(MgO_{Cli} - MgO_{NCRM} \right) \times 1.092$$

Where:

EF_{Cli} = Monthly CO_2 emission factor for the clinker, in metric tons of CO_2 per metric ton of clinker;

CaO_{Cli} = Monthly content of calcium oxide in the clinker, in metric tons of calcium oxide per metric ton of clinker;

CaO_{NCRM} = Monthly content of non-calcined calcium oxide in the clinker, in metric tons of non-calcined calcium oxide per metric ton of clinker.

The non-calcined calcium oxide content is the sum of the calcium oxide that enters the kiln as a non-carbonate species and the calcium oxide remaining in the clinker after oxidation. These values must be measured using, respectively, the methods in paragraphs 7 and 8 of QC.4.4;

0.785 = Ratio of molecular weights, CO_2 to calcium oxide;

MgO_{Cli} = Monthly content of magnesium oxide in the clinker, in metric tons of magnesium oxide per metric ton of clinker;

MgO_{NCRM} = Monthly content of non-calcined magnesium oxide in the clinker, in metric tons of non-calcined magnesium oxide per metric ton of clinker.

The non-calcined magnesium oxide content is the sum of the magnesium oxide that enters the kiln as a non-carbonate species and the magnesium oxide remaining in the clinker after oxidation. These values must be measured using, respectively, the methods in paragraphs 7 and 8 of QC.4.4;

1.092 = Ratio of molecular weights, CO_2 to magnesium oxide;

Equation 4-3

$$EF_{CKD} = (CaO_{CKD} - CaO_{NCP}) \times 0.785 + (MgO_{CKD} - MgO_{NCP}) \times 1.092$$

Where:

EF_{CKD} = Quarterly CO_2 emission factor for the dust discarded that is not recycled to the cement kiln, in metric tons of CO_2 per metric ton of dust;

CaO_{CKD} = Quarterly content of calcium oxide in the dust discarded that is not recycled to the cement kiln, in metric tons of calcium oxide per metric ton of dust;

CaO_{NCP} = Quarterly content of non-calcined calcium oxide in the dust discarded that is not recycled to the cement kiln, in metric tons of non-calcined calcium oxide per metric ton of dust.

The non-calcined calcium oxide content is the sum of the calcium oxide that enters the kiln as a non-carbonate species and the calcium oxide remaining in the discarded kiln dust that is not recycled following oxidation. These values must be measured using respectively the methods in paragraphs 9 and 10 of QC.4.4;

0.785 = Ratio of molecular weights, CO_2 to calcium oxide;

MgO_{CKD} = Quarterly content of magnesium oxide in the dust discarded that is not recycled to the cement kiln, in metric tons of magnesium oxide per metric ton of dust;

MgO_{NCP} = Quarterly content of non-calcined magnesium oxide in the dust discarded that is not recycled to the cement kiln, in metric tons of non-calcined calcium oxide per metric ton of dust.

The non-calcined magnesium oxide content is the sum of the magnesium oxide that enters the kiln as a non-carbonate species and the magnesium oxide remaining in the discarded kiln dust that is not recycled following oxidation. These values must be measured using respectively the methods in paragraphs 9 and 10 of QC.4.4;

1.092 = Ratio of molecular weights, CO_2 to magnesium oxide;";

(k) by replacing "4-5" and "**4-5**" in subparagraph *b* of paragraph 1 of QC.4.3.2 and in the heading of equation 4-5 by "4-4" et "**4-4**" respectively;

(*l*) by replacing "0.02" in the definition of factor "TOC_{RM}" of equation 4-5 in QC.4.3.2 by "0.002 (2%)";

(m) by replacing "cement kilns" in paragraph 2 of QC.4.3.2 by "each cement kiln";

(*n*) by replacing "an enterprise, facility" in the part preceding paragraph 1 of QC.4.4 by "a facility";

(*o)* by replacing paragraphs 1 to 4 of QC.4.4 by the following:

"(1) determine monthly the calcium oxide and magnesium oxide content of the clinker, in accordance with ASTM C114-11 “Standard Test Methods for Chemical Analysis of Hydraulic Cement”, the measurements being made daily from clinker drawn from the exit of the kiln or monthly from clinker drawn from bulk storage;

(2) determine monthly the quantity of clinker produced using one of the following methods:

(a) direct weight measurement using the same plant instruments used for inventory purposes, such as weigh hoppers or belt weigh feeders;

(b) direct measurement of raw kiln feed applying a kiln-specific feed-to-clinker conversion factor, the accuracy of the factor being verified by the emitter on a monthly basis;

(3) determine monthly the quantity of raw materials consumed by direct weight measurement using the same plant instruments used for inventory purposes, such as weigh hoppers or belt weigh feeders;

(4) determine monthly the calcium oxide and magnesium oxide content of the clinker that enters the kiln as a non-carbonate species or use the value of 0;

(5) determine monthly the calcium oxide and magnesium oxide content remaining in the clinker after oxidation or use the value of 0;

(6) determine quarterly the calcium oxide and magnesium oxide content in the dust discarded that is not recycled to the cement kiln and in the feedstock in accordance with ASTM C114-11, the measurements being made daily at the exit of the kiln or quarterly if the dust is in bulk storage;

(7) determine quarterly the calcium oxide and magnesium oxide content in the discarded dust that is not recycled that enters the kiln as a non-carbonate species or use the value of 0;

(8) determine quarterly the calcium oxide and magnesium oxide content remaining in the discarded kiln dust that is not recycled following oxidation or use the value of 0;

(9) determine quarterly the quantity of discarded kiln dust that is not recycled to the cement kiln by direct weight measurement using the same plant instruments used for inventory purposes, such as weigh hoppers or belt weigh feeders;

(10) take samples annually of each category of raw materials in bulk storage and determine the total organic carbon content of the raw materials in accordance with ASTM C114-11.";

(*p*) by adding the following at the end of QC.4.4:

"**QC.4.5. Methods for estimating missing data**

When sampling or measurement data required by this Regulation for the calculation of emissions is missing, the emitter must use replacement data determined as follows:

(1) when emissions are calculated using a continuous emission monitoring and recording system, the method in paragraph 2 of QC.1.6 must be used;

(2) for the data needed to calculate CO_2 emissions attributable to calcination and the oxidation of organic carbon, a new analysis must be conducted;

(3) for each missing value concerning clinker production, the emitter must use the first data estimated after the missing data period or use the maximum daily production capacity and multiply by the number of days in the month;

(4) for each missing value concerning raw material consumption, the emitter must use the first data estimated after the missing data period or use the maximum daily raw material throughput of the kiln and multiply by the number of days in the month. ";

(5) in QC.5:

(a) by adding the following after paragraph 3 of QC.5.2:

"(4) the number of times that the methods for estimating missing data provided for in QC.5.5 were used:

(5) the annual greenhouse gas emissions in the "other" category corresponding to the emissions referred to in paragraph 1, in metric tons CO_2 equivalent.";

(b) by replacing equation 5-1 of QC.5.3 by the following:

"**Equation 5-1**

$$CH_4 = \sum_{i=1}^{n} \left(PC_i \times EF_i \right) \times 0.6772 \times 0.001$$

Where:

CH_4 = Annual CH_4 fugitive emissions from coal storage, for each type of coal *i*, in metric tons;

n = Total number of types of coal;

i = Type of coal;

PC_i = Annual purchases of coal, for each type of coal *i*, in metric tons;

EF_i = CH_4 emission factor for type of coal *i*, established in accordance with paragraph 2, in cubic metres of CH_4 per metric ton of coal;

0.6772 = Conversion factor, cubic metres to kilograms of CH_4;

0.001 = Conversion factor, kilograms to metric tons;";

(c) by replacing "QC.5.5" in subparagraphs *a* and *b* of paragraph 2 of QC.5.3 by "QC.5.6";

(*d*) by replacing "an enterprise, facility" in the part preceding paragraph 1 of QC.5.4 by "a facility";

(e) by replacing the heading of QC.5.5 by the following:

"**QC.5.5. Methods for estimating missing data**

When data relating to the total quantity of carbon purchased is missing, the replacement data must be estimated using all the data relating to the processes used.

QC.5.6. Tables";

(6) in QC.6:

(a) by replacing "carbon" in subparagraph 4 of the first paragraph of QC.6.2 by "average carbon";

(b) by adding the following after subparagraph 5 of the first paragraph of QC.6.2:

"(6) the number of times that the methods for estimating missing data provided for in AC.6.5 were used;

(7) the total greenhouse gas emissions for each type of emissions, namely:

(a) the annual fixed process emissions corresponding to the emissions referred to in subparagraph 1, in metric tons CO_2 equivalent;

(b) the annual combustion emissions corresponding to the emissions referred to in subparagraph 5, in metric tons CO_2 equivalent.";

(c) by replacing QC.6.3.2 by the following:

"QC.6.3.2. Calculation by feedstock material balance

The annual CO_2 emissions attributable to the production of hydrogen may be calculated by feedstock material balance using equations 6-1 to 6-3, depending on the type of feedstock:

(1) for gaseous feedstocks, the emitter must use equation 6-1:

Equation 6-1

$$CO_2 = \sum_{j=1}^{12} Q_j \times CF_j \times \frac{MW}{MVC} \times 3.664 \times 0.001$$

Where:

CO_2 = Annual CO_2 emissions attributable to the production of hydrogen, in metric tons;

j = Month;

Q_j = Quantity of gaseous feedstock consumed in month *j*, in cubic metres at standard conditions;

CF_j = Average carbon content of feedstock based on the analysis results for month *j* and measured by an emitter in accordance with QC.6.4, in kilograms of carbon per kilogram of feedstock;

MW = Molecular weight of feedstock, in kilograms per kilomole or, when a mass flowmeter is used to measure the flow, in kilograms per unit of time, replace $\left[\frac{MW}{MVC}\right]$ by 1;

MVC = Molar volume conversion factor of 24.06 m^3 per kilomole, at standard conditions;

3.664 = Ratio of molecular weights, CO_2 to carbon;

0.001 = Conversion factor, kilograms to metric tons;

(2) for liquid feedstocks, the emitter must use equation 6-2:

Equation 6-2

$$CO_2 = \sum_{j=1}^{12} Q_j \times CF_j \times 3.664 \times 0.001$$

Where:

CO_2 = Annual CO_2 emissions attributable to the production of hydrogen, in metric tons;

j = Month;

Q_j = Quantity of liquid feedstock consumed in month *j*, in kilolitres;

CF_j = Average carbon content of feedstock based on the analysis results for month *j* and measured by an emitter in accordance with QC.6.4, in kilograms of carbon per kilolitre of feedstock;

3.664 = Ratio of molecular weights, CO_2 to carbon;

0.001 = Conversion factor, kilograms to metric tons;

(3) for solid feedstocks, the emitter must use equation 6-3:

Equation 6-3

$$CO_2 \times \sum_{j=1}^{12} Q_j \times CF_j \times 3.664 \times 0.001$$

Where:

CO_2 = Annual CO_2 emissions attributable to the production of hydrogen, in metric tons;

j = Month;

Q_j = Quantity of solid feedstock consumed in month *j*, in kilograms;

CF_j = Average carbon content of feedstock based on the analysis results for month *j* and measured by an emitter in accordance with QC.6.4, in kilograms of carbon per kilogram of feedstock;

3.664 = Ratio of molecular weights, CO_2 to carbon;

0.001 = Conversion factor, kilograms to metric tons.";

(d) by replacing "carbon content using the methods specified in QC.1.5.5" in paragraph 2 of QC.6.4 by "average carbon content using the methods specified in paragraph 5";

(e) by replacing "measure" in paragraph 3 of QC.6.4 by "determine the";

(f) by adding the following after paragraph 3 of QC.6.4:

"(4) determine, quarterly, the quantity of CO_2 and of carbon monoxide transferred off-site;

(5) use the following analysis methods to measure the average carbon content of each type of feedstock:

(a) for solid feedstocks, ASTM D2013 / D2013M - 09 "Standard Practice for Preparing Coal Samples for Analysis", ASTM D2234 / D2234M - 10 "Standard Practice for Collection of a Gross Sample of Coal", ASTM D3176-09 "Standard Practice for Ultimate Analysis of Coal and Coke", ASTM D6609-08 "Standard Guide for Part-Stream Sampling of Coal", ASTM D6883-04 "Standard Practice for Manual Sampling of Stationary Coal from Railroad Cars, Barges, Trucks, or Stockpiles" or ASTM D7430-10b "Standard Practice for Mechanical Sampling of Coal";

(b) for liquid feedstocks, ASTM D2597-10 "Standard Test Method for Analysis of Demethanized Hydrocarbon Liquid Mixtures Containing Nitrogen and Carbon Dioxide by Gas Chromatography", ASTM D4057-06 "Standard Practice for Manual Sampling of Petroleum and Petroleum Products", ASTM D4177-95 (2010) "Standard Practice for Automatic Sampling of Petroleum and Petroleum Products", ISO 3170:2004 "Petroleum Liquids—Manual sampling" or ISO 3171:1988 "Petroleum liquids—Automatic pipeline sampling";

(c) for gaseous feedstocks, UOP539-97 "Refinery Gas Analysis by Gas Chromatography" or GPA 2261-00 "Analysis for Natural Gas and Similar Gaseous Mixtures by Gas Chromatography".";

(g) by adding the following after QC.6.4:

"QC.6.5. Methods for estimating missing data

When sampling or measurement data required by this Regulation for the calculation of emissions is missing, the emitter must use replacement data determined as follows:

(1) when emissions are calculated using a continuous emission monitoring and recording system, the method in paragraph 2 of QC.1.6 must be used;

(2) for each missing value concerning feedstock consumption, the replacing data must be estimated using all the data relating to the processes used;

(3) each missing value concerning the carbon content or molecular weight must be replaced by the arithmetic average of the data sampled or measured immediately preceding and following the missing data period. If no data are available prior to the missing data period, the emitter must use the first data obtained after the missing data period.";

(7) in QC.7:

(a) by replacing "and metallurgical coke production processes" in QC.7.1 by ", metallurgical coke production processes and iron ore or taconite pellet firing processes";

(b) by striking out subparagraphs *c* and *d* of subparagraph 2 of the first paragraph of QC.7.2;

(c) by striking out "and coke breeze" in subparagraph *g* of subparagraph 2 of the first paragraph of QC.7.2;

(d) by inserting the following after subparagraph *g* of subparagraph 2 of the first paragraph of QC.7.2:

"(*g*.1) the annual quantity of air pollution control residue collected, in metric tons;";

(e) by replacing "subparagraphs *b* to *g*" in subparagraph *h* of subparagraph 2 of the first paragraph of QC.7.2 by "subparagraphs *b* to *g*.1";

(f) by adding the following after subparagraph *h* of subparagraph 2 of the first paragraph of QC.7.2:

"(*h*.1) the CH_4 emission factors determined by the emitter and the methods used to estimate them;";

(g) by replacing subparagraphs 3 to 5 of the first paragraph of QC.7.2 by the following:

"(3) for steel production using a basic oxygen furnace:

(a) the annual CO_2 and CH_4 emissions attributable to steel production using a basic oxygen furnace, in metric tons;

(b) the annual consumption of molten iron and ferrous scrap, in metric tons;

(c) the annual consumption of each carbon-containing raw material, in metric tons;

(d) the annual production of steel, in metric tons;

(e) the quantity of slag produced, in metric tons;

(f) the quantity of basic oxygen furnace gas transferred off-site during the year, in metric tons;

(g) the annual quantity of air pollution control residue collected, in metric tons;

(h) the carbon content of the materials used in iron and steel production, referred to in subparagraphs *b* to *g*, and of derivatives of those materials, in metric tons of carbon per metric ton of material;

(i) the CH_4 emission factors determined by the emitter and the methods used to estimate them;

(4) for sinter production:

(a) the annual CO_2 and CH_4 emissions attributable to sinter production, in metric tons;

(b) the annual quantity of each carbonaceous material used in sinter production, in metric tons;

(c) the annual consumption of each raw material used in sinter production, other than carbonaceous materials, in metric tons;

(d) the annual production of sinter, in metric tons;

(e) the annual quantity of air pollution control residue collected, in metric tons;

(f) the carbon content of the materials used in sinter production, referred to in subparagraphs *b* to *e*, and of derivatives of those materials, in metric tons of carbon per metric ton of material;

(g) the CH_4 emission factors determined by the emitter and the methods used to estimate them;

(5) for steel production using an electric arc furnace:

(a) the annual CO_2 and CH_4 emissions attributable to steel production using an electric arc furnace, in metric tons;

(b) the annual consumption of direct reduced iron pellets, in metric tons;

(c) the annual consumption of ferrous scrap, in metric tons;

(d) the annual consumption of each flux material, in metric tons;

(e) the annual consumption of carbon electrodes, in metric tons;

(f) the annual consumption of each carbon-containing raw material, in metric tons;

(g) the annual production of steel, in metric tons;

(h) the quantity of slag produced, in metric tons;

(i) the annual quantity of air pollution control residue collected, in metric tons;

(j) the carbon content of the materials used in steel production, referred to in subparagraphs *b* to *i,* and of derivatives of those materials, in metric tons of carbon per metric ton of material;

(k) the CH_4 emission factors determined by the emitter and the methods used to estimate them;

(6) for the argon-oxygen decarburization of molten steel:

(a) the annual CO_2 and CH_4 emissions attributable to the argon-oxygen decarburization of molten steel, in metric tons;

(b) the annual quantity of molten steel charged to the process, in metric tons;

(c) the carbon content of the molten steel before decarburization, in metric tons of carbon per metric ton of molten steel;

(d) the carbon content of the molten steel after decarburization, in metric tons of carbon per metric ton of molten steel;

(e) the annual quantity of air pollution control residue collected, in metric tons;

(f) the carbon content of the air pollution control residue collected, in metric tons of carbon per metric ton of residue;

(g) the CH_4 emission factors determined by the emitter and the methods used to estimate them;

(7) for iron production using the direct reduction process:

(a) the annual CO_2 and CH_4 emissions attributable to iron production by direct reduction, in metric tons;

(b) the annual consumption of ore or pellets, in metric tons;

(c) the annual consumption of each carbon-containing raw material, other than ore or pellets, in metric tons;

(d) the annual production of reduced iron pellets, in metric tons;

(e) the annual quantity of non-metallic by-products, in metric tons;

(f) the annual quantity of air pollution control residue collected, in metric tons;

(g) the carbon content of the materials used in iron production, referred to in subparagraphs *b* to *f*, and of derivatives of those materials, in metric tons of carbon per metric ton of material;

(h) the CH_4 emission factors determined by the emitter and the methods used to estimate them;

(8) for iron production using a blast furnace:

(a) the annual CO_2 and CH_4 emissions attributable to iron production using a blast furnace, in metric tons;

(b) the annual consumption of ore or pellets, in metric tons;

(c) the annual consumption of each carbon-containing raw material, other than ore or pellets, in metric tons;

(d) the annual consumption of each flux material, in metric tons;

(e) the annual production of iron, in metric tons;

(f) the annual quantity of non-metallic by-products, in metric tons;

(g) the annual quantity of air pollution control residue collected, in metric tons;

(h) the carbon content of the materials used in iron production, referred to in subparagraphs *b* to *g*, and of derivatives of those materials, in metric tons of carbon per metric ton of material;

(i) the CH_4 emission factors determined by the emitter and the methods used to estimate them;

(9) for the indurating of iron ore pellets:

(a) the annual CO_2 and CH_4 emissions attributable to the indurating of iron ore pellets, in metric tons;

(b) the annual consumption of greenball pellets, in metric tons;

(c) the annual production of each type of fired pellets, in metric tons;

(d) the annual quantity of air pollution control residue collected, in metric tons;

(e) the carbon content of the materials used in the production of iron, referred to in subparagraphs *b* to *d*, and of derivatives of those materials, in metric tons of carbon per metric ton of material;

(f) the annual quantities of each raw material used, other than greenball pellets, in metric tons;

(g) the annual quantity of each type of ore pellets produced, in metric tons;

(h) the annual emissions of each type of ore pellets produced, in metric tons CO_2 equivalent;

(10) the number of times that the methods for estimating missing data provided for in QC.7.6 were used;

(11) the total greenhouse gas emissions for each type of emissions, namely:

(a) the annual fixed process emissions corresponding to the total of the emissions referred to in subparagraph *a* of subparagraphs 2 to 9, in metric tons CO_2 equivalent;

(b) the annual combustion emissions corresponding to the emissions referred to in subparagraph *b* of subparagraph 1, in metric tons CO_2 equivalent;

(12) the annual quantity of steel exiting each rolling mill, in metric tons;

(13) the annual quantity of forged steel produced, in metric tons.";

(h) by replacing the second paragraph of QC.7.2 by the following:

"Subparagraph *h* of subparagraph 2, subparagraph *h* of subparagraph 3, subparagraph *f* of subparagraph 4, subparagraph *j* of subparagraph 5, subparagraphs *c, d* and *f* of subparagraph 6, subparagraph *g* of subparagraph 7, subparagraph *h* of subparagraph 8 and subparagraph *e* of subparagraph 9 of the first paragraph do not apply to the CO_2 emissions of an emitter who calculates emissions using data from a continuous emission monitoring and recording system.";

(i) by replacing QC.7.3 and QC.7.4 by the following:

"**QC.7.3. Calculation methods for CO_2 emissions**

An emitter must calculate the annual CO_2 emissions attributable to primary processes to produce both iron and steel, secondary steelmaking processes, iron production processes, metallurgical coke production processes and ore or taconite pellet indurating processes using one of the calculation methods in QC.7.3.1 and QC.7.3.2.

QC.7.3.1. Use of a continuous emission monitoring and recording system

The annual CO_2 emissions attributable to primary processes to produce both iron and steel, secondary steelmaking processes, iron production processes, metallurgical coke production processes and ore or taconite pellet indurating processes may be calculated using data from a continuous emission monitoring and recording system in accordance with QC.1.3.4.

QC.7.3.2. Calculation by mass balance

The annual CO_2 emissions attributable to primary processes to produce both iron and steel, secondary steelmaking processes, iron production processes, metallurgical coke production processes and ore or taconite pellet indurating processes must be calculated using the methods in paragraphs 1 to 9 depending on the process used, expressed

(1) for primary processes to produce both iron and steel, secondary steelmaking processes, iron production processes, metallurgical coke production processes and ore or taconite pellet indurating processes, using equation 7-1:

Equation 7-1

$$CO_2 = CO_{2,COKE} + CO_{2,BOF} + CO_{2,SINTER} + CO_{2,EAF} + CO_{2,AOD} + CO_{2,DR} + CO_{2,BF} + CO_{2,IP}$$

Where:

CO_2 = Annual CO_2 emissions attributable to primary processes to produce both iron and steel, secondary steelmaking processes, iron production processes, metallurgical coke production processes and ore or taconite pellet indurating processes, in metric tons;

$CO_{2,\ COKE}$ = Annual CO_2 emissions attributable to the production of metallurgical coke, calculated in accordance with equation 7-2, in metric tons;

$CO_{2,\ BOF}$ = Annual CO_2 emissions attributable to steel production using a basic oxygen furnace, calculated in accordance with equation 7-3, in metric tons;

$CO_{2,\ SINTER}$ = Annual CO_2 emissions attributable to sinter production, calculated in accordance with equation 7-4, in metric tons;

$CO_{2,\ EAF}$ = Annual CO_2 emissions attributable to steel production using an electric arc furnace, calculated in accordance with equation 7-5, in metric tons;

$CO_{2,\ AOD}$ = Annual CO_2 emissions attributable to the argon-oxygen decarburization process, calculated in accordance with equation 7-6, in metric tons;

$CO_{2,\ DR}$ = Annual CO_2 emissions attributable to iron production by direct reduction, calculated in accordance with equation 7-7, in metric tons;

$CO_{2,\ BF}$ = Annual CO_2 emissions attributable to iron production using a blast furnace, calculated in accordance with equation 7-8, in metric tons;

$CO_{2,\ IP}$ = Annual CO_2 emissions attributable to the indurating of iron ore pellets, calculated in accordance with equation 7-9, in metric tons;

(2) for the production of metallurgical coke, using equation 7-2:

Equation 7-2

$$CO_{2,COKE} = \left[(CC \times C_{CC}) - (GOC \times C_{GOC}) - (MC \times C_{MC}) - (R \times C_R) - \sum_{j=1}^{n} (COB_j \times C_{COB,j}) \right] \times 3.664$$

Where:

$CO_{2,\ COKE}$ = Annual CO_2 emissions attributable to la production of metallurgical coke, in metric tons;

CC = Annual consumption of coking coal, in metric tons;

C_{CC} = Carbon content of coking coal, in metric tons of carbon per metric ton of coking coal;

GOC = Quantity of coke oven gas transferred off-site during the year, in metric tons;

C_{GOC} = Carbon content of the coke oven gas transferred off-site during the year, in metric tons of carbon per metric ton of coke oven gas;

MC = Annual production of metallurgical coke, in metric tons;

C_{MC} = Carbon content of the metallurgical coke produced, in metric tons of carbon per metric ton of metallurgical coke;

R = Annual quantity of air pollution control residue collected, in metric tons;

C_R = Carbon content of the collection and air cleaning system, in metric tons of carbon per metric ton of residue;

COB_i = Quantity of coke oven by-product *i* transferred off-site during the year, in metric tons;

$C_{COB,\,i}$ = Carbon content of coke oven by-product *i* transferred off-site during the year, in metric tons of carbon per metric ton of by-product *i*;

n = Number of coke oven by-products transferred off-site during the year;

i = Type of by-product;

3.664 = Ratio of molecular weights, CO_2 to carbon;

(3) for steel production using a basic oxygen furnace, using equation 7-3:

Equation 7-3

$$CO_{2,BOF} = \begin{bmatrix} (MI \times C_{MI}) + (SC \times C_{SC}) + (FL \times C_{FL}) + (CAR \times C_{CAR}) \\ -(ST \times C_{ST}) - (SL \times C_{SL}) - (BOG \times C_{BOG}) - (R \times C_R) \end{bmatrix} \times 3.664$$

Where:

$CO_{2,\,BOF}$ = Annual CO_2 emissions attributable to steel production using a basic oxygen furnace, in metric tons;

MI = Annual consumption of molten iron, in metric tons;

C_{MI} = Carbon content of molten iron, in metric tons of carbon per metric ton of molten iron;

SC = Annual consumption of ferrous scrap, in metric tons;

C_{SC}= Carbon content of ferrous scrap, in metric tons of carbon per metric ton of ferrous scrap;

FL = Annual quantity of each flux material used, in metric tons;

C_{FL} = Carbon content of each flux material, in metric tons of carbon per metric ton of flux material;

CAR = Annual consumption of each carbonaceous material, in metric tons;

C_{CAR} = Carbon content of each carbonaceous material, in metric tons of carbon per metric ton of carbonaceous material;

ST = Annual production of molten steel, in metric tons;

C_{ST} = Carbon content of molten steel, in metric tons of carbon per metric ton of molten steel;

SL = Annual production of slag, in metric tons;

C_{SL} = Carbon content of slag, in metric tons of carbon per metric ton of slag;

BOG = Quantity of basic oxygen furnace gas transferred off-site during the year, in metric tons;

C_{BOG} = Carbon content of the basic oxygen furnace gas transferred off-site during the year, in metric tons of carbon per metric ton of basic oxygen furnace gas;

R = Annual consumption of air pollution control residue, in metric tons;

C_R = Carbon content of the air pollution control residue, in metric tons of carbon per metric ton of residue;

3.664 = Ratio of molecular weights, CO_2 to carbon;

(4) for sinter production, using equation 7-4:

Equation 7-4

$$CO_{2,SINTER} = \left[\sum_{j=1}^{m}\left(CAR_j \times C_{CAR,j}\right) + \sum_{i=1}^{n}\left(RM_i \times C_{RM,i}\right) - \left(SINTER \times C_{SINTER}\right) - \left(R \times C_R\right)\right] \times 3.664$$

Where:

$CO_{2,\,SINTER}$ = Annual CO_2 emissions attributable to sinter production, in metric tons;

m = Number of carbonaceous material;

j = Type of carbonaceous material;

CAR_j = Annual consumption of carbonaceous material *j*, in metric tons;

$C_{CAR,j}$ = Carbon content of carbonaceous material *j*, in metric tons of carbon per metric ton of carbonaceous material;

n = Number of raw materials other than carbonaceous materials;

i = Type of raw material other than carbonaceous materials;

RM_j = Annual consumption of raw material *j* other than carbonaceous materials, required for sinter production, such as natural gas or fuel oil, in metric tons;

$C_{RM,j}$ = Carbon content of raw material *j* other than carbonaceous materials, required for sinter production, in metric tons of carbon per metric ton of raw material *j*;

SINTER = Sinter production, in metric tons;

C_{SINTER} = Carbon content of sinter, in metric tons of carbon per metric ton of sinter;

R = Annual consumption of air pollution control residue, in metric tons;

C_R = Carbon content of air pollution control residue, in metric tons of carbon per metric ton of residue;

3.664 = Ratio of molecular weights, CO_2 to carbon;

(5) for steel production using an electric arc furnace, using equation 7-5:

Equation 7-5

$$CO_{2,EAF} = \begin{bmatrix} (I \times C_I) + (SC \times C_{SC}) + (FL \times C_{FL}) + (EL \times C_{EL}) \\ + \sum_{i=1}^{n} (CAR_i \times C_{CAR,i}) - (ST \times T_{ST}) - (SL \times C_{SL}) - (R \times C_R) \end{bmatrix} \times 3.664$$

Where:

$CO_{2,\ EAF}$ = Annual CO_2 emissions attributable to steel production using an electric arc furnace, in metric tons;

I = Annual consumption of direct reduced iron pellets, in metric tons;

C_I = Carbon content of direct reduced iron pellets, in metric tons of carbon per metric ton of direct reduced iron pellets;

SC = Annual consumption of ferrous scrap, in metric tons;

C_{SC}= Carbon content of ferrous scrap, in metric tons of carbon per metric ton of ferrous scrap;

FL = Annual quantity of each flux material used, in metric tons;

C_{FL} = Carbon content of each flux material used, in metric tons of carbon per metric ton of flux material;

EL = Annual consumption of carbon electrodes, in metric tons;

C_{EL} = Carbon content of the carbon electrodes, in metric tons of carbon per metric ton of carbon electrodes;

n = Total number of carbonaceous material;

i= Carbonaceous material;

CAR_i = Annual consumption carbonaceous material *i*, in metric tons;

$C_{CAR,i}$ = Carbon content of carbonaceous material *i*, in metric tons of carbon per metric ton of carbonaceous material;

ST = Annual production of molten steel, in metric tons;

C_{ST} = Carbon content of molten steel, in metric tons of carbon per metric ton of molten steel;

SL = Annual production of slag, in metric tons;

C_{SL} = Carbon content of slag, in metric tons of carbon per metric ton of slag;

R = Annual consumption of air pollution control residue, in metric tons;

C_R = Carbon content of the air pollution control residue, in metric tons of carbon per metric ton of residue;

3.664 = Ratio of molecular weights, CO_2 to carbon;

(6) for the argon-oxygen decarburization process, using equation 7-6:

Equation 7-6

$$CO_{2,AOD} = \left[Steel \times \left(C_{Steel,in} - C_{Steel,out}\right) - \left(R \times C_R\right)\right] \times 3.664$$

Where:

$CO_{2,AOD}$ = Annual CO_2 emissions attributable to the argon-oxygen decarburization process, in metric tons;

Steel = Quantity of molten steel charted to the argon-oxygen decarburization process, in metric tons;

$C_{Steel,in}$ = Carbon content of molten steel before decarburization, in metric tons of carbon per metric ton of molten steel;

$C_{Steel,out}$ = Carbon content of molten steel after decarburization, in metric tons of carbon per metric ton of molten steel;

R = Annual consumption of air pollution control residue, in metric tons;

C_R = Carbon content of the air pollution control residue, in metric tons of carbon per metric ton of residue;

3.664 = Ratio of molecular weights, CO_2 to carbon;

(7) for iron production by direct reduction, using equation 7-7:

Equation 7-7

$$CO_{2,DR} = \left[\left(Ore \times C_{Ore}\right) + \sum_{i=1}^{n}\left(RM_i \times C_{RM,i}\right) + \sum_{j=1}^{m}\left(CAR_j \times C_{CAR,j}\right) - \left(I \times C_I\right) - \left(NM \times C_{NM}\right) - \left(R \times C_R\right)\right] \times 3.664$$

Where:

$CO_{2,\,DR}$ = Annual CO_2 emissions attributable to iron production by direct reduction, in metric tons;

Ore = Annual consumption of ore or pellets, in metric tons;

C_{Ore} = Carbon content of ore or pellets, in metric tons of carbon per metric ton of ore or pellets;

n = Number of raw materials, other than carbonaceous materials and ore;

i = Type of raw material, other than carbonaceous materials and ore;

RM_i = Annual consumption of raw material *i* other than carbonaceous materials and ore, such as natural gas or fuel oil, in metric tons;

$C_{RM, i}$ = Carbon content of raw material *i* other than carbonaceous materials and ore, in metric tons of carbon per metric ton of raw material *i*;

m = Number of carbonaceous materials;

j = Type of carbonaceous material;

CAR_j = Annual consumption of each carbonaceous material *j*, in metric tons;

$C_{CAR, j}$ = Carbon content of each carbonaceous material *j*, in metric tons of carbon per metric ton of carbonaceous material *j*;

I = Annual production of iron produced by direct reduction, in metric tons;

C_I = Carbon content of iron produced by direct reduction, in metric tons of carbon per metric ton of iron produced by direct reduction;

NM = Annual production of non-metallic by-products, in metric tons;

C_{NM} = Carbon content of non-metallic by-products, in metric tons of carbon per metric ton of non-metallic by-products;

R = Annual consumption of air pollution control residue, in metric tons;

C_R = Carbon content of the air pollution control residue, in metric tons of carbon per metric ton of residue;

3.664 = Ratio of molecular weights, CO_2 to carbon;

(8) for iron production using a blast furnace, using equation 7-8:

Equation 7-8

$$CO_{2,BF} = \left[\sum_{i=1}^{n} \left(RM_i \times C_{RM,i} \right) + \sum_{j=1}^{m} \left(CAR_j \times C_{CAR,j} \right) + \sum_{k=1}^{p} \left(F_k \times C_{F,k} \right) + \left(Ore \times C_{Ore} \right) - \left(I \times C_I \right) - \left(NM \times C_{NM} \right) - \left(R \times C_R \right) \right] \times 3.664$$

Where:

$CO_{2,\,BF}$ = Annual CO_2 emissions attributable to iron production using a blast furnace, in metric tons;

n = Number of raw materials, other than carbonaceous materials and ore;

i = Type of raw material other than carbonaceous materials and ore;

RM_i = Annual consumption of raw material *i* other than carbonaceous materials and ore, in metric tons;

$C_{RM,\,i}$ = Carbon content of raw material *i* other than carbonaceous materials and ore, in metric tons of carbon per metric ton of raw material *i*;

m = Number of carbonaceous materials;

j = Type of carbonaceous material;

CAR_j = Annual consumption of each carbonaceous material *j*, in metric tons;

$C_{CAR,\,j}$ = Carbon content of each carbonaceous material *j*, in metric tons of carbon per metric ton of carbonaceous material *j*;

p = Number of flux materials;

k = Type of flux material;

F_k = Annual quantity of each flux material *k* used, in metric tons;

$C_{F,k}$ = Carbon content of each flux material *k*, in metric tons of carbon per metric ton of flux material *k*;

Ore = Annual consumption of ore or pellets, in metric tons;

C_{Ore} = Carbon content of ore or pellets, in metric tons of carbon per metric ton of ore or pellets;

I = Annual production of iron using a blast furnace, in metric tons;

C_I = Carbon content of iron produced using a blast furnace, in metric tons of carbon per metric ton of iron produced using a blast furnace;

NM = Annual production of non-metallic by-products, in metric tons;

C_{NM} = Carbon content of non-metallic by-products, in metric tons of carbon per metric ton of non-metallic by-products;

R = Annual consumption of air pollution control residue, in metric tons;

C_R = Carbon content of the air pollution control residue, in metric tons of carbon per metric ton of residue;

3.664 = Ratio of molecular weights, CO_2 to carbon;

(9) for the indurating of iron ore pellets, using equation 7-9:

Equation 7-9

$$CO_{2,IP} = \left[(GBP \times C_{GBP}) - (FP \times C_{FP}) - (R \times C_R)\right] \times 3.664$$

Where:

$CO_{2,\ IP}$ = Annual CO_2 emissions attributable to the indurating of iron ore pellets, in metric tons;

GBP = Consumption of greenball pellets, in metric tons;

C_{GBP} = Carbon content of greenball pellets, in metric tons of carbon per metric ton of greenball pellets;

FP = Quantity of fired pellets produced by the indurating process, in metric tons;

C_{FP} = Carbon content of fired pellets, in metric tons of carbon per metric ton of fired pellets;

R = Annual consumption of air pollution control residue, in metric tons;

C_R = Carbon content of the air pollution control residue, in metric tons of carbon per metric ton of residue;

3.664 = Ratio of molecular weights, CO_2 to carbon.

QC.7.4. Calculation methods for CH_4 emissions

An emitter must calculate the annual CH_4 emissions attributable to primary processes to produce both iron and steel, secondary steelmaking processes, iron production processes, metallurgical coke production processes and ore or taconite pellet indurating processes using one of the calculation methods in QC.7.4.1 and QC.7.4.2.

QC.7.4.1. Use of a continuous emission monitoring and recording system

The annual CH_4 emissions attributable to primary processes to produce both iron and steel, secondary steelmaking processes, iron production processes, metallurgical coke production processes and ore or taconite pellet indurating processes may be calculated using data from a continuous emission monitoring and recording system in accordance with QC.1.3.4.

QC.7.4.2. Calculation using establishment-specific emission factors

The annual CH_4 emissions attributable to primary processes to produce both iron and steel, secondary steelmaking processes, iron production processes, metallurgical coke production processes and ore or taconite pellet indurating processes must be calculated using establishment-specific emission factors determined by the emitter.

QC.7.5. Sampling, analysis and measurement requirements

QC.7.5.1. Carbon content

An emitter who operates a facility or establishment that produces iron or steel or who operates the indurating of iron ore or taconite pellets must use the data provided by the supplier or determine carbon content by analyzing a minimum of 3 representative samples using the following methods:

(1) for fossil fuels, in accordance with QC.1.5.5;

(2) for by-products needed in iron and steel production such as blast furnace gas, coke oven gas, coal tar, light oil, slag dust or sinter off gas, by measuring fuel carbon content to ±5% using data from a continuous monitoring and recording system or the methods in QC.1.5.1 and QC.1.5.5;

(3) for flux materials such as limestone or dolomite, using ASTM C25-06 "Standard Test Methods for Chemical Analysis of Limestone, Quicklime, and Hydrated Lime";

(4) for coal, coke and the carbon electrodes used in electric arc furnaces, using ASTM D5373-08 "Standard Test Methods for Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Laboratory Samples of Coal" or, for fuels, raw materials or liquid products, ASTM D7582-10 "Standard Test Methods for Proximate Analysis of Coal and Coke by Macro Thermogravimetric Analysis";

(5) for iron and ferrous scrap, using ASTM E1019-08 "Standard Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Fusion Techniques";

(6) for the steel produced, using one of the following methods:

(a) ASM CS-104 UNS G10460 "Carbon Steel of Medium Carbon Content" published by ASM International;

(b) ISO/TR 15349-1:1998 "Unalloyed steel – Determination of low carbon content, Part 1: Infrared absorption method after combustion in an electric resistance furnace (by peak separation)";

(c) ISO/TR 15349-3:1998 "Unalloyed steel – Determination of low carbon content, Part 3: Infrared absorption method after combustion in an electric resistance furnace (with preheating)";

(d) ASTM E415-08 "Standard Test Method for Atomic Emission Vacuum Spectrometric Analysis of Carbon and Low-Alloy Steel";

(7) for iron ore or taconite pellets, using ASTM E1915-09 "Standard Test Methods for Analysis of Metal Bearing Ores and Related Materials for Carbon, Sulfur, and Acid-Base Characteristics".

QC.7.5.2. Consumption of process materials

The emitter must determine the quantity of solid, liquid and gaseous process inputs and outputs and the quantity of by-products used in the production of iron and steel using the same plant instruments used for inventory purposes, such as weigh hoppers or belt weigh feeders.

QC.7.6. Methods for estimating missing data

When sampling or measurement data required by this Regulation for the calculation of emissions is missing, the emitter must use replacement data determined as follows:

(1) missing data on carbon content must be replaced by the arithmetic average of the data sampled or measured immediately preceding and following the missing data period. If no data are available prior to the missing data period, the emitter must use the first data obtained after the missing data period;

(2) missing data on the quantity of raw materials consumed monthly must be estimated using all the data relating to the processes used.";

(8) in QC.8:

(a) by replacing QC.8.1 by the following:

"**QC.8.1. Covered sources**

The covered sources are all the processes used in lime production, except the lime kilns used in a pulp and paper plant and the processes used to process sludge containing calcium carbonate.";

(b) by striking out "quick" in subparagraph 2 of the first paragraph of QC.8.2;

(c) by inserting "and annual" after "monthly" in subparagraph *b* of subparagraph 3 of the first paragraph of QC.8.2;

(d) by adding the following after subparagraph *d* of subparagraph 4 of the first paragraph of QC.8.2:

"(*e*) the annual quantity of calcined by-products and residue sold, in metric tons;";

(*e*) by adding the following after subparagraph 6 of the first paragraph of QC.8.2:

"(7) the number of times that the methods for estimating missing data in section QC.8.5 were used to determine lime production as required by subparagraph 3 of the first paragraph;

(8) the total greenhouse gas emissions for each type of emission, namely:

(a) the annual fixed process emissions corresponding to the emissions referred to in subparagraph 2, in metric tons CO_2 equivalent;

(b) the annual combustion emissions corresponding to the total of the emissions referred to in subparagraphs 5 and 6, in metric tons CO_2 equivalent.";

(f) by striking out the second paragraph of QC.8.2;

(*g*) by striking out "quick" in the part of paragraph 1 of QC.8.3.2 preceding equation 8-1;

(h) by replacing equation 8-1 in paragraph 1 of of QC.8.3.2 by the following:

"**Equation 8-1**

$$CO_2 = \sum_{i}^{12}\sum_{j}^{k}\left[L \times EF_L\right]_{ij} + \sum_{x}^{4}\sum_{y}^{z}\left[CBP \times EF_{CBP}\right]_{xy}$$

Where:

CO_2 = CO_2 emissions from kilns, in metric tons;

i = Month;

k = Total number of types of lime;

j = Type of lime;

L = Production of lime *j* for month *i*, in metric tons;

EF_L = CO_2 emission factor of lime *j* for month *i*, calculated in accordance with equation 8-2, in metric tons of CO_2 per metric ton of lime;

x = Quarter;

z = Total number of types of calcined by-products and wastes;

y = Type of calcined by-products and wastes;

CBP = Production of calcined by-products and wastes *y* in quarter *x*, including lime kiln dust, scrubber sludge and other calcined wastes, in metric tons;

EF_{CBP} = CO_2 emission factor for calcined by-products and wastes *y* for quarter *x*, calculated in accordance with equation 8-3, in metric tons of CO_2 per metric ton of calcined by-products and wastes;";

(i) by replacing subparagraph *a* of paragraph 1 of QC.8.3.2 by the following:

"*(a)* the monthly CO_2 emission factor for lime (EF_L) must be calculated, for each type of lime, using equation 8-2:

Equation 8-2

$$EF_L = (CaO_L \times 0.785) + (MgO_L \times 1.092)$$

Where:

EF_L = Monthly CO_2 emission factor for lime, in metric tons of CO_2 per metric ton of lime;

CaO_L = Monthly content of calcium oxide in the lime, in metric tons of calcium oxide per metric ton of lime;

0.785 = Ratio of molecular weights, CO_2 to calcium oxide;

MgO_L = Monthly content of magnesium oxide in the lime, in metric tons of magnesium oxide per metric ton of lime;

1.092 = Ratio of molecular weights, CO_2 to magnesium oxide;";

(j) by replacing "an enterprise, facility" in the part preceding paragraph 1 of QC.8.4 by "a facility";

(*k*) by replacing ", ASTM C1301-95 (2009) e1 "Standard Test Method for Major and Trace Elements in Limestone and Lime by Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP) and Atomic Absorption (A(A)" or ASTM C1271-99 (2006) "Standard Test Method for X-ray Spectrometric Analysis of Lime and Limestone"" in paragraph 1 of QC.8.4 by "or the National Lime Association's "CO_2 Emissions Calculation Protocol for the Lime Industry", revised in February 2008";

(l) by adding the following after paragraph 5 of QC.8.4:

"(6) follow the quality assurance/quality control procedures in the National Lime Association's "CO_2 Emissions Calculation Protocol for the Lime Industry", revised in February 2008.";

(m) by adding the following after QC.8.4:

"QC.8.5. Methods for estimating missing data

When sampling or measurement data required by this Regulation for the calculation of emissions is missing, the emitter must use replacement data determined as follows:

(1) when emissions are calculated using a continuous emission monitoring and recording system, the method in paragraph 2 of QC.1.6 must be used;

(2) for each missing value concerning the quantity of lime produced and the quantity of calcined by-products and wastes, the missing data must be estimated using all the data relating to the processes used;

(3) for the data needed to estimate the monthly calcium oxide and magnesium oxide contents, a new analysis must be conducted.";

(9) in QC.9:

(a) by replacing "asphalt" in QC.9.1 by "bitumen";

(b) by adding the following at the end of QC.9.1:

"Facilities that distill only pipeline transmix, in other words off-spec material created when different specification products mix during pipeline transportation, are excluded.";

(c) by inserting ", CH_4 and N_2O" after CO_2 in paragraph 2 of QC.9.2;

(d) by inserting the following after paragraph 6:

"(6.1) the annual CO_2 emissions attributable to hydrogen production processes, calculated in accordance with QC.6, in metric tons;";

(e) by striking out "above-ground" in paragraph 8 of QC.9.2;

(f) by adding the following after paragraph 13 of QC.9.2:

"(14) the annual CO_2, CH_4 and N_2O emissions from coke calcining, in metric tons;

(15) the annual CH_4 emissions from purging systems, in metric tons;

(16) the annual CH_4 emissions from loading operations, in metric tons;

(17) the annual CH_4 emissions from delayed coking, in metric tons;

(18) the number of times that the methods for estimating missing data provided for in QC.9.5 were used;

(19) the total greenhouse gas emissions for each type of emissions, namely:

(a) the annual fixed process emissions corresponding to the total of the emissions referred to in paragraphs 2, 6.1, 14 and 17, in metric tons CO_2 equivalent;

(b) the annual combustion emissions corresponding to the total of the emissions referred to in paragraphs 1 and 6, in metric tons CO_2 equivalent;

(c) the "other" category emissions corresponding to the total of the emissions referred to in paragraphs 3 to 5, 7 to 11, 15 and 16, in metric tons CO_2 equivalent;

(20) the annual quantity of crude oil refined, in kilolitres.";

(g) by replacing QC.9.3.1 by the following:

"QC.9.3.1. Calculation of CO_2, CH_4 and N_2O emissions attributable to catalyst regeneration

The annual CO_2, CH_4 and N_2O emissions attributable to catalyst regeneration for a facility equipped with a continuous emission monitoring and recording system must be calculated in accordance with QC.1.3.4 or, in the absence of such a system, in accordance with the following methods, depending on the process involved:

(1) for the continuous regeneration of catalyst material in fluid catalytic cracking units and fluid cokers:

(a) using the average coke consumption and equations 9-1, 9-2 and 9-3:

Equation 9-1

$$CO_2 = \sum_{j=1}^{n} (CB_j)_n \times C \times 3.664 \times 0.001$$

Where:

CO_2 = Annual CO_2 emissions attributable to the continuous regeneration of catalyst material in fluid catalytic cracking units and fluid cokers, in metric tons;

n = Number of hours of operation during the year;

j = Hour;

CB_j = Hourly coke burn for hour *j*, calculated in accordance with equation 9-2 or determined by the emitter, in kilograms;

C = Carbon content of coke burned, in kilograms of carbon per kilogram of coke burned;

3.664 = Ratio of molecular weights, CO_2 to carbon;

0.001 = Conversion factor, kilograms to metric tons;

Equation 9-2

$$CB_j = K_1 Q_r \times (\%CO_2 + \%CO) + K_2 Q_a - K_3 Q_r \times (\%CO/2 + \%CO_2 + \%O_2) + K_3 Q_{oxy} \times \%O_{2,\,oxy}$$

Where:

CB_j = Hourly coke burn, in kilograms;

K_1, K_2, K_3 = Material balance and conversion factors (K_1, K_2 and K_3) from Table 9-1 in QC.9.6;

Q_r = Volumetric flow of exhaust gas before entering the antipollution system, calculated in accordance with equation 9-3 or measured continuously, in cubic metres per minute, at standard conditions and on a dry basis;

$\%CO_2$ = CO_2 concentration in regenerator exhaust, in cubic metres of CO_2 per cubic metre of gas on a dry basis, expressed as a percentage;

%CO = Concentration of carbon monoxide in regenerator exhaust, in cubic metres of carbon monoxide per cubic metre of gas on a dry basis, expressed as a percentage;

Q_a = Volumetric flow of air to regenerator, in cubic metres per minute, at standard conditions and on a dry basis;

$\%O_2$ = Concentration of oxygen in regenerator exhaust, in cubic metres of oxygen per cubic metre of gas on a dry basis, expressed as a percentage;

Q_{oxy} = Volumetric flow of oxygen to regenerator, in cubic metres per minute, at standard conditions and on a dry basis;

$\%O_{2,oxy}$ = Concentration of oxygen in enriched air stream inlet to regenerator, expressed as a percentage by volume on a dry basis;

Equation 9-3

$$Q_r = \frac{\left[79 \times Q_a + \left(100 - \%O_{2,oxy}\right) \times Q_{oxy}\right]}{\left[100 - \%CO_2 - \%CO - \%O_2\right]}$$

Where:

Q_r = Volumetric flow of exhaust gas from regenerator before entering the antipollution system, in cubic metres per minute, at standard conditions and on a dry basis;

79 = Nitrogen concentration in air, expressed as a percentage;

Q_a = Volumetric flow of air to regenerator, in cubic metres per minute, at standard conditions and on a dry basis;

$\%O_{2,oxy}$ = Concentration of oxygen in enriched air stream inlet, in cubic metres of oxygen per cubic metre of air stream on a dry basis, expressed as a percentage;

Q_{oxy} = Volumetric flow of oxygen in enriched air stream inlet, in cubic metres per minute, at standard conditions and on a dry basis;

$\%CO_2$ = CO_2 concentration in regenerator exhaust, in cubic metres of CO_2 per cubic metre of gas on a dry basis, expressed as a percentage;

%CO = Concentration of carbon monoxide in regenerator exhaust, in cubic metres of carbon monoxide per cubic metre of gas on a dry basis, expressed as a percentage.

When no auxiliary fuel is burned and the emitter does not use a continuous CO monitoring and recording system, the percentage is zero;

$\%O_2$ = Concentration of oxygen in regenerator exhaust, in cubic metres of oxygen per cubic metre of gas on a dry basis, expressed as a percentage;

(b) using the CO_2 and carbon monoxide concentrations in the regenerator exhaust and equation 9-3.1:

Equation 9-3.1

$$CO_2 = \sum_{j=1}^{n} \left[Q_r \times \left(\frac{\%CO_2 + \%CO}{100\%} \right) \right]_j \times \frac{44}{MVC} \times 0.001$$

Where:

CO_2 = Annual CO_2 emissions attributable to the continuous regeneration of catalyst material in fluid catalytic cracking units and fluid cokers, in metric tons;

n = Number of hours of operation during the year;

j = Hour;

Q_r = Volumetric flow of exhaust gas from regenerator before entering the antipollution system, in cubic metres per minute, at standard conditions and on a dry basis;

$\%CO_2$ = CO_2 concentration in regenerator exhaust, in cubic metres of CO_2 per cubic metre of gas on a dry basis, expressed as a percentage;

%CO = Concentration of carbon monoxide in regenerator exhaust, in cubic metres of carbon monoxide per cubic metre of gas on a dry basis, expressed as a percentage.

When there is no post-combustion device, the percentage is zero;

44 = Molecular weight of CO_2, in kilograms per kilomole;

MVC = Molar volume conversion factor (4.06 m^3 per kilomole at standard conditions);

0.001 = Conversion factor, kilograms to metric tons;

(2) for periodic catalyst regeneration processes, using equation 9-4:

Equation 9-4

$$CO_2 = \sum_{i=1}^{n} (CB)_n \times C \times 3.664 \times 0.001$$

Where:

CO_2 = Annual CO_2 emissions attributable to periodic catalyst regeneration processes, in metric tons;

n = Number of regeneration cycles during the year;

i = Regeneration cycle;

CB = Quantity of coke burned, in kilograms per regeneration;

C = Carbon content of coke burned, measured or estimated by the emitter, or using a default value of 0.94 kg of carbon per kilogram of coke burned;

3.664 = Ratio of molecular weights, CO_2 to carbon;

0.001 = Conversion factor, kilograms to metric tons;

(3) for continuous catalyst regeneration processes in catalysers used for operations other than fluid catalytic cracking and fluid coking, using equation 9-5:

Equation 9-5

$$CO_2 = CRR \times \left(CF_{spent} - CF_{regen}\right) \times H \times 3.664$$

Where:

CO_2 = Annual CO_2 emissions attributable to continuous catalyst regeneration processes in catalysers used for operations other than fluid catalytic cracking and fluid coking, in metric tons;

CRR = Average catalyst regeneration rate, in metric tons per hour;

CF_{spent} = Carbon content of spent catalyst, in kilograms of carbon per kilogram of spent catalyst;

CF_{regen} = Carbon content of the regenerated catalyst, in kilograms of carbon per kilogram of regenerated catalyst.

If no carbon content in the regenerated catalyst is detected, the carbon content of the catalyst is zero;

H = Number of hours of operation of regenerator during the year;

3.664 = Ratio of molecular weights, CO_2 to carbon;

(4) the CH_4 emissions attributable to catalyst regeneration must be calculated using equation 9-5.1:

Equation 9-5.1

$$CH_4 = CO_2 \times \frac{EF_{CH4}}{EF_{CO2}}$$

Where:

CH_4 = CH_4 emissions from catalyst regeneration, in metric tons;

CO_2 = Annual CO_2 emissions from catalyst regeneration, calculated using equation 9-1, in metric tons;

EF_{CH4} = CH_4 emission factor, 2.8×10^{-3} kg per gigajoule;

EF_{CO2} = CO_2 emission factor, 97 kg per gigajoule;

(5) the N_2O emissions attributable to catalyst regeneration must be calculated using equation 9-5.2:

Equation 9-5.2

$$N_2O = CO_2 \times \frac{EF_{N2O}}{EF_{CO2}}$$

Where:

N_2O = Annual N_2O emissions from catalyst regeneration, in metric tons;

CO_2 = Annual CO_2 emissions from catalyst regeneration, calculated using equation 9-1, in metric tons;

EF_{N2O} = N_2O emission factor, 5.7×10^{-4} kg per gigajoule;

EF_{CO2} = CO_2 emission factor, 97 kg per gigajoule;”;

(h) by inserting ", for each process vent with a CO_2 flow of over 2% by volume, a CH_4 flow of over 0.5% by volume, or an N_2O flow of over 0.01% by volume" after "using equation 9-6" in the part of QC.9.3.2 preceding equation 9-6 in QC.9.3.2;

(i) by adding ",or, when a mass flowmeter is used to measure the flow in kilograms per unit of time, replace $\left[\frac{MW}{MVC}\right]$ by 1", at the end of the definition of the factor MW_x in equation 9-6 in QC.9.3.2;

(j) by replacing QC.9.3.3 by the following:

"QC.9.3.3. Calculation of CO_2 and CH_4 emissions attributable to bituminous product blowing processes

The annual CO_2 and CH_4 emissions attributable to bituminous product blowing processes must be calculated using the method in QC.9.3.2, or in accordance with the following methods:

(1) for bituminous product blowing operations without antipollution equipments, or bituminous product blowing activities controlled by a steam gas purification system, using the following equations:

Equation 9-7

$$CO_2 = Q_{BP} \times EF_{BP,CO2}$$

Where:

CO_2 = Annual CO_2 emissions attributable to uncontrolled bituminous product blowing operations, in metric tons;

Q_{BP} = Annual quantity of bituminous product blown, in millions of barrels;

$EF_{BP,CO2}$ = CO_2 emission factor for uncontrolled bituminous product blowing operations determined by the emitter, or a default value of 1,100 metric tons per million barrels;

Equation 9-8

$$CH_4 = Q_{BP} \times EF_{BP,CH4}$$

Where:

CH_4 = CH_4 emissions attributable to uncontrolled bituminous product blowing operations, in metric tons;

Q_{BP} = Annual quantity of bituminous product blown, in millions of barrels;

$EF_{BP,CH4}$ = CH_4 emission factor for uncontrolled bituminous product blowing operations determined by the emitter, or a default value of 580 metric tons per million barrels;

(2) for bituminous product blowing operations controlled by thermal oxidizer or flare, using equations 9-8.1 and 9-8.2, except if the emissions have already been calculated in accordance with QC.9.3.5 or QC.1.3:

Equation 9-8.1

$$CO_2 = Q_{BP} \times C_{BP} \times 0.98 \times 3.664$$

Where:

CO_2 = Annual CO_2 emissions attributable to controlled bituminous product blowing operations, in metric tons;

Q_{BP} = Annual quantity of bituminous products blown, in millions of barrels;

C_{BP} = Carbon content of bituminous product blown determined by the emitter, or a default value of 2,750 metric tons per million barrels;

0.98 = Efficiency of thermal oxidizer or flare;

3.664 = Ratio of molecular weights, CO_2 to carbon;

Equation 9-8.2

$$CH_4 = Q_{BP} \times EF_{BP,CH4} \times 0.02$$

Where:

CH_4 = Annual CH_4 emissions attributable to controlled bituminous product blowing operations, in metric tons;

Q_{BP} = Annual quantity of bituminous product blown, in millions of barrels;

$EF_{BP,CH4}$ = CH_4 emission factor for bituminous product blowing operations without antipollution equipments determined by the emitter, or a default value of 580 metric tons per million barrels;

0.02 = Fraction of CH_4 uncombusted in thermal oxidizer or flare, in percentage expressed in decimal form.";

(k) by inserting "or, when a mass flowmeter is used to measure gas flow in kilograms per year, replace $\left[\frac{MW_{CO2}}{MVC}\right]$ by 1" after "kilomole" in the definition of the factor "MW_{CO2}" in equation 9-9 in QC.9.3.4;

(l) by replacing QC.9.3.5 to QC.9.3.9 by the following:

"QC.9.3.5. Calculation of CO_2, CH_4 and N_2O emissions attributable to combustion of hydrocarbons in flares and other antipollution equipments

The annual CO_2, CH_4 and N_2O emissions attributable to combustion of hydrocarbons in flares and other antipollution equipments must be calculated in accordance with the calculation methods in QC.1, except the CO_2 emissions attributable to the combustion of hydrocarbons in flares that must be calculated, based on the type of equipment used, using the following methods:

(1) for a flare equipped with a continuous monitoring and recording system to measure the flow and the parameters used to determine the carbon content of the gas, or if the parameters are measured at least weekly, using equation 9-10:

Equation 9-10

$$CO_2 = \left[\sum_{p=1}^{n}\left(Flare_p \times \frac{MW_p}{MVC} \times C_p \times 3.664\right)\right] \times 0.98 \times 0.001$$

Where:

CO_2 = Annual CO_2 emissions attributable to the combustion of hydrocarbons in flares, in metric tons;

n = Number of measurement periods; minimum of 52 for weekly measurements and maximum of 366 for daily measurements;

p = Measurement period;

$Flare_p$ = Volume of flare gas combusted during measurement period *p*, in cubic metres at standard conditions;

MW_p = Average molecular weight of flare gas combusted during measurement period *p* in kilograms per kilomole or, when a mass flowmeter is used to measure flare gas flow in kilograms per measurement period, replace $\frac{MW_p}{MVC}$ by 1.

If measurements are taken more frequently than daily, the arithmetic average of measurement values must be used;

MVC = Molar volume conversion factor (24.06 m^3 per kilomole at standard conditions);

C_p = Average carbon content of flare gas during measurement period *p*, in kilograms of carbon per kilogram of flare gas.

If measurements are taken more frequently than daily, the arithmetic average of measurement values must be used;

3.664 = Ratio of molecular weights, CO_2 to carbon;

0.98 = Combustion efficiency of flare;

0.001 = Conversion factor, kilograms to metric tons;

(2) for a flare equipped with a continuous monitoring and recording system to measure the flow and the parameters used to determine the high heat value of the gas, or if the parameters are measured at least weekly, using equation 9-11:

Equation 9-11

$$CO_2 = \left[\sum_{p=1}^{n} \left(Flare_p \times HHV_p \times EF \right) \right] \times 0.98 \times 0.001$$

Where:

CO_2 = Annual CO_2 emissions attributable to the combustion of hydrocarbons in flares, in metric tons;

n = Number of measurement periods; minimum of 52 for weekly measurements and maximum of 366 for daily measurements;

p = Measurement period;

$Flare_p$ = Volume of flare gas during measurement period *p*, in cubic metres at standard conditions.

If a mass flowmeter is used, the molecular weight must be measured and the molecular weight and mass flow must be converted to a volumetric flow using equation 9-12;

HHV_p = High heat value of the gas combusted during the measurement period, in gigajoules per cubic metre;

EF = Default CO_2 emission factor of 57 kg per gigajoule;

0.98 = Combustion efficiency of flare;

0.001 = Conversion factor, kilograms to metric tons;

Equation 9-12

$$Flare_p\left(m^3\right) = Flare_p\left(kg\right) \times \frac{MCV}{MW_p}$$

Where:

$Flare_p$ (m^3) = Volume of flare gas combusted during measurement period *p*, in cubic metres;

$Flare_p$ (kg) = Masse of flare gas combusted during measurement period *p*, in kilograms;

MVC = Molar volume conversion factor (24.06 m^3 per kilomole at standard conditions);

MW_p = Average molecular weight of flare gas during measurement period *p*, in kilograms per kilomole;

(3) when it is not possible to measure the parameters required in equations 9-10 and 9-11 during startup, shutdown or equipment malfunction, the quantity of gas discharged to the flare must be calculated for each startup, shutdown or malfunction and the CO_2 emissions must be calculated using equation 9-13 :

Equation 9-13

$$CO_2 = \left[\sum_{p=1}^{n}\left(Flare_{SSM,p} \times \frac{MW_p}{MVC} \times C_p \times 3.664\right)\right] \times 0.98 \times 0.001$$

Where:

CO_2 = Annual CO_2 emissions attributable to the combustion of hydrocarbons in flare during startup, shutdown or malfunction, in metric tons;

n = Annual number of startups, shutdowns or malfunctions;

p = Periods of startup, shutdown or malfunction;

$Flare_{SSM,p}$ = Volume of flare gas combusted during startup, shutdown or malfunction period *p*, in cubic metres at standard conditions;

MW_p = Average molecular weight of flare gas during measurement period *p*, in kilograms per kilomole;

MVC = Molar volume conversion factor (24.06 m^3 per kilomole at standard conditions);

C_p = Average carbon content of flare gas during measurement period *p*, in kilograms of carbon per kilogram of flare gas;

3.664 = Ratio of molecular weights, CO_2 to carbon;

0.98 = Combustion efficiency of flare;

0.001 = Conversion factor, kilograms to metric tons;

(4) the CH_4 emissions attributable to the combustion of hydrocarbons in flares must be calculated using equation 9-14:

Equation 9-14

$$CH_4 = \left[CO_2 \times \frac{EF_{CH4}}{EF_{CO2}} \right] + \left[CO_2 \times \frac{0.02}{0.98} \times \frac{16}{44} \times f_{CH4} \right]$$

Where:

CH_4 = Annual CH_4 emissions attributable to the combustion of hydrocarbons in flares, in metric tons;

CO_2 = Annual CO_2 emissions attributable to the combustion of hydrocarbons in flares, calculated using equations 9-10 to 9-12 or in accordance with QC.1, in metric tons;

EF_{CH4} = CH_4 emission factor of 2.8×10^{-3} kG per gigajoule;

EF_{CO2} = CO_2 emission factor of 57 kG per gigajoule;

0.02/0.98 = Correction factor for flare combustion efficiency;

16/44 = Correction factor for the molecular weight ratio of CH_4 to CO_2;

f_{CH4} = Fraction of carbon in CH_4 in flare gas prior to combustion, in kilograms of carbon in CH_4 in flare gas per kilograms of carbon in flare gas, or default value of 0.4;

(5) the N_2O emissions attributable to the combustion of hydrocarbons in flares must be calculated using equation 9-15:

Equation 9-15

$$N_2O = CO_2 \times \frac{EF_{N2O}}{EF_{CO2}}$$

Where:

N_2O = Annual N_2O emissions attributable to the combustion of hydrocarbons in flares, in metric tons;

CO_2 = Annual CO_2 emissions attributable to the combustion of hydrocarbons in flares, calculated using equations 9-10 to 9-12 or in accordance with QC.1, in metric tons;

EF_{N2O} = N_2O emission factor of 5.7×10^{-4} kg per gigajoule;

EF_{CO2} = CO_2 emission factor of 57 kg per gigajoule;

(6) when equipment or methods other than flares are used to destroy low Btu gases such as coker flue gas, gases from vapour recovery systems, casing vents and product storage tanks, the CO_2 emissions must be calculated using equation 9-16:

Equation 9-16

$$CO_2 = \sum_{p=1}^{n} \left[GV_p \times C_p \times \frac{MW_p}{MVC} \right] \times 3.664 \times 0.001$$

Where:

CO_2 = Annual CO_2 emissions attributable to the combustion of low Btu gases, in metric tons;

n = Total number of low Btu gases;

p = Low Btu gas;

GV_p = Annual volume of gas *p*, in cubic metres at standard conditions;

C_p = Carbon content of gas *p*, in kilograms of carbon per kilogram of gas;

MW_p = Molecular weight of the gas in kilograms per kilomole or, when a mass flowmeter is used to measure the flow of gas *p* in kilograms, replace $\frac{MW_p}{MVC}$ by 1;

MVC = Molar volume conversion factor (24.06 m^3 per kilomole at standard conditions);

3.664 = Ratio of molecular weights, CO_2 to carbon;

0.001 = Conversion factor, kilograms to metric tons.

QC.9.3.6. Calculation of CH_4 emissions from storage tanks

The CH_4 emissions of the following storage tanks do not have to be calculated: units permanently attached to conveyances such as trucks, trailers, rail cars, barges, or ships; pressure vessels designed to operate in excess of 204.9 kPa and without emissions to the atmosphere; bottoms receivers or sumps; vessels storing wastewater; and reactor vessels associated with a manufacturing process unit.

The annual CH_4 emissions from all other storage tanks must be calculated using the following methods:

(1) for storage tanks other than those used for unstabilized crude oil that have a vapour-phase CH_4 concentration of 0.5% volume percent or more by volume, the CH_4 emissions must be calculated using the following methods:

(a) when the CH_4 composition is known, according to the procedures provided for in section 7.1 of the AP-42: “Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Areas Sources”, including TANKS Model (version 4.09(D), published by the U.S. Environmental Protection Agency (USEPA);

(b) using equation 9-17:

Equation 9-17

$$CH_4 = Q_{CO} \times 0.1$$

Where:

CH_4 = Annual CH_4 emissions from storage tanks, in metric tons;

Q_{co} = Annual quantity of crude oil and intermediate products received from off-site that are processed at the establishment, in millions of barrels;

0.1= Default emission factor for storage tanks, in metric tons of CH_4 per million barrels;

(2) for storage tanks for unstabilized crude oil, the CH_4 emissions must be calculated using the following methods:

(a) when the CH_4 concentration is known, by measuring directly the vapour generated;

(b) using equation 9-18:

Equation 9-18

$$CH_4 = (995{,}000 \times Q_{un} \times \Delta P) \times MF_{CH4} \times \frac{16}{MVC} \times 0.001$$

Where:

CH_4 = Annual CH_4 emissions from storage tanks, in metric tons;

995,000 = Equation correlation factor, in cubic feet at standard conditions per million barrels per kilopascals;

Q_{un} = Annual quantity of unstabilized crude oil, in millions of barrels;

ΔP = Pressure differential from storage pressure to atmospheric pressure, in kilopascals;

MF_{CH4}= Mole fraction of CH_4 in vent gas from the unstabilized crude oil storage tank, measured by the emitter, in kilomoles of CH_4 per kilomole of gas, or a value of 0.27;

16 = Molecular weight of CH_4, in kilograms per kilomole;

MVC = Molar volume conversion factor (24.06 m^2 per kilomole at standard conditions);

0.001 = Conversion factor, kilograms to metric tons.

QC.9.3.7. Calculation of CH_4 and N_2O emissions attributable to anaerobic wastewater treatment

The annual emissions attributable to anaerobic wastewater treatment must be calculated:

(1) for CH_4 emissions, using equation 9-19 or equation 9-20:

Equation 9-19

$$CH_4 = Q \times COD_{qave} \times B \times MCF \times 0.001$$

Where:

CH_4 = Annual CH_4 emissions attributable to wastewater treatment, in metric tons;

Q = Quantity of wastewater treated annually, in cubic metres;

COD_{qave} = Quarterly average chemical oxygen demand of the wastewater, in kilograms per cubic metre;

B = CH_4 generation capacity of 0.25 kg of CH_4 per kilogram of chemical oxygen demand;

MCF = Conversion factor for CH_4 specified in Table 9-3 of QC.9.6, depending on the process;

0.001 = Conversion factor, kilograms to metric tons;

Equation 9-20

$$CH_4 = Q \times BOD_{5qave} \times B \times MCF \times 0.001$$

Where:

CH_4 = Annual CH_4 emissions attributable to wastewater treatment, in metric tons;

Q = Quantity of wastewater treated annually, in cubic metres;

BOD_{5qave} = Average quarterly five-day biochemical oxygen demand of the wastewater, in kilograms per cubic metre;

B = CH_4 generation capacity of 0.25 kg of CH_4 per kilogram of chemical oxygen demand;

MCF = Conversion factor for CH_4 specified in Table 9-3 of QC.9.6, depending on the process;

0.001 = Conversion factor, kilograms to metric tons;

(2) for anaerobic processes from which biogas is recovered and not emitted, the CH_4 emissions must be calculated by subtracting the quantity recovered;

(3) for N_2O emissions, using equation 9-21:

Equation 9-21

$$N_2O = Q \times N_{qave} \times EF_{N2O} \times 1.571 \times 0.001$$

Where:

N_2O = Annual N_2O emissions attributable to wastewater treatment, in metric tons;

Q = Quantity of wastewater treated annually, in cubic metres;

N_{qave} = Quarterly average nitrogen content in effluent, in kilograms per cubic metre;

EF_{N2O} = N_2O emission factor from discharged wastewater of 0.005 kg of nitrogen produced by the decomposition of nitrous oxide (N_2O-N) per kilogram of total nitrogen;

1.571 = Conversion factor, kilograms of N_2O-N to kilograms of N_2O;

0.001 = Conversion factor, kilograms to metric tons.

QC.9.3.8. Calculation of CH_4 emissions from oil-water separators

The annual CH_4 emissions from oil-water separators must be calculated using equation 9-22:

Equation 9-22

$$CH_4 = EF_{NMHC} \times Q_{water} \times CF_{NMHC} \times 0.001$$

Where:

CH_4 = Annual CH_4 emissions from oil-water separators, in metric tons;

EF_{NMHC} = Emission factor for hydrocarbons other than CH_4 as specified in Table 9-4 in QC.9.6, in kilograms per cubic metre;

Q_{water} = Quantity of wastewater treated annually by the separator, in cubic metres;

CF_{NMHC} = Conversion factor, non-methane hydrocarbons to CH_4, obtained by sampling and analysis at each separator or, in the absence of such data, a factor of 0.6;

0.001 = Conversion factor, kilograms to metric tons.

QC.9.3.9. Calculation of fugitive emissions of CH_4 from system components

Annual fugitive emissions of CH_4 must be calculated using one of the two following methods:

(1) using process-specific CH_4 composition data for each process and one of the emission estimation procedures provided for in the EPA-453/R-095-017, NTIS PB96-175401 "Protocol for Equipment Leak Emission Estimates" published by the U.S. Environmental Protection Agency (USEPA);

(2) using equation 9-23:

Equation 9-23

$$CH_4 = 0.4 \times N_C \times 0.2 \times N_{PU,1} \times 0.1 \times N_{PU,2} \times 4.3 \times N_{H2} \times N_{rgc}$$

Where:

CH_4 = Annual CH_4 emissions attributable to fugitive emissions from system components, in metric tons;

N_c = Number of crude oil distillation columns;

$N_{PU,1}$ = Cumulative number of catalytic cracking units, coking units (delayed or fluid), hydrocracking, and full-range distillation columns (including depropanizer and debutanizer distillation columns);

$N_{PU,2}$ Cumulative number of hydrotreating/hydrorefining units, catalytic reforming units, and visbreaking units;

N_{H2} Total number of hydrogen production units;

N_{rgc} Total number of fuel gas systems.

QC.9.3.10. Coke calcining

The annual CO_2, CH_4 and N_2O emissions attributable to coke calcining must be calculated using the following methods:

(1) the CO_2 emissions attributable to coke calcining must be calculated in accordance with QC.1.3.4 when the facility is equipped with a continuous emission monitoring and recording system or, in the absence of such a system, using equation 9-24:

Equation 9-24

$$CO_2 = \left[M_{in} \times C_{GC} - \left(M_{out} + M_{CBR}\right) \times C_{MPC}\right] \times 3.664$$

Where:

CO_2 = Annual CO_2 emissions attributable to coke calcining, in metric tons;

M_{in} = Annual mass of green coke entering the coke calcining process, in metric tons;

C_{GC} = Average mass fraction carbon content of the green coke, in metric tons of carbon per metric ton of green coke;

M_{out} = Annual mass of marketable coke, in metric tons of petroleum coke;

M_{CBR} = Annual mass of petroleum coke breeze collected in the dust collection system of the coke calcining unit, in metric tons of dust per metric ton of calcined coke;

C_{MPC} = Average mass fraction carbon content of marketable petroleum coke, in metric tons of carbon per metric ton of petroleum coke;

3.664 = Ratio of molecular weights, CO_2 to carbon;

(2) the annual CH_4 emissions attributable to coke calcining must be calculated using equation 9-25:

Equation 9-25

$$CH_4 = CO_2 \times \frac{EF_{CH4}}{EF_{CO2}}$$

Where:

CH_4 = Annual CH_4 emissions attributable to coke calcining, in metric tons;

CO_2 = Annual CO_2 emissions from coke calcining, calculated using equation 9-1, in metric tons;

EF_{CH4} = CH_4 emission factor determined by the emitter or a default value of 2.8 x 10^{-3} kg per gigajoule;

EF_{CO2} = CO_2 emission factor of 97 kg per gigajoule;

(3) the annual N_2O emissions attributable to coke calcining must be calculated using equation 9-26:

Equation 9-26

$$N_2O = CO_2 \times \frac{EF_{N2O}}{EF_{CO2}}$$

Where:

N_2O = Annual N_2O emissions attributable to coke calcining, in metric tons;

CO_2 = Annual CO_2 emissions attributable to coke calcining, calculated using equation 9-1, in metric tons;

EF_{N2O} = N_2O emission factor of 5.7 x 10^{-4} kg per gigajoule;

EF_{CO2} = CO_2 emission factor of 97 kg per gigajoule.

QC.9.3.11. Uncontrolled blowdown systems

The annual CO_2, CH_4 and N_2O emissions from uncontrolled blowdown systems must be calculated using the calculation methods in QC.9.3.2.

QC.9.3.12. Loading operations

The CH_4 emissions attributable to crude oil, intermediate, or product loading operations must be calculated using equilibrium vapour-phase CH_4 composition data and the procedures in Section 5.2 of the AP-42: "Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources" published by the U.S. Environmental Protection Agency (USEPA). When the equilibrium vapour-phase concentration of CH_4 is less than 0.5%, zero CH_4 emissions may be assumed.

QC.9.3.13. Delayed coking processes

The CH_4 emissions attributable to the depressurization of the vessels in each coking unit to the atmosphere must be calculated using one of the calculation methods in paragraphs 1 and 2, except in the case of an emitter who adds water or steam to the vessel once it is vented to the atmosphere, who must use the method in paragraph 1:

(1) the CH_4 emissions attributable to the depressurization of the vessels in each coking unit to the atmosphere must be calculated using equation 9-6 and the CH_4 emissions attributable to the subsequent opening of the vessel for coke cutting operations must be calculated, for each vessel with the same dimensions, using equation 9-27:

Equation 9-27

$$CH_4 = N \times H \times \frac{(P_{CV} + 101.325)}{101.325} \times f_{void} \times \frac{\Pi \times D^2}{4} \times \frac{16}{MVC} \times MF_{CH4} \times 0.001$$

Where:

CH_4 = Annual CH_4 emissions attributable to delayed coking processes, in metric tons;

N = Annual number of vessel openings for all vessels of the same dimensions in the coking unit;

H = Height of coking vessel, in metres;

P_{cv} = Gauge pressure of the coking vessel when opened to the atmosphere prior to coke cutting or, if the method in paragraph 2 is used, gauge pressure of the coking vessel when depressurization gases are first routed to the atmosphere, in kilopascals;

101.325 = Atmospheric pressure, in kilopascals;

f_{void} = Volumetric void fraction of coking vessel prior to the injection of water or steam, in cubic metres of gas at standard conditions per cubic metre of vessel;

Π = Pi, i.e. 3.1416;

D^2 = Diameter of coking vessel, in square metres;

16 = Molecular weight of CH_4, in kilograms per kilomole;

MVC = Molar volume conversion factor (24.06 m^3 per kilomole at standard conditions);

MF_{CH4} = Average mole fraction of CH_4 in coking vessel gas based on the analysis of at least two samples per year, collected at least four months apart, in kilomoles of CH_4 per kilomole of gas, wet basis;

0.001 = Conversion factor, kilograms to metric tons;

(2) the annual CH_4 emissions from the depressurization vents and the subsequent opening of the vessels in each coking unit for coke cutting operations must be calculated using equation 9-27 and the manometric pressure of the coking vessel when the depressurization gases are first routed to the atmosphere. ";

(m) by replacing "days" in subparagraph *e* of paragraph 1 of QC.9.4.1 by "hours";

(*n)* by adding the following at the end of QC.9.4.1:

"The values measured daily or weekly can be used to determine the minute or hourly data required for the corresponding equations.";

(*o)* by replacing QC.9.4.5 to QC.9.4.7 by the following:

"QC.9.4.5. Flares and other antipollution equipments

For flares and other antipollution equipments, an emitter must:

(1) if using a continuous emission monitoring and recording system on the flare, use the measured flow rate when it is within the calibrated range of the measurement device, or, determine the flow rate according to a sector-recognized method when it is not measured by the system;

(2) if using the method in subparagraph 1 of the second paragraph of QC.9.3.5, measure the parameters used to determine the carbon content of the flare gas daily;

(3) if using the method in subparagraph 2 of the second paragraph of QC.9.3.5, measure the parameters used to determine the high heat value of the flare gas daily.

When the continuous monitoring and recording system does not provide the parameters used to determine the carbon content of the gas, the emitter must measure those parameters at least weekly.

QC.9.4.6. Storage tanks

For storage tanks, the emitter must determine the annual throughput of all types of products for each storage tank using one of the following methods:

(1) by measuring them directly using measurement devices;

(2) by using any other measured or collected data.

QC.9.4.7. Wastewater treatment

For wastewater treatment, the emitter must

(1) collect weekly samples to analyse the chemical oxygen demand and 5-day biochemical oxygen demand (DBO5) of the wastewater from the anaerobic treatment process following preliminary treatment;

(2) measure weekly the flow rate of wastewater entering the anaerobic wastewater treatment process, at the flow measurement location used to collect samples under paragraph 1 to analyse the chemical oxygen demand and 5-day biochemical oxygen demand (DBO5);

(3) determine quarterly the nitrogen content of the wastewater.";

(*p*) by replacing QC.9.4.9 by the following:

"QC.9.4.9. Coke calcining

For coke calcining, the emitter must measure the mass and carbon content of the petroleum coke using one of the following methods:

(1) ASTM D3176-09 "Standard Practice for Ultimate Analysis of Coal and Coke";

(2) ASTM D5291-10 "Standard Test Methods for Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Petroleum Products and Lubricants";

(3) ASTM D5373-08 "Standard Test Methods for Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Laboratory Samples of Coal".

QC.9.5. Methods for estimating missing data

When sampling or measurement data required by this Regulation is missing, the emitter must use replacement data determined as follows:

(1) each missing value concerning the carbon content, molecular weight and high heat value of the fuel must be replaced by the arithmetic average of the data sampled or measured immediately preceding and following the missing data period. If no data are available prior to the missing data period, the emitter must use the first data obtained after the missing data period;

(2) for each missing value concerning CO_2, CH_4, N_2O, carbon monoxide and oxygen concentrations, and gas flow rate, the replacement data must be estimated using all the data relating to the processes used.

QC.9.6. Tables";

(*q*) by striking out Tables 9-2 and 9-5;

(*r*) by replacing "ethane" by “methane” in note *a* under Table 9-4 in QC9.5;

(10) in QC.10:

(a) by replacing paragraphs 1 to 3 of QC.10.2 by the following:

"(1) the annual CO_2 emissions attributable to the combustion of biomass, including black liquor, in recovery furnaces and lime kilns, calculated in accordance with QC.1, in metric tons;

(2) the annual CH_4 and N_2O emissions attributable to the combustion of biomass, including black liquor, in recovery furnaces and lime kilns, calculated in accordance with QC.1, in metric tons;

(3) the annual CO_2 emissions attributable to the addition of carbonate materials in recovery furnaces and lime kilns, calculated in accordance with QC.25.3, in metric tons;

(3.1) the annual CO_2, CH_4 and N_2O emissions attributable to production of electricity, calculated in accordance with QC.16, in metric tons;";

(b) by adding the following after paragraph 7 of QC.10.2:

"(8) the number of times that the methods for estimating missing data provided for in QC.10.5 were used;

(9) the annual greenhouse gas emissions for each type of emissions, namely:

(a) the annual fixed process emissions corresponding to the total of the emissions referred to in paragraphs 1 and 3, in metric tons CO_2 equivalent;

(b) the annual combustion emissions corresponding to the total of the emissions referred to in paragraphs 3.1 and 4, in metric tons CO_2 equivalent;

(c) the "other" category emissions corresponding to the emissions referred to in paragraph 2, in metric tons CO_2 equivalent;

(10) the annual production of each pulp and paper product manufactured, in dry metric tons.";

(c) by replacing QC.10.3 by the following:

"QC.10.3. Calculation methods for CO_2, CH_4 and N_2O emissions

The annual CO_2, CH_4 and N_2O emissions attributable to the manufacture of pulp and paper products must be calculated in accordance with the calculation methods in QC.10.3.1 to QC.10.3.3.

QC.10.3.1. Calculation of CO_2, CH_4 and N_2O emissions attributable to the combustion of biomass

The annual CO_2, CH_4 and N_2O emissions attributable to the combustion of biomass, including black liquor, in recovery furnaces and rotary lime kilns in sulphite pulp and soda pulp mills, in combustion units for recovered sulphites or bisulphites, or in independent combustion units for semi-chemical pulp process, must be calculated in accordance with QC.1.

The high heat value or carbon content of the biomass must be determined by the emitter in accordance with QC.10.4.

QC.10.3.2. Calculation of CO_2, CH_4 and N_2O emissions attributable to the addition of carbonate materials

The annual CO_2, CH_4 and N_2O emissions attributable to the addition of carbonate materials in recovery furnaces and lime kilns must be calculated in accordance with QC.25.3.

QC.10.3.3. Calculation of CO_2, CH_4 and N_2O emissions attributable to the production of electricity

The annual CO_2, CH_4 and N_2O emissions attributable to the production of electricity must be calculated in accordance with QC.16.";

(d) by replacing paragraph 1 of QC.10.4 by the following:

"(1) determine the quantity of black liquor produced each year using one of the following methods:

(a) by measuring it in accordance with TAPPI T 650 om-09 "Solids content of black liquor" published by the Technical Association of the Pulp and Paper Industry;

(b) by measuring it using a continuous monitoring and recording system;

(1.1) determine the high heat value of the black liquor in accordance with TAPPI T 684 om-11 (R2011) "Gross heating value of black liquor";";

(e) by adding "or ASTM 5291 "Standard Test Methods for Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Petroleum Products and Lubricant" at the end of paragraph 2 of QC.10.4;

(f) by replacing "Table 10-1 in QC.10.5" in subparagraph *b* of paragraph 4 of QC.10.4 by "Table 25-1 in QC.25.6";

(g) by replacing QC.10.5 by the following:

"**QC.10.5. Methods for estimating missing data**

When sampling or measurement data required by this Regulation for the calculation of emissions is missing, the emitter must use replacement data determined as follows:

(1) when the missing data concerns the carbon content or high heat value of the black liquor, a new analysis must be conducted in accordance with QC.10.4;

(2) when the missing data concerns the quantity or the mass flow rate of the black liquor produced, the replacement value must be the lesser of the maximum mass or flow entering the kiln and the maximum mass of flow that can be measured by the continuous monitoring and recording system;

(3) when the missing data concerns the monthly quantity of carbonate materials, the missing data must be estimated using all the data relating to the processes used or the data used for inventory purposes;

(4) when the missing data concerns the carbonate content of the carbonate materials, the replacement value must be the default value of 1.0.";

(11) in QC.11:

(a) by replacing "sodium carbonate bearing ore or brine" in QC.11.1 by "trona or sodium sesquicarbonate, and all liquid alkaline feedstock processes that produce CO_2";

(b) by replacing "all soda ash calcining kilns" in paragraph 1 of QC.11.2 by "sodium carbonate production";

(c) by replacing paragraph 3 of QC.11.2 by the following:

"(3) the monthly consumption of trona, sodium sesquicarbonate and liquid alkaline feedstock, in metric tons;";

(d) by replacing "monthly" in paragraph 4 of QC.11.2 by "annual";

(e) by inserting the following after paragraph 4 by the following:

"(4.1) the number of times that the methods for estimating missing data specified in QC.11.5 were used;

(4.2) the total greenhouse gas emissions for each type of emissions, namely:

(a) the annual fixed process emissions corresponding to the emissions referred to in paragraph 1 in metric tons CO_2 equivalent;

(b) the annual combustion emissions corresponding to the emissions referred to in paragraph 2 in metric tons CO_2 equivalent;";

(f) by striking out paragraphs 5 to 9 of QC.11.2;

(g) by replacing QC.11.3 to QC.11.4 by the following:

"**QC.11.3. Calculation methods for CO_2 emissions**

The annual CO_2 emissions from sodium carbonate production unit must be calculated using one of the calculation methods in QC.11.3.1 to QC.11.3.3.

QC.11.3.1. Calculation method using data from a continuous emission monitoring and recording system

The annual CO_2 emissions from a sodium carbonate production unit may be calculated using data from a continuous emission monitoring and recording system in accordance with QC.1.3.4.

QC.11.3.2. Calculation method using inorganic carbon content

The annual CO_2 emissions from a sodium carbonate production unit may be calculated using equation 11-1 or 11-2:

Equation 11-1

$$CO_2 = \sum_{i=1}^{12} (CI_{TR} \times TR)_i \times 0.097$$

Where:

CO_2 = Annual CO_2 emissions attributable to sodium carbonate production, in metric tons;

i = Month;

CI_{TR} = Monthly inorganic carbon content of trona at kiln input for month *i*, in kilograms of carbon per kilogram of trona;

TR = Monthly quantity of trona input in month *i*, in metric tons;

0.097 = Ratio of CO_2 emitted for each metric ton of trona, in metric tons of CO_2 per metric ton of trona;

Equation 11-2

$$CO_2 = \sum_{i=1}^{12} (CI_{SC} \times SC)_i \times 0.138$$

Where:

CO_2 = Annual CO_2 emissions attributable to sodium carbonate production, in metric tons;

i = Month;

CI_{SC} = Monthly inorganic carbon content of sodium carbonate at kiln output for month *i*, in kilograms of carbon per kilogram of sodium carbonate;

SC = Monthly quantity of sodium carbonate produced during month *i*, in metric tons;

0.138 = Ratio of CO_2 emitted for each metric ton of sodium carbonate produced, in metric tons of CO_2 per metric ton of sodium carbonate.

QC.11.3.3. Calculation method using site-specific emission factor

The annual CO_2 emissions from a sodium carbonate production unit using liquid alkaline feedstock may be calculated using equations 11-3 to 11-5:

Equation 11-3

$$CO_2 = EF_{CO2} \times V_a \times H$$

Where:

CO_2 = Annual CO_2 emissions attributable to sodium carbonate production, in metric tons;

EF_{CO2} = CO_2 emission factor, in metric tons of CO_2 per metric ton of process vent flow from water stripper/evaporator, calculated using equation 11-4;

V_a = Process vent mass flow of water stripper/evaporator, in metric tons per hour;

H = Number of hours of operation during the year;

Equation 11-4

$$EF_{CO2} = \frac{ER_{CO2}}{V_{tp}}$$

Where:

EF_{CO2} = CO_2 emission factor, in metric tons of CO_2 per metric ton of process vent flow from water stripper/evaporator;

ER_{CO2} = CO_2 emission rate, in metric tons per hour, calculated using equation 11-5;

V_{tp} = Process vent mass flow of water stripper/evaporator, measured during performance test, in metric tons per hour;

Equation 11-5

$$ER_{CO2} = \left[\left(C_{CO2} \times 10,000 \times 4.16 \times 10^{-8} \times 44\right) \times \left(VF \times 60\right)\right] \times 0.001$$

Where:

ER_{CO2} = CO_2 emission rate, in metric tons per hour;

C_{CO2} = Hourly concentration of CO_2 in the gas, determined in accordance with QC.11.4, expressed as a percentage;

10,000 = Conversion factor, percentage to ppm;

4.16×10^{-8} = Conversion factor, ppm to kilomoles per cubic metre at standard conditions;

44 = Molecular weight of CO_2, kilograms per kilomole;

VF = Volumetric flow of gas, in cubic metres at standard conditions per minute;

60 = Conversion factor, minutes to hours;

0.001 = Conversion factor, kilograms to metric tons.

QC.11.4. Sampling, analysis and measurement requirements

An emitter who uses equation 11-1 or 11-2 in QC.11.3.2 must:

(1) determine the monthly inorganic carbon content of the trona or sodium carbonate from a weekly composite sample for each production unit, in accordance with ASTM E359-00 (2005) e1 "Standard Test Methods for Analysis of Soda Ash (Sodium Carbonat(e)";

(2) measure the quantity of trona or sodium carbonate for each production unit using the same plant instruments as those used for inventory purposes.

An emitter who uses equations 11-3 to 11-5 in QC.11.3.3 must conduct an annual performance test in normal operating conditions, during which the emitter must:

(1) conduct 3 emissions test runs of one hour each;

(2) determine the hourly CO_2 concentration in accordance with Method 3A in appendix A-2 of Part 60 of Title 40 of the Code of Federal Regulations "Determination of Oxygen and Carbon Dioxide Concentrations in Emissions From Stationary Sources (Instrumental Analyzer Procedur(e)" published by the U.S. Environmental Protection Agency (USEPA);

(3) determine the stack gas volumetric flow rate using one of the methods published by the U.S. Environmental Protection Agency (USEPA):

(a) Method 2 in Appendix A-1 of Part 60 of Title 40 of the Code of Federal Regulations "Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)";

(b) Method 2A in Appendix A-1 of Part 60 of Title 40 of the Code of Federal Regulations "Direct Measurement of Gas Volumetric Through Pipes and Small Ducts";

(c) Method 2C in Appendix A-1 of Part 60 of Title 40 of the Code of Federal Regulations "Determination of Gas Velocity and Volumetric Flow Rate in Small Stacks or Ducts (Standard Pitot Tube)";

(d) Method 2D in Appendix A-1 of Part 60 of Title 40 of the Code of Federal Regulations "Measurement of Gas Volume Flow Rates in Small Pipes and Ducts";

(e) Method 2F in Appendix A-1 of Part 60 of Title 40 of the Code of Federal Regulations "Determination of Stack Gas Velocity and Volumetric Flow Rate with Three-Dimensional Probes";

(f) Method 2G in Appendix A-2 of Part 60 of Title 40 of the Code of Federal Regulations "Determination of Stack Gas Velocity and Volumetric Flow Rate With Two-Dimensional Probes";

(4) prepare a CO_2 emission factor determination report containing all the information needed to calculate the emission factor and the sample reports prepared pursuant to paragraph 1;

(5) determine the average process vent flow from the water stripper/evaporator;

(6) determine the annual vent flow rate from the mine water stripper/evaporator from monthly data using the same plant instruments as those used for inventory purposes, such as a volumetric flowmeter.

QC.11.5. Methods for estimating missing data

When sampling or measurement data required by this Regulation for the calculation of emssions is missing, the emitter must use replacement data determined as follows:

(1) when emissions are calculated using a continuous emission monitoring and recording system, the method in paragraph 2 of QC.1.6 must be used;

(2) each missing monthly value concerning the inorganic carbon content of the trona or sodium carbonate must be replaced by the arithmetic average of the data sampled or measured immediately preceding and following the missing data period. If no data are available prior to the missing data period, the emitter must use the first data obtained after the missing data period;

(3) for each missing monthly value concerning the quantity of trona or sodium carbonate, the missing data must be estimated using all the data relating to the processes used or using the same plant instruments as those used for inventory purposes;

(4) for each missing value of hourly CO_2 concentration, the stack gas volumetric flow rate or the average process vent flow from the mine water stripper/evaporator during a performance test, a new performance test must be conducted;

(5) for each missing monthly value concerning the vent flow rate from the mine water stripper/evaporator, the missing data must be estimated using all the data relating to the processes used or the lesser of the maximum vent capacity or the maximum flow rate the flowmeter can measure.”;

(12) in QC.12:

(a) by replacing QC.12.1 by the following:

"**QC.12.1. Covered sources**

The covered sources are all the processes used in the production of petrochemical products from feedstocks derived from petroleum, or petroleum and natural gas liquids, but not from feedstocks derived from biomass.

The production of methanol, hydrogen, or ammonia from synthesis gas is also covered if the annual production of methanol exceeds the combined production of both hydrogen recovered as a product and ammonia. However, if the annual mass of hydrogen recovered exceeds the combined annual production of methanol and ammonia, the emissions must be calculated in accordance with QC.6 with respect to hydrogen production. In addition, if the annual production of ammonia exceeds the combined annual production of both hydrogen recovered as a product and methanol, the emissions must be calculated in accordance with QC.23 with respect to ammonia production.

A process that produces only a petrochemical by-product, and a direct chlorination process that is operated independently of an oxychlorination process to produce ethylene dichloride, is not covered.";

(b) by inserting the following after paragraph 2 of QC.12.2:

"(2.1) the annual CO_2 emissions attributable to hydrogen production processes, calculated in accordance with QC.6, in metric tons;";

(c) by replacing "chemical" in paragraph 3 of QC.12.2 by "petrochemical";

(d) by striking out "above-ground" in paragraph 8 of QC.12.2;

(e) by replacing "gas" in paragraph 12 of QC.12.2 by "materials consumed";

(f) by adding the following after paragraph 13 of QC.12.2:

"(14) the number of times that the methods for estimating missing data provided for in QC.12.5 were used;

(15) the total greenhouse gas emissions for each type of emissions, namely:

(a) the annual fixed process emissions corresponding to the total of the emissions referred to in paragraphs 2.1, 3 and 4, in metric tons CO_2 equivalent;

(b) the annual combustion emissions corresponding to the total of the emissions referred to in paragraphs 1 and 2, in metric tons CO_2 equivalent;

(c) the "other" category emissions corresponding to the total of the emissions referred to in paragraphs 5 to 10 in metric tons CO_2 equivalent. ";

(g) by adding "or, when a mass flowmeter is used to measure the gas input flow in kilograms for month *n*, replace $\left[\frac{MW_{GP}}{MVC}\right]$ by 1" at the end of the definition of the factor "$(MM_{GP})_i$" in equation 12-1 in QC.12.3.1;

(h) by replacing QC.12.3.3 by the following:

"<u>QC.12.3.3. Calculation of CO_2, CH_4 and N_2O emissions attributable to combustion in flares and other antipollution equipments</u>

The annual CO_2, CH_4 and N_2O emissions attributable to combustion in flares must be calculated in accordance with the calculation methods in QC.9.3.5.

The annual CO_2, CH_4 and N_2O emissions attributable to combustion in other antipollution equipments must be calculated in accordance with the calculation methods in QC.1, except CH_4 and N_2O emissions attributable to process off-gas combustion which must be calculated using equation 1-12 in QC.1.4.2 with emission factors of 2.8×10^{-3} kg per gigajoule for CH_4 and 5.7×10^{-4} kg per gigajoule for N_2O.";

(i) by adding the following at the beginning of QC.12.3.4:

"For each process vent that contains over 2% CO_2 by volume, over 0.5% CH_4 by volume, or over 0.01% N_2O by volume,";

(j) by replacing "QC.9.3.9" in QC.12.3.5 by "paragraph 1 of QC.9.3.9";

(k) by striking out the words "above-ground" wherever they occur in QC.12.3.6;

(l) by adding "and determine quarterly the carbon content and high heat value" at the end of QC.12.4.2;

(m) by striking out the words "above-ground" wherever they occur in QC.12.4.5;

(*n)* by replacing QC.12.4.8 by the following:

"QC.12.4.8. Feedstock consumption and products

An emitter who calculates greenhouse gas emissions in accordance with QC.12.3.1 must determine, monthly, the quantity of feedstock consumed and the quantity of products produced using the following methods:

(1) if the feedstock and product are gases, using a flowmeter;

(2) if the feedstock and product are liquids, using a flowmeter or by measuring the liquid level in a storage tank;

(3) if the feedstock and product are solids, using the same plant instruments as those used for inventory purposes, such as weigh hoppers or belt weight feeders.

The emitter must determine carbon content monthly and, in the case of a gas, its molecular weight, using the sampling and analysis results indicated by the supplier or samples taken by the emitter. When more than one monthly value is available, the arithmetic average must be used.

When the monthly average concentration of a specific compound in a feedstock or product is greater than 99.5% by weight or, in the case of a gas, by volume then, as an alternative, the emitter may determine the carbon content by assuming that 100% of that feedstock or product is the specific compound in normal operating conditions. A determination made using this alternative must be re-evaluated after any process change that affects the feedstock or product composition. However, this alternative may not be used for products during periods of operation when off-specification product is produced, or when the average monthly concentration falls below 99.5%.";

(*o)* by adding the following after QC.12.4.8:

"**QC.12.5. Methods for estimating missing data**

When sampling or measurement data required by this Regulation for the calculation of emissions is missing, the emitter must use replacement data determined as follows:

(1) each missing value concerning carbon content or molecular weight must be replaced by the arithmetic average of the data sampled or measured immediately preceding and following the missing data period. If no data are available prior to the missing data period, the emitter must use the first data obtained after the missing data period;

(2) for each missing value concerning a quantity of feedstock or product, the missing data must be estimated using all the data relating to the processes used. ";

(13) in QC.13:

(a) by replacing QC.13.1 by the following:

"**QC.13.1. Covered sources**

The covered sources are all the oxidization processes used for the production of adipic acid.";

(b) by inserting "attributable to the production of adipic acid" after "emissions" in subparagraph 1 of the first paragraph of QC.13.2;

(c) by inserting the following after subparagraph 1 of the first paragraph of QC.13.2:

"(1.1) the annual CO_2, CH_4 and N_2O emissions attributable to combustion, calculated in accordance with QC.1, in metric tons;";

(d) by inserting "total" after "the" in subparagraph 2 of the first paragraph of QC.13.2;

(e) by inserting the following after subparagraph 2 of the first paragraph of QC.13.2:

"(2.1) the annual production of adipic acid when the antipollution system is used, in metric tons;"

(f) by adding the following after subparagraph 5 of the first paragraph of QC.13.2:

"(6) the number of times that the methods for estimating missing data in QC.13.5 were used;

(7) the total greenhouse gas emissions for each type of emissions, namely:

(a) the annual fixed process emissions corresponding to the emissions referred to in subparagraph 1, in metric tons CO_2 equivalent;

(b) the annual combustion emissions corresponding to the emissions referred to in subparagraph 1.1, in metric tons CO_2 equivalent.";

(g) by striking out the second paragraph of QC.13.2;

(h) by replacing "one of the two calculation methods in QC.13.3.1 and QC.13.3.2" in QC.13.3 by "the calculation method in QC.13.3.1 for each of the facility's antipollution equipments";

(i) by replacing QC.13.3.1 by the following:

"QC.13.3.1. Calculation method using the N_2O emission factor and destruction factors and the use of antipollution equipment

The annual N_2O emissions must be calculated using equation 13-1:

Equation 13-1

$$N_2O = \sum_{i=1}^{n} \left[EF_{N2O} \times P_{AA} \times \left(1 - \left(F_D \times F_U\right)\right)\right]_i \times 0.001$$

Where:

N_2O = N_2O emissions attributable to the oxidation process, in metric tons;

n = Total number of periods. When a performance test is conducted annually, "n" is 1. If data is obtained from a continuous emission monitoring and recording system, "n" is at least 12;

i = Period;

EF_{N2O} = N_2O emission factor for period *i*, calculated in accordance with equation 13-2 or 13-3, in kilograms of N_2O per metric ton of adipic acid produced;

P_{AA} = Production of adipic acid in period *i*, in metric tons;

F_D = Destruction factor for the antipollution equipment for period *i*, determined in accordance with QC.13.4;

F_U = Use factor for the antipollution equipment, calculated in accordance with equation 13-4;

0.001 = Conversion factor, kilograms in metric tons;

Equation 13-2

$$EF_{N2O} = \sum_{i=1}^{n} \left[\frac{C_{N2O} \times Q_{fg} \times 1.826 \times 10^{-6}}{P} \right]_i \times \frac{1}{n}$$

Where:

EF_{N2O} = N_2O emission factor, in kilograms of N_2O per metric ton of adipic acid produced;

n = Number of performance tests;

i = Performance test conducted in accordance with QC.13.4;

C_{N2O} = N_2O concentration in the gas stream during performance test *i*, in ppm;

Q_{fg} = Volumetric flow of gas stream during performance test *i*, in cubic metres at standard conditions per hour;

1.826×10^{-6} = Conversion factor of ppm, kilograms per cubic metre at standard conditions;

P = Production rate of adipic acid during performance test *i*, in metric tons per hour;

Equation 13-3

$$EF_{N2O} = \frac{C_{N2O} \times Q_{fg} \times 1.826 \times 10^{-6}}{P}$$

Where:

EF_{N2O} = N_2O emission factor, in kilograms of N_2O per metric ton of adipic acid produced;

C_{N2O} = N_2O concentration in the continuously-measured gas stream, in ppm;

Q_{fg} = Volumetric flow of continuously-measured gas stream, in cubic metres at standard conditions per hour;

1.826×10^{-6} = Conversion factor of ppm, in kilograms per cubic metre at standard conditions;

P = Production rate of adipic acid measured continuously, in metric tons per hour;

Equation 13-4

$$F_U = \frac{P_{AA,1}}{P_{AA,2}}$$

Where:

F_U = Use factor of antipollution equipment;

$P_{AA,1}$ = Production of adipic acid when the antipollution equipment is used, in metric tons;

$P_{AA,2}$ = Annual production of adipic acid, in metric tons.";

(j) by replacing QC.13.4 by the following:

"QC.13.4. Sampling, analysis and measurement requirements

An emitter who operates a facility or establishment that produces adipic acid must use a continuous monitoring and recording system or conduct performance tests.

In the latter case, the performance test must be conducted annually on the waste gas stream from the nitric acid oxidation step when the adipic acid production process is changed either by altering the ratio of cyclohexanone to cyclohexanol or be conducted when installing an antipollution system, in normal operating conditions and when the antipollution system is not used. A report on the determination of the N_2O emission factor, containing all the information needed to calculate the emission factor, must be prepared.

An emitter who does not use a continuous monitoring and recording system must also

(1) measure the N_2O concentration using one of the following methods:

(*a*) Method 320 in appendix A of Part 63 of Title 40 of the Code of Federal Regulations "Measurement of Vapor Phase Organic and Inorganic Emissions by Extractive Fourier Transform Infrared (FTIR) Spectroscopy", published by the U.S. Environmental Protection Agency (USEPA);

(*b*) ASTM D6348-03 (2010) "Standard Test Method for Determination of Gaseous Compounds by Extractive Direct Interface Fourier Transform Infrared (FTIR) Spectroscopy";

(*c*) determine the adipic acid production rate using annual sales data or using a measuring instrument such as a flowmeter or weight scales.

In all cases, an emitter must

(1) determine the total monthly quantity of adipic acid produced and, when the antipollution system is used, the quantity of adipic acid produced, using one of the methods in subparagraph *c* of subparagraph 1 of the third paragraph;

(2) determine the destruction factor using one of the following methods:

(*a*) using the manufacturer’s specified destruction factor;

(*b*) estimating the destruction factor based on all data relating to the processes used;

(*c*) conducting a performance test on the gas flow from the antipollution system;

(*d*) using a continuous emission monitoring and recording system.";

(k) by adding the following after QC.13.4:

"**QC.13.5. Methods for estimating missing data**

When sampling or measurement data required by this Regulation for the calculation of emissions is missing, the emitter must use replacement data determined as follows:

(1) every missing monthly value concerning adipic acid production must be estimated based on data from all the processes used or using the same plant instruments as those used for inventory purposes;

(2) for each missing value from the performance test, including the N_2O emission factor, the production rate and the N_2O concentration, a new performance test must be conducted.";

(14) in QC.14:

(a) by inserting "attributable to lead production" after "emissions" in paragraph 1 of QC.14.2;

(b) by inserting the following after paragraph 2 of QC.14.2:

"(2.1) the annual CO_2, CH_4 and N_2O emissions attributable to the use of stationary combustion equipment, calculated in accordance with QC.1, in metric tons;";

(c) by adding ", in metric tons of carbon per metric ton of material" at the end of paragraph 4 of QC.14.2;

(d) by adding the following paragraphs after paragraph 4 of QC.14.2:

"(5) the number of times that the methods for estimating missing data in QC.14.5 were used;

(6) the total greenhouse gas emissions for each type of emissions, namely:

(a) the annual fixed process emissions corresponding to the emissions referred to in paragraph 2, in metric tons CO_2 equivalent;

(b) the annual combustion emissions corresponding to the emissions referred to in paragraph (2.1), in metric tons CO_2 equivalent;

(7) the annual quantity of lead produced, in metric tons.";

(e) by inserting "except a material contributing less than 0.5% of the carbon in the process, which may be excluded by the emitter" after "used," in the definition of the factor "M_j" in equation 14-1;

(*f*) by replacing "an enterprise, facility" in the part preceding paragraph 1 of QC14.4. by "a facility";

(g) by replacing paragraph 1 of QC.14.4 by the following:

"(1) obtain annually the carbon content of each carbon-containing material used in the furnace, either by using the data provided by the material supplier or the following methods, based on a minimum of 3 representative samples:

(a) for solid carbonaceous reducing agents and carbon electrodes, in accordance with ASTM D5373-08 "Standard Test Methods for Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Laboratory Samples of Coal";

(b) for liquid reducing agents, in accordance with ASTM D2502-04 (2009) "Standard Test Method for Estimation of Molecular Weight (Relative Molecular Mass) of Petroleum Oils From Viscosity Measurements", ASTM D2503-92 (2007) "Standard Test Method for Relative Molecular Mass (Molecular Weight) of Hydrocarbons by Thermoelectric Measurement of Vapor Pressure", ASTM D3238-95 (2010) "Standard Test Method for Calculation of Carbon Distribution and Structural Group Analysis of Petroleum Oils by the n-d-M Method" or ASTM D5291-10 "Standard Test Methods for Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Petroleum Products and Lubricants";

(c) for gaseous reducing agents, in accordance with ASTM D1945-03 (2010) "Standard Test Method for Analysis of Natural Gas by Gas Chromatograph" or ASTM D1946-90 (2006) "Standard Practice for Analysis of Reformed Gas by Gas Chromatography";

(d) for waste-based carbon-containing materials, by operating the furnace both with and without the waste-reducing agents while keeping the composition of other carbon-containing materials introduced constant;";

(h) by replacing "by direct weight measurement" in paragraph 2 of QC.14.4 by "by adding together the monthly quantities of the material, which must be weighed";

(i) by adding the following after QC.14.4:

"**QC.14.5. Methods for estimating missing data**

When sampling or measurement data required by this Regulation for the calculation of emissions is missing, the emitter must use replacement data determined as follows:

(1) when emissions are calculated using a continuous emission monitoring and recording system, the method in paragraph 2 of QC.1.6 must be used;

(2) for each missing value concerning carbon content, a new analysis must be conducted;

(3) for each missing value concerning a quantity of carbon-containing material, the missing data must be estimated using all the data relating to the processes used or using the same plant instruments as those used for inventory purposes.";

(15) in QC.15:

(a) by inserting "attributable to zinc production" after "emissions" in paragraph 1 of QC.15.2;

(b) by inserting the following after paragraph 2 of QC.15.2:

"(2.1) the annual CO_2, CH_4 and N_2O emissions attributable to combustion, calculated in accordance with QC.1, in metric tons;";

(c) by adding ", in metric tons of carbon per metric ton of material" at the end of paragraph 4 of QC.15.2;

(d) by adding the following after paragraph 4 of QC.15.2:

"(5) the number of times that the methods for estimating missing data in QC.15.5 were used;

(6) the total greenhouse gas emissions for each type of emissions, namely:

(a) the annual fixed process emissions corresponding to the emissions referred to in paragraph 2, in metric tons CO_2 equivalent;

(b) the annual combustion emissions corresponding to the emissions referred to in paragraph 2.1, in metric tons CO_2 equivalent;

(7) the annual quantity of cathodic zinc produced, in metric tons.";

(e) by inserting "except a material contributing less than 0.5% of the carbon in the process, which may be excluded by the emitter" after "used" in the definition of the factor "M_j" in equation 15-1;

(f) by replacing "an enterprise, facility" in the part preceding paragraph 1 of QC.15.4 by "a facility";

(g) by adding the following after subparagraph *c* of paragraph 1 of QC.15.4:

"*(d)* for waste-based carbon-containing material, by operating the furnace both with and without the waste-based materials while keeping the composition of other carbon-containing materials constant;";

(h) by adding the following after QC.15.4:

"QC.15.5. Methods for estimating missing data

When sampling or measurement data required by this Regulation for the calculation of emissions is missing, the emitter must use replacement data determined as follows:

(1) when emissions are calculated using a continuous emission monitoring and recording system, the method in paragraph 2 of QC.1.6 must be used;

(2) for each missing value concerning carbon content, a new analysis must be conducted;

(3) for each missing value concerning a quantity of carbon-containing material, the missing data must be estimated using all the data relating to the processes used or using the same plant instruments as those used for inventory purposes. ";

(16) in QC.16:

(a) by adding the following at the end of QC.16.1:

"However, emergency generators and other equipment used in an emergency with a rated capacity under 10 megawatts are not covered.";

(b) by inserting ", for each stationary combustion unit" after "information" in the part preceding subparagraph 1 of the first paragraph of QC.16.2;

(c) by inserting "each" after "of" in subparagraph 9 of the first paragraph of QC.16.2;

(d) by adding the following after subparagraph 15 of the first paragraph of QC.16.2:

"(16) the number of times that the methods for estimating missing data provided for in QC.16.7 were used;

(17) the annual production of steam, in metric tons;

(18) the total greenhouse gas emissions for each type of emissions, namely:

(a) the annual fixed process emissions corresponding to the emissions referred to in subparagraph 8, in metric tons CO_2 equivalent;

(b) the annual combustion emissions corresponding to the emissions referred to in subparagraph 1, except emissions from the combustion of biomass, in metric tons CO_2 equivalent;

(c) the annual "other" category emissions corresponding to the total of the emissions referred to in subparagraphs 9 and 10, in metric tons CO_2 equivalent. ";

(e) by adding the following at the end of QC.16.3:

"For a facility or establishment with natural gas or diesel-powered units that are not equipped with a flowmeter or reservoir and for which data cannot be obtained using a continuous emission monitoring and recording system, an emitter may quantify CO_2, CH_4 and N_2O emissions using data from a measurement device common to all the units.

To determine the emissions attributable to each fixed combustion unit, the estimate must be based on total emissions, the hours of operation and the combustion efficiency of the unit. For diesel-powered units, the estimate may be based on the total quantity of energy produced, the energy produced by each unit, and the total quantity of diesel fuel consumed.";

(f) by adding "or a fuel specified in Table 1-2" at the end of paragraph 1 of QC.16.3.2;

(g) by inserting "other than those in Table 1-2" after "as a fuel" in paragraph 3 of QC.16.3.2;

(h) by replacing "fossil fuels" in paragraphs 8 and 9 of QC.16.3.2 by "a mixture of fossil fuels";

(i) by adding the following after paragraph 9 of QC.16.3.2:

"(10) for an emitter who determines the high heat value of fuels using measurements made in accordance with QC.1.5.4 or data indicated by the fuel supplier at the intervals specified in QC.1.5.1, in accordance with QC.1.3.2, QC.1.3.3 and QC.1.3.4.";

(j) by adding the following after QC.16.6.4:

"**QC.16.7. Methods for estimating missing data**

When sampling or measurement data required by this Regulation for the calculation of emissions is missing, a replacement value must be used in accordance with QC.1.6.";

(17) in QC.17:

(a) by adding the following after the first paragraph of QC.17.1:

"For the purposes of this Part, a facility is considered identifiable when it meets the following conditions:

(1) the importation of the reported electricity is subject to a written contract between the facility and the first importer;

(2) the imported and reported electricity, as the case may be,

(a) comes from an electricity production facility built after 1 January 2008;

(b) is the result of an increase in production of the facility that occurred after 1 January 2008;

(c) was imported from a facility within the framework of a contract entered into before 1 January 2008 that is still in force or was imported from that facility after the end of the contract.";

(b) by replacing Table 17-1 in QC.17.4 by the following:

"

Canadian province and North American market	**Default emission factor (t/MWh)**
Newfoundland and Labrador	0.021
Nova Scotia	0.833
New Brunswick	0.544
Québec	0.002
Ontario	0.167
New England Independent System Operator (NE-ISO), including all or part of the following states: - Connecticut - Massachusetts - Maine - Rhode Island - Vermont - New Hampshire	0.457

New York Independent System Operator (NY-ISO)	0.567
Pennsylvania Jersey Maryland Interconnection Regional Transmission Organization (PJM-RTO), including all or part of the following states: - Delaware - Indiana - Illinois - Kentucky - Maryland - Michigan - New Jersey - Ohio - Pennsylvania - Virginia - West Virginia - District of Columbia	0.933
Midwest Independent Transmission System Operator (MISO-RTO), including all or part of the following states: - North Dakota - South Dakota - Minnesota - Iowa - Missouri - Wisconsin - Illinois - Michigan - Indiana - Ohio - Montana - Kentucky	0.999

";

(18) by adding the following after QC.17:

"QC.18. NICKEL AND COPPER PRODUCTION

QC.18.1. Covered sources

The covered sources are all the processes used for nickel and copper production in metal smelting and refining facilities.

More specifically, the processes covered are those used to remove impurities from nickel or copper ore concentrate by adding carbonate flux reagents and to extract metals from their oxides using reducing agents, and processes involving the use of materials for slag cleaning, the consumption of electrodes in electric arc furnaces, and the use of carbon-containing raw materials, such as recycled secondary materials.

QC.18.2. Greenhouse gas reporting requirements

The greenhouse gas emissions report referred to in section 6.2 must include the following information:

(1) the annual CO_2 emissions attributable to the production of nickel and copper, in metric tons;

(2) the annual CO_2, CH_4 and N_2O emissions attributable to combustion, calculated in accordance with QC.1, in metric tons;

(3) the annual CO_2 emissions attributable to the use of carbonate flux reagents, in metric tons;

(4) the annual CO_2 emissions attributable to the use of reducing agents and other materials for slag cleaning, in metric tons;

(5) the annual CO_2 emissions attributable to the carbon contained in the nickel or copper ore processed, in metric tons;

(6) the annual CO_2 emissions attributable to the consumption of carbon electrodes in electric arc furnaces, in metric tons;

(7) the annual CO_2 emissions attributable to the carbon contained in carbon-containing raw materials such as recycled secondary materials, in metric tons;

(8) the annual consumption of each carbonate flux reagent, in metric tons;

(9) the carbon content of each carbonate flux reagent, in metric tons of carbon per metric ton of carbonate flux reagent;

(10) the annual consumption of each reducing agent and each material used for slag cleaning, in metric tons;

(11) the carbon content of each reducing agent and each material used for slag cleaning, in metric tons of carbon per metric ton of reducing agent;

(12) the annual consumption of carbon electrodes, in metric tons;

(13) the carbon content of carbon electrodes, in metric tons of carbon per metric ton of carbon electrode;

(14) the annual quantity of nickel or copper ore processed, in metric tons;

(15) the carbon content of the nickel or copper ore processed, in metric tons of carbon per metric ton of ore;

(16) the annual consumption of other carbon-containing raw materials, in metric tons;

(17) the carbon content of the other carbon-containing raw materials, in metric tons of carbon per metric ton of raw materials;

(18) the number of times that the methods for estimating missing data in QC.18.5 were used;

(19) the total greenhouse gas emissions for each type of emissions, namely:

(a) the annual fixed process emissions corresponding to the total of the emissions referred to in paragraphs 3 to 7, in metric tons CO_2 equivalent;

(b) the annual combustion emissions corresponding to the emissions referred to in paragraph 2, in metric tons CO_2 equivalent;

(20) the quantity of nickel produced, in metric tons;

(21) the quantity of copper produced, in metric tons.

Subparagraphs 9, 11, 13, 15 and 17 of the first paragraph do not apply to the CO_2 emissions of an emitter who calculates emissions using data from a continuous emission monitoring and recording system.

QC.18.3. Calculation methods for CO_2 emissions

The annual CO_2 emissions attributable to nickel and copper production must be calculated using one of the calculation methods in QC.18.3.1 and QC.18.3.2.

QC.18.3.1. Use of a continuous emission monitoring and recording system

The annual CO_2 emissions attributable to nickel and copper production may be calculated using data from a continuous emission monitoring and recording system in accordance with QC.1.3.4.

QC.18.3.2. Calculation by mass balance

The annual CO_2 emissions attributable to nickel and copper production must be calculated using the methods in paragraphs 1 to 6, depending on the process used, expressed:

(1) for the processes used in nickel and copper production, using equation 18-1:

Equation 18-1

$$CO_2 = CO_{2,CR} + CO_{2,RA} + CO_{2,ORE} + CO_{2,CE} + CO_{2,RM}$$

Where:

CO_2 = Annual CO_2 emissions attributable to nickel and copper production, in metric tons;

$CO_{2,\,CR}$ = Annual CO_2 emissions attributable to the use of carbonate flux reagents, calculated in accordance with equation 18-2, in metric tons;

$CO_{2,\,RA}$ = Annual CO_2 emissions attributable to the use of reducing agents and materials used for slag cleaning, calculated in accordance with equation 18-3, in metric tons;

$CO_{2,\,ORE}$ = Annual CO_2 emissions attributable to carbon contained in the nickel or copper ore processed, calculated in accordance with equation 18-4, in metric tons;

$CO_{2,\ CE}$ = Annual CO_2 emissions attributable to the consumption of carbon electrodes in electric arc furnaces, calculated in accordance with equation 18-5, in metric tons;

$CO_{2,\ RM}$ = Annual CO_2 emissions attributable to carbon contained in other carbon-containing raw materials, calculated in accordance with equation 18-6, in metric tons;

(2) for the use of carbonate flux reagents, using equation 18-2:

Equation 18-2

$$CO_{2,CR} = \left[LS \times C_{LS} \times \left(\frac{44}{100}\right)\right] + \left[D \times C_D \times \left(\frac{88}{184}\right)\right]$$

Where:

$CO_{2,\ CR}$ = Annual CO_2 emissions attributable to the use of carbonate flux reagents, in metric tons;

LS = Annual consumption of limestone, in metric tons;

C_{LS} = Calcium carbonate content of the limestone, in metric tons of calcium carbonate per metric ton of limestone;

44/100 = Ratio of molecular weights, CO_2 to calcium carbonate;

D = Annual consumption of dolomite, in metric tons;

C_D = Calcium carbonate and magnesium carbonate content, in metric tons of carbonates per metric ton of dolomite;

88/184 = Ratio of molecular weights, CO_2 to calcium carbonate and magnesium carbonate;

(3) for the use of reducing agents and materials used for slag cleaning, using equation 18-3:

Equation 18-3

$$CO_{2,RA} = \sum_{i=1}^{n} \left[RA \times C_{RA} \right]_i \times 3.664$$

Where:

$CO_{2,\ RA}$ = Annual CO_2 emissions attributable to the use of reducing agents and materials used for slag cleaning, in metric tons;

n = Number of reducing agents and materials used for slag cleaning;

i = Reducing agent and materials used for slag cleaning;

RA = Annual consumption of each reducing agent *i* and material used for slag cleaning, in metric tons;

C_{RA} = Carbon content of each reducing agent *i*, in metric tons of carbon per metric ton of reducing agent *i*;

3.664 = Ratio of molecular weights, CO_2 to carbon;

(4) for the nickel or copper ore processed, using equation 18-4:

Equation 18-4

$$CO_{2,ORE} = ORE \times C_{ORE} \times 3.664$$

Where:

$CO_{2,\ ORE}$ = Annual CO_2 emissions attributable to carbon contained in the nickel or copper ore processed, in metric tons;

ORE = Annual consumption of nickel or copper ore, in metric tons;

C_{ORE} = Carbon content of nickel or copper ore, in metric tons of carbon per metric ton of ore;

3.664 = Ratio of molecular weights, CO_2 to carbon;

(5) for the consumption of carbon electrodes in electric arc furnaces, using equation 18-5:

Equation 18-5

$$CO_{2,CE} = CE \times C_{CE} \times 3.664$$

Where:

$CO_{2, CE}$ = Annual CO_2 emissions attributable to consumption of carbon electrodes in electric arc furnaces, in metric tons;

CE = Annual consumption of carbon electrodes in electric arc furnaces, in metric tons;

C_{CE} = Carbon content of the carbon electrodes, in metric tons of carbon per metric ton of carbon electrodes;

3.664 = Ratio of molecular weights, CO_2 to carbon;

(6) for the consumption of other carbon-containing raw materials, using equation 18-6:

Equation 18-6

$$CO_{2,RM} = \sum_{i=1}^{n} \left[RM_i \times C_{RM,i} \right] \times 3.664$$

Where:

$CO_{2,RM}$ = Annual CO_2 emissions attributable to carbon contained in other raw materials, in metric tons;

n = Number of raw materials;

i = Raw material;

RM_i = Annual consumption of raw material *i*, in metric tons;

$C_{RM, i}$ = Carbon content of raw material *i*, in metric tons of carbon per metric ton of raw material *i*;

3.664 = Ratio of molecular weights, CO_2 to carbon.

QC.18.4. Sampling, analysis and measurement requirements

An emitter who operates a facility or establishment producing nickel or copper must

(1) obtain annually the carbon content of each carbon-containing material used, either by using data from the material supplier or by using the following methods:

(a) for coal and coke, ASTM D5373-08 "Standard Test Methods for Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Laboratory Samples of Coal and Coke";

(b) for petroleum-based liquid fuels and liquid waste-derived fuels, ASTM D5291-10 "Standard Test Methods for Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Petroleum Products and Lubricants", the ultimate analysis method or calculations in ASTM D3238-95(2010) "Standard Test Method for Calculation of Carbon Distribution and Structural Group Analysis of Petroleum Oils by the n-d-M Method" and either ASTM D2502-04(2009) "Standard Test Method for Estimation of Molecular Weight (Relative Molecular Mass) of Petroleum Oils From Viscosity Measurements" or ASTM D2503-92(2007) "Standard Test Method for Relative Molecular Mass (Molecular Weight) of Hydrocarbons by Thermoelectric Measurement of Vapor Pressure";

(c) for gaseous fuels, ASTM D1945-03(2010) "Standard Test Method for Analysis of Natural Gas by Gas Chromatography" or ASTM D1946-90(2006) "Standard Practice for Analysis of Reformed Gas by Gas Chromatography";

(d) for limestone and dolomite, ASTM C25-06 "Standard Test Methods for Chemical Analysis of Limestone, Quicklime, and Hydrated Lime";

(e) for other raw materials, the methods in QC.1.5.1 and QC.1.5.5;

(2) calculate the annual consumption of each carbon-containing material by weighing the materials using the same plant instruments as those used for inventory purposes, such as weigh hoppers or belt weight feeders, or using calculations based on data from the process control system.

QC.18.5. Methods for estimating missing data

When sampling or measurement data required by this Regulation for the calculation of emissions is missing, the emitter must use replacement data determined as follows:

(1) when emissions are calculated using a continuous emission monitoring and recording system, the method in paragraph 2 of QC.1.6 must be used;

(2) when the missing data concerns the carbon content, a new analysis must be conducted in accordance with QC.18.4;

(3) when the missing data concerns the quantity of raw materials consumed, the missing data must be estimated using all the data relating to the processes used or data used for inventory purposes.

QC.19. FERROALLOY PRODUCTION

QC.19.1. Covered sources

The covered sources are all the processes that use pyrometallurgical techniques for ferrochromium, ferromanganese, ferromolybdenum, ferronickel, ferrosilicon, ferrotitanium, ferrotungsten, ferrovanadium, silicomanganese or silicon metal production.

QC.19.2. Greenhouse gas reporting requirements

The greenhouse gas emissions report referred to in section 6.2 must include the following information:

(1) the annual CO_2 and CH_4 emissions attributable to processes that use pyrometallurgical techniques;

(2) for each electric arc furnace:

(a) the annual CO_2 emissions attributable to ferroalloy production, in metric tons;

(b) the annual CH_4 emissions attributable to production of the ferroalloys listed in Table 19-1, in metric tons;

(c) the annual production of each ferroalloy, in metric tons;

(d) the annual consumption of each carbon-containing material, in metric tons;

(e) the average carbon content of each carbon-containing material, in metric tons of carbon per ton of material;

(3) the annual CO_2, CH_4 and N_2O emissions attributable to the use of fixed combustion units, calculated in accordance with QC.1, in metric tons;

(4) the annual CO_2, CH_4 and N_2O emissions attributable to the use of biomass in electric arc furnaces, calculated in accordance with QC.1, in metric tons;

(5) the number of times that the methods for estimating missing data in QC.19.6 were used;

(6) the total greenhouse gas emissions for each type of emissions, namely:

(a) the annual fixed process emissions corresponding to the total of the emissions referred to in subparagraph *a* of subparagraph 2, in metric tons CO_2 equivalent;

(b) the annual combustion emissions corresponding to the emissions referred to in subparagraph 3, in metric tons CO_2 equivalent;

(*c*) the "other" category emissions corresponding to the emissions referred to in subparagraph *b* of subparagraph 2, in metric tons CO_2 equivalent.

Subparagraph *e* of subparagraph 2 of the first paragraph does not apply to the CO_2 emissions of an emitter who calculates emissions using data from a continuous emission monitoring and recording system.

QC.19.3. Calculation methods for CO_2 emissions

The annual CO_2 emissions attributable to processes that use pyrometallurgical techniques for ferroalloy production must be calculated using one of the calculation methods in QC.19.3.1 and QC.19.3.2.

QC.19.3.1. Calculation method using a continuous emission monitoring and recording system

The annual CO_2 emissions attributable to processes that use pyrometallurgical techniques for ferroalloy production may be calculated using a continuous emission monitoring and recording system in accordance with QC.1.3.4.

QC.19.3.2. Calculation method for CO_2 emissions by mass balance

The annual CO_2 emissions attributable to ferroalloy production using an electric arc furnace must be calculated using equation 19-1; materials entering the electric arc furnace and products that contribute less than 1% of the total carbon in the pyrometallurgical process may be excluded.

Equation 19-1

$$CO_2 = \sum_{i=1}^{n} \begin{bmatrix} (RA \times C_{RA}) + (CE \times C_{CE}) + (ORE \times C_{ORE}) \\ + (FM \times C_{FM}) - (FEA \times C_{FEA}) - (NAM \times C_{NAM}) \end{bmatrix}_i \times 3.664$$

Where:

CO_2 = Annual CO_2 emissions attributable to ferroalloy production using an electric arc furnace, in metric tons;

n = Number of electric arc furnaces;

i = Electric arc furnace;

RA = Annual consumption of reducing agents, in metric tons;

C_{RA} = Carbon content of reducing agents, in metric tons of carbon per metric ton of reducing agent;

CE = Annual consumption of carbon electrodes, in metric tons;

C_{CE} = Carbon content of carbon electrodes, in metric tons of carbon per metric ton of carbon electrodes;

ORE = Annual consumption of ore, in metric tons;

C_{ORE} = Carbon content of ore, in metric tons of carbon per metric ton of ore ;

FM = Annual consumption of flux material, in metric tons;

C_{FM} = Carbon content of flux material, in metric tons of carbon per metric ton of flux material;

FEA = Annual production of ferroalloys, in metric tons;

C_{FEA} = Carbon content ferroalloy products, in metric tons of carbon per metric ton of ferroalloy;

NAM = Annual production of non-alloy materials, in metric tons;

C_{NAM} = Carbon content of the non-alloy materials produced, in metric tons of carbon per metric ton of material;

3.664 = Ratio of molecular weights, CO_2 to carbon.

QC.19.4. Calculation method for CH_4 emissions

The annual CH_4 emissions attributable to ferroalloy production listed in Table 19-1 must be calculated using equation 19-2:

Equation 19-2

$$CH_4 = \sum_{i=1}^{n} \sum_{j=1}^{m} \left[FEA_j \times EF_j\right]_i$$

Where:

CH_4 = Annual CH_4 emissions attributable to ferroalloy production listed in Table 19-1, in metric tons;

n = Number of electric arc furnaces;

i = Electric arc furnace;

m = Number of ferroalloys;

j = Type of ferroalloy;

FEA_j = Annual production of ferroalloy *j*, in metric tons;

EF_j = CH_4 emission factor for ferroalloy *j* as specified in Table 19-1, in metric tons of CH_4 per metric ton of ferroalloy *j*.

QC.19.5. Sampling, analysis and measurement requirements

An emitter who operates a facility or establishment that uses a pyrometallurgical process for ferroalloy production must

(1) obtain annually the carbon content of each carbon-containing material used in the electric arc furnaces based on the data indicated by the supplier or the analysis of a minimum of 3 representative samples and using the following methods:

(a) for metal ores and ferroalloy products, ASTM E1941-10 “Standard Test Method for Determination of Carbon in Refractory and Reactive Metals and Their Alloys by Combustion Analysis”;

(b) for carbonaceous reducing agents and carbon electrodes, ASTM D5373-08 “Standard Test Methods for Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Laboratory Samples of Coal”;

(c) for flux materials, ASTM C25-06 “Standard Test Methods for Chemical Analysis of Limestone, Quicklime, and Hydrated Lime”;

(2) calculate the annual consumption of each carbon-containing material entering the electric arc furnace by weighing the materials using the same plant instruments as those used for inventory purposes, such as weigh hoppers or belt weight feeders.

QC.19.6. Methods for estimating missing data

When sampling or measurement data required by this Regulation for the calculation of emissions is missing, the emitter must use replacement data determined as follows:

(1) when emissions are calculated using a continuous emission monitoring and recording system, the method in paragraph 2 of QC.1.6 must be used;

(2) when the missing data concerns the carbon content, a new analysis must be conducted in accordance with QC.19.5;

(3) when the missing data concerns the quantity of raw material consumed or products produced, the missing data must be estimated using all the data relating to the processes used or the data used for inventory purposes.

QC.19.7. Table

Table 19-1. CH_4 emission factors by electric arc furnace charging mode

(QC.19.4)

Ferroalloy	**Electric arc furnace charging mode**		
	Batch-charging	**Spinkle-charging**[a]	**Sprinkle-charging and > 750 °C**[b]
Silicon metal	0.0015	0.0012	0.0007
Ferrosilicon 90%	0.0014	0.0011	0.0006
Ferrosilicon 75%	0.0013	0.0010	0.0005
Ferrosilicon 65%	0.0013	0.0010	0.0005

[a] Sprinkle-charging is charging intermittently every minute.
[b] Temperature measured in off-gas channel downstream of the furnace hood

QC.20. MAGNESIUM PRODUCTION

QC.20.1. Covered sources

The covered sources are all the processes used for magnesium production through smelting, electrolytic smelting, refining or remelting, or processes in which molten magnesium is used in alloying, casting, drawing, extruding, forming or rolling operations.

QC.20.2. Greenhouse gas reporting requirements.

The greenhouse gas emissions report referred to in section 6.2 must include the following information:

(1) the annual emissions of each greenhouse gas listed in Schedule A.1, attributable to their use as a cover gas or carrier gas in magnesium production, in metric tons;

(2) the annual CO_2, CH_4 and N_2O emissions attributable to the use of fixed combustion units, calculated in accordance with QC.1, in metric tons;

(3) the annual quantity of magnesium produced or processed, by process type, in metric tons;

(4) the number of times that the methods for estimating missing data provided for in QC.20.5 were used;

(5) an explanation of any change greater than 30 percent in the cover gas usage rate;

(6) a description of any new melt protection technologies adopted to account for a change in the greenhouse gas emissions attributable to their use as cover gas or carrier gas;

(7) the total greenhouse gas emissions for each type of emissions, namely:

(a) the annual combustion emissions corresponding to the emissions referred to in paragraph 2, in metric tons CO_2 equivalent;

(b) the "other" category emissions corresponding to the emissions referred to in paragraph 1, in metric tons CO_2 equivalent.

QC.20.3. Calculation methods for annual greenhouse gas emissions attributable to use of cover gas and carrier gas

The annual greenhouse gas emissions attributable to the use of cover gas and carrier gas in magnesium production must be calculated using one of the calculation methods in QC.20.3.1 and QC.20.3.2.

QC.20.3.1. Calculation based on changes in inventory

The annual greenhouse gas emissions attributable to the use of cover gas and carrier gas in magnesium production may be calculated on the basis of inventory changes using equation 20-1:

Equation 20-1

$$GHG_k = G_{Inv-Begin} - G_{Inv-End} + G_{Purchased} - G_{Delivered}$$

Where:

GHG_k = Annual emissions of gas *k* used as a cover gas or carrier gas, in metric tons;

$G_{Inv-Begin}$ = Quantity of gas *k* in inventory at the beginning of the year, in metric tons;

$G_{Inv\text{-}End}$ = Quantity of gas *k* in inventory at the end of the year, in metric tons;

$G_{Purchased}$ = Quantity of gas *k* purchased during the year, in metric tons;

$G_{Delivered}$ = Quantity of gas *k* transferred off-site during the year, in metric tons;

k = Cover gas or carrier gas.

QC.20.3.2. Calculation based on the monitoring of changes in individual storage containers

The annual greenhouse gas emissions attributable to the use of cover gas and carrier gas in magnesium production may be calculated by monitoring changes in the mass of individual storage containers using equation 20-2:

Equation 20-2

$$GHG_k = \sum_{i=1}^{n} \left(C_{Begin} - C_{End} \right)_n$$

Where:

GHG_k = Annual emissions of gas *k* used as a cover gas or carrier gas, in metric tons;

n = Number of periods of use;

i = Period of use;

C_{Begin} = Quantity of gas *k* in the container at the beginning of period of use *n*, in metric tons;

C_{End} = Quantity of gas *k* in the container at the end of period of use *n*, in metric tons.

When the facility is equipped with flowmeters to track and record mass flow data, the mass of each gas must replace "(C_{Begin} – C_{End})" for period of use *n*;

k = Cover gas or carrier gas.

QC.20.4. Sampling, analysis and measurement requirements

An emitter who operates a facility or establishment that uses cover gases or carrier gasses in magnesium production must

(1) calibrate, prior to the first emissions report and thereafter at the minimum frequency specified by the manufacturer, all flowmeters, load cells and scales used to measure quantities of cover gas or carrier gas;

(2) measure the mass flow of the cover gas or carrier gas into the gas distribution system. If flowmeters are used, the minimum accuracy must be of 1% of their full scale;

(3) determine annually the quantities of gas used using the following methods:

(a) for an emitter who calculates emissions under QC.20.3.1, by measuring all quantities of cover gas or carrier gas using scales or load cells with a minimum accuracy of 1% of their full scale, taking into account the mass of the empty container;

(b) for an emitter who calculates emissions using QC.20.3.2, by keeping a full record of the contents and mass of containers entering or leaving storage. The mass of containers returning to storage must be measured immediately before the containers are put back into storage. In addition, the emitter must measure all quantities of cover gas or carrier gas using scales or load cells with a minimum accuracy of 1% of their full scale, taking into account the mass of the empty container;

(4) ensure that the quantities of gas obtained from the supplier of the cover gas or carrier gas are determined in accordance with subparagraph *b* of paragraph 3.

QC.20.5. Methods for estimating missing data

When sampling or measurement data required by this Regulation for the calculation of emissions is missing, the emitter must use replacement data determined as follows:

(1) each missing value concerning the calculation of emissions attributable to cover gas or carrier gas must be replaced by multiplying the magnesium production during the missing data period by the cover gas or carrier gas usage rate, calculated using equation 20-3. The data must be taken from the most recent period when operating conditions were similar to those for the missing data period.

Equation 20-3

$$R_k = \frac{C_k}{Mg}$$

Where:

R_k = Usage rate of cover gas or carrier gas *k* during the period when operating conditions were similar to those for the missing data period, in metric tons of gas per metric ton of metallic magnesium;

C_k = Consumption of cover gas or carrier gas *k* during the period of comparable operation, in metric tons;

Mg = Quantity of magnesium produced or fed into the process during the period of comparable operation, in metric tons;

k = Cover gas or carrier gas;

(2) if the precise gas weights before and after use are not available, the emitter must assume that the container was emptied in the process and that the quantity of gas used is equal to the quantity of gas purchased.

QC.21. NITRIC ACID PRODUCTION

QC.21.1. Covered sources

The covered sources are all nitric acid production units.

QC.21.2. Greenhouse gas reporting requirements

The greenhouse gas emissions report referred to in section 6.2 must include the following information:

(1) the annual N_2O emissions attributable to nitric acid production, in metric tons;

(2) the annual CO_2, CH_4 and N_2O emissions attributable to the use of fixed combustion units, calculated in accordance with QC.1, in metric tons;

(3) for each nitric acid production unit:

(a) annual nitric acid production, in metric tons, 100% acid basis;

(b) annual nitric acid production when the antipollution system is used, in metric tons, 100% acid basis;

(c) average N_2O emission factor, in kilograms of N_2O per metric ton of nitric acid produced, 100% acid basis;

(4) the number of times that the methods for estimating missing data in QC.21.5 were used;

(5) the total greenhouse gas emissions for each type of emissions, namely:

(a) the annual fixed process emissions corresponding to the emissions referred to in paragraph 1, in metric tons CO_2 equivalent;

(b) the annual combustion emissions corresponding to the emissions referred to in paragraph 2, in metric tons CO_2 equivalent.

QC.21.3. Calculation methods for annual N_2O emissions

The annual N_2O emissions attributable to nitric acid production must be calculated using one of the calculation methods in QC.21.3.1 and QC.21.3.2.

QC.21.3.1. Calculation method using a continuous emission monitoring and recording system

The annual N_2O emissions attributable to nitric acid production may be calculated using a continuous emission monitoring and recording system in accordance with QC.1.3.4.

QC.21.3.2. Calculation method using the N_2O emission factor and production data

The annual N_2O emissions attributable to nitric acid production must be calculated using equations 21-1 to 21-4:

Equation 21-1

$$N_2O = \sum_{k=1}^{n} N_2O_k$$

Where:

N_2O = Annual N_2O emissions attributable to nitric acid production, in metric tons;

n = Number of nitric acid production units;

k = Nitric acid production unit;

N_2O_k = Annual N_2O emissions attributable to nitric acid production for production unit *k*, calculated in accordance with equation 21-2, in metric tons;

Equation 21-2

$$N_2O_k = \sum_{i=1}^{n} \left[1 - \left(F_{D,k} \times F_{U,k}\right)\right]_i \times EF_k \times P_k \times 0.001$$

Where:

N_2O_k = Annual N_2O emissions attributable to nitric acid production for production unit *k*, in metric tons;

n = Total number of types of antipollution equipment used;

i = Type of antipollution equipment;

$F_{D,k}$ = Destruction factor for antipollution equipment *i* used in production unit *k*, in kilograms of N_2O per kilogram of gas processed;

$F_{U,k}$ = Use factor for antipollution equipment *i* used in production unit *k*, calculated in accordance with equation 21-3;

EF_k = Average N_2O emission factor for production unit *k*, calculated in accordance with equation 21-4, in kilograms of N_2O per ton of nitric acid, 100% acid basis;

P_k = Annual nitric acid production for production unit *k*, in tons of nitric acid produced, 100% acid basis;

0.001 = Conversion factor, kilograms to metric tons;

k = Nitric acid production unit;

Equation 21-3

$$FU_k = \frac{P_{k,EA}}{P_k}$$

Where:

FU_k = Use factor for antipollution equipment *i* at production unit *k*;

$P_{k,\ EA}$ = Annual nitric acid production at production unit *k* when antipollution equipment *i* is used, in metric tons, 100% acid basis;

P_k = Annual nitric acid production at production unit *k*, in metric tons, 100% acid basis;

i = Type of antipollution equipment;

k = Nitric acid production unit;

Equation 21-4

$$EF_k = \sum_{i=1}^{n} \left[\frac{C_{N2O} \times Q_{fg} \times 1.826 \times 10^{-6}}{PR} \right] \times \frac{1}{n}$$

Where:

EF_k = Average N_2O emission factor for production unit *k*, in kilograms of N_2O per ton of nitric acid, 100% acid basis;

n = Number of performance tests;

i = Performance test conducted in accordance with QC.21.4;

C_{N2O} = N_2O concentration in the gas stream during performance test *i*, in ppm;

Q_{fg} = Volumetric flow of gas stream during performance test *i*, in cubic metres at standard conditions per hour;

1.826×10^{-6} = Conversion factor of ppm, kilograms per cubic metre at standard conditions;

PR = Nitric acid production rate during performance test *i*, in metric tons per hour, 100% acid basis.

k = Nitric acid production unit.

QC.21.4. Sampling, analysis and measurement requirements

An emitter who operates a facility or establishment that produces nitric acid must

(1) conduct a performance test under normal operating conditions and without using the antipollution system. The test must be conducted annually and when changes occur at the production unit, including when an antipollution system is installed. During the test, the emitter must

(a) determine the average N_2O emission factor for each nitric acid production unit;

(b) determine the N_2O concentration in accordance with one of the following methods:

i. Method 320 in Appendix A of Part 63 of Title 40 of the Code of Federal Regulations "Measurement of Vapor Phase Organic and Inorganic Emissions by Extractive Fourier Transform Infrared (FTIR) Spectroscopy", published by the U.S. Environmental Protection Agency (USEPA);

ii. ASTM D6348-03 (2010) "Standard Test Method for Determination of Gaseous Compounds by Extractive Direct Interface Fourier Transform Infrared (FTIR) Spectroscopy";

(c) determine the production rate and N_2O concentration in the gas stream for each production unit in accordance with one of the following methods:

i. using a measuring instrument such as a flowmeter or weigh scales;

ii. using the same plant instruments as those used for inventory purposes, such as weigh hoppers or belt weight feeders;

(d) keep a full record of each performance test conducted, including raw data, sampling results, the calculations used to determine the N_2O emission factors and the information used to determine the nitric acid production rate;

(2) determine monthly nitric acid production for each production unit, both with and without the antipollution system, using one of the methods in subparagraph *b* of paragraph 1;

(3) determine the destruction factor using one of the following methods:

(a) by using the manufacturer's specified destruction factor;

(b) by estimating the destruction factor based on all data from the processes used;

(c) by conducting an additional performance test on gas stream from the antipollution system.

QC.21.5. Methods for estimating missing data

When sampling or measurement data required by this Regulation for the calculation of emissions is missing, the emitter must use replacement data determined as follows:

(1) for each missing monthly value concerning nitric acid production, the missing data must be estimated using all the data relating to the processes used or using the same plant instruments as those used for inventory purposes;

(2) for each missing value determined following the performance test, including the N_2O emission factor, the production rate and the N_2O concentration, a new performance test must be conducted.

QC.22. PHOSPHORIC ACID PRODUCTION

QC.22.1. Covered sources

The covered sources are all wet-process processes used to produce phosphoric acid by reacting phosphate rock with acid.

QC.22.2. Greenhouse gas reporting requirements

The greenhouse gas emissions report referred to in section 6.2 must include the following information:

(1) the annual CO_2 emissions attributable to phosphoric acid production, in metric tons;

(2) the annual CO_2, CH_4 and N_2O emissions attributable to the use of fixed combustion units, calculated in accordance with QC.1, in metric tons;

(3) the annual quantity of phosphoric acid produced, in metric tons;

(4) the monthly inorganic carbon of the phosphate rock, in metric tons of carbon per metric ton of phosphate rock;

(5) the monthly and annual consumption of phosphate rock, in metric tons;

(6) the number of times that the methods for estimating missing data in QC.22.5 were used;

(7) the total greenhouse gas emissions for each type of emissions, namely:

(a) the annual fixed process emissions corresponding to the emissions referred to in paragraph 1, in metric tons CO_2 equivalent;

(b) the annual combustion emissions corresponding to the emissions referred to in paragraph 2, in metric tons CO_2 equivalent.

Subparagraph 4 of the first paragraph does not apply to the CO_2 emissions of an emitter who calculates emissions using data from a continuous emission monitoring and recording system.

QC.22.3. Calculation methods for annual CO_2 emissions

For each process, the annual CO_2 emissions attributable to phosphoric acid production must be calculated using one of the calculation methods in QC.22.3.1 and QC.22.3.2.

QC.22.3.1. Use of a continuous emission monitoring and recording system

The annual CO_2 emissions may be calculated using data from a continuous emission monitoring and recording system in accordance with QC.1.3.4.

QC.22.3.2. Calculation of annual CO_2 emissions attributable to phosphoric acid production

The annual CO_2 emissions attributable to phosphoric acid production may be calculated using equation 22-1:

Equation 22-1

$$CO_2 = \sum_{i=1}^{12} \left[PR_i \times C_i \right] \times 3.664$$

Where:

CO_2 = Annual CO_2 emissions attributable to phosphoric acid production, in metric tons;

i = Month;

PR_i = Consumption of phosphate rock for month *i*, in metric tons;

C_i = Carbon content of phosphate rock for month *i*, in metric tons of carbon per metric ton of phosphate rock;

3.664 = Ratio of molecular weights, CO_2 to carbon.

QC.22.4. Sampling, analysis and measurement requirements

An emitter who operates a facility or establishment that produces phosphoric acid must

(1) take a monthly sample of each type of phosphate rock when the rock comes from different sources, or produce a composite sample by combining representative samples;

(2) determine the inorganic carbon content of each phosphate rock sample taken monthly from the feed system in accordance with the method in "Analytical Methods Manual in 2010 (10th edition), version 1.92" published by the Association of Fertilizer and Phosphate Chemists;

(3) determine the monthly consumption of phosphate rock using the same plant instruments as those used for inventory purposes, such as weigh hoppers or belt weight feeders.

QC.22.5. Methods for estimating missing data

When sampling or measurement data required by this Regulation for the calculation of emissions is missing, the emitter must use replacement data determined as follows:

(1) for each missing monthly value concerning the inorganic carbon content of the phosphate rock, the replacement value must be the arithmetic average of the data sampled immediately preceding and following the missing data period. If no data are available prior to the missing data period, the emitter must use the first data sampled or measured after the missing data period;

(2) for each missing value concerning the monthly consumption of phosphate rock, the missing data must be estimated using all the data relating to the processes used or data used for inventory purposes.

QC.23. AMMONIA PRODUCTION

QC.23.1. Covered sources

The covered sources are all the ammonia manufacturing processes in which ammonia is manufactured via steam reforming of fossil-based feedstocks or the gasification of solid and liquid raw material.

QC.23.2. Greenhouse gas reporting requirements.

The greenhouse gas emissions report referred to in section 6.2 must include the following information:

(1) the annual CO_2 emissions attributable to ammonia production via steam reforming or gasification processes, in metric tons;

(2) the annual CO_2, CH_4 and N_2O emissions attributable to the use of fixed combustion units, calculated in accordance with QC.1, in metric tons;

(3) the monthly and annual consumption of each raw material used in ammonia production, expressed

(a) in cubic metres at standard conditions for gases;

(b) in kilolitres for liquids;

(c) in metric tons for solids;

(4) the monthly carbon content of each raw material used in ammonia production, namely,

(a) in kilograms of carbon per kilogram of raw material in the case of gases and solids;

(b) in kilograms of carbon per kilolitre of raw material in the case of liquids;

(5) the annual CO_2 emissions attributable to the combustion of gas from the waste recycle stream, in metric tons;

(6) the annual consumption of gaseous fuels from the waste recycle stream, in cubic metres at standard conditions;

(7) the monthly carbon content of gas from the waste recycle stream, in kilograms of carbon per kilogram of gas;

(8) the annual production of ammoniac, in metric tons;

(9) if CO_2 from ammonia production is used to produce urea, the annual production of urea, in metric tons;

(10) the number of times that the methods for estimating missing data provided for in QC.23.5 were used;

(11) the total greenhouse gas emissions for each type of emissions, namely:

(a) the annual fixed process emissions corresponding to the emissions referred to in subparagraph 1, in metric tons CO_2 equivalent;

(b) the annual combustion emissions corresponding to the total of the emissions referred to in subparagraphs 2 and 5, excluding emissions attributable to the combustion or fermentation of biomass and biofuels, in metric tons CO_2 equivalent.

Subparagraphs 4 to 7 of the first paragraph do not apply to the CO_2 emissions of an emitter who calculates emissions using data from a continuous emission monitoring and recording system.

QC.23.3. Calculation methods for annual CO_2 emissions

For each process used, the annual CO_2 emissions attributable to ammonia production must be calculated using one of the calculation methods in QC.23.3.1 and QC.23.3.2 and the annual CO_2 emissions attributable to the combustion of gas from the waste recycle stream must be calculated in accordance with QC.23.3.3.

QC.23.3.1. Use of a continuous emission monitoring and recording system

The annual CO_2 emissions may be calculated using data from a continuous emission monitoring and recording system in accordance with QC.1.3.4.

QC.23.3.2. Calculation of annual CO_2 emissions attributable to ammonia production

The annual CO_2 emissions attributable to ammonia production must be calculated using equations 23-1 to 23-4:

Equation 23-1

$$CO_2 = \sum_{k=1}^{n} \left[CO_{2,G} + CO_{2,L} + CO_{2,S} \right]_k$$

Where:

CO_2 = Annual CO_2 emissions attributable to ammonia production, in metric tons;

n = Total number of ammonia production units;

k = Ammonia production unit;

$CO_{2,G}$ = Annual CO_2 emissions attributable to ammonia production for production unit *k* from gaseous feedstock, calculated in accordance with equation 23-2, in metric tons;

$CO_{2,L}$ = Annual CO_2 emissions attributable to ammonia production for production unit *k* from liquid feedstock, calculated in accordance with equation 23-3, in metric tons;

$CO_{2,S}$ = Annual CO_2 emissions attributable to ammonia production for production unit *k* from solid feedstock, calculated in accordance with equation 23-4, in metric tons;

Equation 23-2

$$CO_{2,G} = \sum_{i=1}^{12} \left[Fdstk_i \times C_i \right] \times \frac{MW}{MVC} \times 3.664 \times 0.001$$

Where:

$CO_{2,G}$ = Annual CO_2 emissions attributable to ammonia production for production unit *k* from gaseous feedstock, in metric tons;

i = Month;

$Fdstk_i$ = Consumption of gaseous feedstock for month *i*, in cubic metres at standard conditions, or, when a flowmeter is used, in metric tons;

C_i = Carbon content of gaseous feedstock consumed in month *i*, in kilograms of carbon per kilogram of feedstock;

MW = Molecular weight of gaseous feedstock in kilograms per kilomole or, when a mass flowmeter is used, replace $\frac{MW}{MVC}$ by 1;

MVC = Molar volume conversion factor of 24.06 m^3 per kilomole at standard conditions;

3.664 = Ratio of molecular weights, CO_2 to carbon;

0.001 = Conversion factor, kilograms to metric tons;

Equation 23-3

$$CO_{2,L} = \sum_{i=1}^{12} \left[Fdstk_i \times C_i \right] \times 3.664 \times 0.001$$

Where:

$CO_{2,L}$ = Annual CO_2 emissions attributable to ammonia production for production unit *k* from liquid feedstock, in metric tons;

i = Month;

$Fdstk_i$ = Consumption of liquid feedstock for month *i,* en kilolitres;

C_i = Carbon content of the liquid feedstock consumed in month *i*, in kilograms of carbon per kilolitre of feedstock;

3.664 = Ratio of molecular weights, CO_2 to carbon;

0.001 = Conversion factor, kilograms to metric tons;

Equation 23-4

$$CO_{2,S} = \sum_{i=1}^{12} \left[Fdstk_i \times C_i \right] \times 3.664 \times 0.001$$

Where:

$CO_{2,S}$ = Annual CO_2 emissions attributable to ammonia production at production unit *k* from solid feedstock, in metric tons;

i = Month;

$Fdstk_i$ = Consumption of solid feedstock for month *i*, in metric tons;

C_i = Carbon content of the solid feedstock consumed in month *i*, in kilograms of carbon per metric ton of feedstock;

3.664 = Ratio of molecular weights, CO_2 to carbon;

0.001 = Conversion factor, kilograms to metric tons.

QC.23.3.2. Calculation of annual CO_2 emissions attributable to the combustion of gas from the waste recycle stream

The annual CO_2 emissions attributable to the combustion of gas from the waste recycle stream of each ammonia production unit must be calculated using equation 23-5:

Equation 23-5

$$CO_{2,WR} = \sum_{i=1}^{12} \left[WRG_i \times C_i \right] \times \frac{MW}{MVC} \times 3.664 \times 0.001$$

Where:

$CO_{2,\ WR}$ = Annual CO_2 emissions attributable to the combustion of gas from the waste recycle stream of production unit, in metric tons;

i = Month;

WRG_i = Quantity of gas from the waste recycle stream for month *i*, in cubic metres at standard conditions;

C_i = Carbon content of gas from the waste recycle stream for month *i*, in kilograms of carbon per kilogram of "feedstock;

MW = Molecular weight of the gas from the "waste recycle stream, in kilograms per kilomole or, when a mass flowmeter is used, replace $\frac{MW}{MVC}$ by 1;

MVC = Molar volume conversion factor (24.06 m^3 per kilomole at standard conditions);

3.664 = Ratio of molecular weights, CO_2 to carbon;

0.001 = Conversion factor, kilograms to metric tons.

QC.23.4. Sampling, analysis and measurement requirements

An emitter who operates a facility or establishment that produces ammoniac must

(1) determine the consumption of feedstocks using the following methods:

(a) using flowmeters for liquid and gaseous feedstocks and for gas from the waste recycle stream;

(b) using the same plant instruments as those used for inventory purposes for solid feedstocks and the ammonia and urea produced;

(2) determine monthly the carbon content and the average molecular weight of each feedstock consumed and of gas from the waste recycle stream, either by using data from the material supplier or by using the following methods:

(a) ASTM D1945-03 (2010) "Standard Test Method for Analysis of Natural Gas by Gas Chromatography";

(b) ASTM D1946-90 (2006) "Standard Practice for Analysis of Reformed Gas by Gas Chromatography";

(c) ASTM D2502-04 (2009) "Standard Test Method for Estimation of Molecular Weight (Relative Molecular Mass) of Petroleum Oils From Viscosity Measurements";

(d) ASTM D2503-92 (2007) “Standard Test Method for Relative Molecular Mass (Molecular Weight) of Hydrocarbons by Thermoelectric Measurement of Vapor Pressure";

(e) ASTM D3238-95 (2010) "Standard Test Method for Calculation of Carbon Distribution and Structural Group Analysis of Petroleum Oils by the n-d-M Method";

(f) ASTM D5291-10 "Standard Test Methods for Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Petroleum Products and Lubricants";

(g) ASTM D3176-09 "Standard Practice for Ultimate Analysis of Coal and Coke”;

(h) ASTM D5373-08 "Standard Test Methods for Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Laboratory Samples of Coal";

(3) calibrate all flowmeters used for liquid or gaseous fuels, except those used for gas billing, and measure tank levels in accordance with the methods in QC.1.5.

QC.23.5. Methods for estimating missing data

When sampling or measurement data required by this Regulation for the calculation of emissions is missing, the emitter must use replacement data determined as follows:

(1) when emissions are calculated using a continuous emission monitoring and recording system, the method in paragraph 2 of QC.1.6 must be used;

(2) when the missing data concerns the carbon content, the replacement value must be the arithmetic average of the data sampled or measured immediately preceding and following the missing data period. If no data are available prior to the missing data period, the emitter must use the first data sampled or measured after the missing data period;

(3) when the missing data concerns the quantity of feedstock or gas from the waste recycle stream consumed, the missing data must be estimated using all the data relating to the processes used or data used for inventory purposes.

QC.24. ELECTRICITY TRANSMISSION AND DISTRIBUTION AND USE OF EQUIPMENT TO PRODUCE ELECTRICITY

QC.24.1. Covered sources

The covered sources are all equipment not covered by the calculation methods provided for in QC.16 used for the transmission and distribution of electricity and those used for producing electricity, in particular, transmission and distribution systems, substations, high-voltage circuit breakers and switches, that use sulphur hexafluoride (SF_6) and perfluorocarbons (PFCs).

Fugitive emissions attributable to equipment at an enterprise are also covered.

QC.24.2. Greenhouse gas reporting requirements

The greenhouse gas emissions report referred to in section 6.2 must include the following information:

(1) annual fugitive SF_6 emissions attributable to electrical equipment, in metric tons;

(2) annual fugitive emissions of each PFC attributable to electrical equipment, in metric tons;

(3) the number of times that the methods for estimating missing data in QC.24.5 were used;

(4) the annual emissions of greenhouse gas in the "other" category, corresponding to the total of the emissions referred to in paragraphs 1 and 2, in metric tons CO_2 equivalent.

QC.24.3. Calculation methods for fugitive SF_6 and PFC emissions

Fugitive SF_6 and PFC emissions must be calculated in accordance with the calculation methods in QC.24.3.1 and QC.24.3.2.

QC.24.3.1. Calculation of fugitive emissions by mass balance

Fugitive SF_6 and PFC emissions must be calculated using a mass-balance method that systematically accounts for all use of SF_6 and PFC by the emitter. For the purposes of the calculation, all quantities of SF_6 and PFC that cannot be accounted for are assumed to have been emitted.

Annual fugitive emissions must be calculated using equations 24-1 to 24-5:

Equation 24-1

$$GHG_j = \left(\Delta S_{INV} + S_{ACQ} - S_{SOLD} - \Delta S_{CAP}\right)_j \times 0.001$$

Where:

GHG_j = Annual fugitive emissions of gas *j*, in metric tons;

ΔS_{INV} = Change in inventory of gas *j* stored in storage containers, other than electrical equipment, calculated in accordance with equation 24-2, in kilograms;

S_{ACQ} = Quantity of gas *j* acquired during the year, contained in electrical equipment or storage containers, calculated in accordance with equation 24-3, in kilograms;

S_{SOLD} = Quantity of gas *j* sold or transferred to other facilities or establishments during the year, contained in electrical equipment or storage containers, calculated in accordance with equation 24-4, in kilograms;

ΔS_{CAP} = Net increase in total nameplate capacity of equipment using gas *j*, calculated in accordance with equation 24-5, in kilograms;

0.001 = Conversion factor, kilograms to metric tons;

j = Type of gas;

Equation 24-2

$$\Delta S_{INV} = S_{Begin} - S_{End}$$

Where:

ΔS_{INV} = Change in inventory of gas *j* stored in storage containers, other than electrical equipment, in kilograms;

S_{Begin} = Quantity of gas *j* stored at the beginning of the year in storage containers, other than electrical equipment, in kilograms;

S_{End} = Quantity of gas *j* stored at the end of the year in storage containers, other than electrical equipment, in kilograms;

j = Type of gas;

Equation 24-3

$$S_{ACQ} = S_{Cvl} + S_{Equip} + S_{\mathrm{Re}turned}$$

Where:

S_{ACQ} = Quantity of gas *j* acquired during the year, contained in electrical equipment or storage containers, in kilograms;

S_{Cyl} = Quantity of gas *j* acquired, contained in containers, in kilograms;

S_{Equip} = Quantity of gas *j* acquired, contained in electrical equipment, in kilograms;

$S_{Returned}$ = Quantity of gas *j* returned to the enterprise after off-site recycling, in kilograms;

j = Type of gas;

Equation 24-4

$$S_{SOLD} = S_{Sales} + S_{\mathrm{Re}turns} + S_{Destruct} + S_{\mathrm{Re}cyc}$$

Where:

S_{SOLD} = Quantity of gas *j* sold or transferred to other facilities or establishments during the year, in storage containers or electrical equipment, in kilograms;

S_{Sales} = Quantity of gas *j* sold to other facilities or establishments, including gas left in electrical equipment that is sold, in kilograms;

$S_{Returns}$ = Quantity of gas *j* returned to suppliers, in kilograms;

$S_{Destruct}$ = Quantity of gas *j* sent to destruction facilities, in kilograms;

S_{Recyc} = Quantity of gas *j* sent off-site for recycling, in kilograms;

j = Type of gas;

Equation 24-5

$$\Delta S_{CAP} = S_{New} - S_{\mathrm{Re}tire}$$

Where:

ΔS_{CAP} = Net increase in total nameplate capacity of electrical equipment using gas *j*, in kilograms;

S_{New} = Total nameplate capacity of new electrical equipment, in kilograms;

S_{Retire} = Total nameplate capacity of retired or sold electrical equipment, in kilograms;

j = Type of gas.

QC.24.3.2. Calculation of fugitive emissions by direct measurement

Fugitive SF6 and PFC emissions must be calculated by directly measuring the mass of gas added to electrical equipment during operation and the quantity of gas collected from decommissioned equipment, using equations 24-6 to 24-8:

Equation 24-6

$$GHG_j = (S_O + S_D)_j \times 0.001$$

Where:

GHG_j = Annual emissions of gas *j* attributable to the operation and decommissioning of electrical equipment, in metric tons;

S_O = Annual emissions of gas *j* during operation phase, calculated in accordance with equation 24-7, in kilograms;

S_D = Annual emissions of gas *j* during decommissioning phase, calculated in accordance with equation 24-8, in kilograms;

0.001 = Conversion factor, kilograms to metric tons;

j = Type of gas;

Equation 24-7

$$S_O = \sum_{i=1}^{n} S_i$$

Where:

S_O = Annual fugitive emissions of gas *j* during operation phase, in kilograms;

n = Number of additions of gas *j* during the year;

i = Addition;

S_i = Quantity of gas *j* added to electrical equipment during addition *i*, in kilograms;

j = Type of gas;

Equation 24-8

$$S_D = \sum_{i=1}^{n} \left(NC - S_C\right)_i$$

Where:

S_D = Annual emissions of gas *j* during decommissioning phase, in kilograms;

n = Number of units of electrical equipment decommissioned during the year;

i = Electrical equipment;

NC = Nameplate capacity of decommissioned electrical equipment *i*, in kilograms;

S_C = Quantity of gas *j* collected from decommissioned electrical equipment *i*, in kilograms;

j = Type of gas.

QC.24.4. Sampling, analysis and measurement requirements

An emitter who operates an electricity transmission or distribution enterprise or uses electrical equipment must

(1) measure additions of SF_6 or PCFs during the operation phase using a measuring instrument such as a flowmeter or weigh scale. If a weigh scale is used, the SF_6 or PFC container must be weighed before and after its contents are added to the electrical equipment, with the difference being equal to the quantity of SF_6 or PFC added to the equipment;

(2) calibrate the instruments used to measure the mass of SF_6 or PFC used to re-charge electrical equipment, using one of the following methods:

(a) by following the instructions of the manufacturer for the use of a flowmeter;

(b) every 6 months, by weighing objects of pre-determined mass and zeroing the weigh scale accordingly.

QC.24.5. Methods for estimating missing data

When sampling or measurement data required by this Regulation for the calculation of emissions is missing, an emitter must use a replacement value based on data from equipment with a similar nameplate capacity for SF_6 and PFCs, and data from similar equipment repair, replacement, and maintenance operations.

QC.25. CARBONATES USE

QC.25.1. Covered sources

The covered sources are all process equipment that uses carbonates such as limestone, dolomite, ankerite, magnesite, siderite, rhodochrosite, sodium carbonate or strontium carbonate.

All equipment that uses carbonates or carbonate-containing raw materials that are consumed in the production of cement, ferroalloys, glass, iron and steel, lead, lime, phosphoric acid, sodium carbonate or zinc and for which special calculation methods are provided for in this Schedule is excluded.

Carbonates contained in the sorbents used in acid gas scrubbing equipment are also excluded, the emissions from which must be quantified and reported in accordance with QC.1.3.6.

QC.25.2. Greenhouse gas reporting requirements.

The greenhouse gas emissions report referred to in section 6.2 must include the following information:

(1) the annual CO_2 emissions attributable to the use of carbonates or carbonate-based raw materials, in metric tons;

(2) the annual consumption of each carbonate or carbonate-based raw material, in metric tons;

(3) when the calculation method in QC25.3.2 is used,

(a) the calcination fraction for carbonates, in tons of carbonate obtained per metric ton of carbonates in the carbonate-based raw material;

(b) the average annual carbonate content of each carbonate-based raw material, in metric tons of carbonates per metric ton of carbonate-based raw material;

(4) the annual quantity of each carbonate-based material output, in metric tons, when the calculation method in QC.25.3.3 is used;

(5) the number of times that the methods for estimating missing data in QC.25.5 were used;

(6) the annual emissions attributable to fixed processes, corresponding to the emissions referred to subparagraph 1, in metric tons CO_2 equivalent.

Subparagraph 3 of the first paragraph does not apply to the CO_2 emissions of an emitter who calculates emissions using data from a continuous emission monitoring and recording system.

QC.25.3. Calculation methods for annual CO_2 emissions

For each process, the annual CO_2 emissions attributable to the use of carbonate-based raw materials must be calculated using one of the calculation methods in QC.25.3.1 to QC.25.3.3.

QC.25.3.1. Use of a continuous emission monitoring and recording system

The annual CO_2 emissions may be calculated using data from a continuous emission monitoring and recording system in accordance with QC.1.3.4.

QC.25.3.2. Calculation method for CO_2 emissions using the calcination fraction

The annual CO_2 emissions attributable to the use of carbonates or carbonate-based raw materials may be calculated using the calcination fraction, using equation 25-1:

Equation 25-1

$$CO_2 = \sum_{i=1}^{n}\left[\sum_{j=1}^{m}\left(RM_{j,i} \times CC_{j,i}\right) \times EF_i \times F_i\right]$$

Where:

CO_2 = Annual CO_2 emissions attributable to the use of carbonate-based raw materials, in metric tons;

n = Number of carbonates contained in the raw materials;

i = Carbonate;

m = Number of carbonate-based raw materials used;

j = Raw material;

$RM_{j,i}$ = Annual consumption of raw material *j* containing carbonate *i*, in metric tons;

$CC_{j,i}$ = Average annual content of carbonate *i* in raw material *j*, in metric tons of carbonate per metric ton of raw material;

EF_i = Emission factor for carbonate *i* as specified in Table 25-1 in QC.25.6, in metric tons of CO_2 per metric ton of carbonate;

F_i = Calcination fraction for carbonate *i*, in metric tons of carbonate obtained per metric ton of carbonate in the raw material, a value of 1.0 corresponding to complete calcination.

QC.25.3.3. Calculation method for CO_2 emissions by mass balance

The annual CO_2 emissions attributable to the use of carbonates or carbonate-based raw materials may be calculated by mass balance, using equation 25-2:

Equation 25-2

$$CO_2 = \sum_{i=1}^{n}\left[\sum_{j=1}^{m}\left(RM_{j,i} \times CC_{j,i}\right) \times EF_i\right] - \sum_{i=1}^{n}\left[\sum_{k=1}^{p}\left(RM_{k,i} \times CC_{k,i}\right) \times EF_i\right]$$

Where:

CO_2 = Annual CO_2 emissions attributable to the use of carbonates or carbonate-based raw materials, in metric tons;

n = Number of carbonates contained in raw materials;

i = Carbonate;

m = Number of carbonate-based raw materials;

j = Raw material;

$RM_{j,i}$ = Annual consumption of carbonate or raw material *j* containing carbonate *i*, in metric tons;

$CC_{j,i}$ = Average annual content of carbonate *i* in raw material *j*, in metric tons of carbonate per metric ton of raw material;

EF_i = Emission factor for carbonate *i* as specified in Table 25-1 in QC.25.6, in metric tons of CO_2 per metric ton of carbonate;

p = Number of carbonate-containing output materials;

k = Carbonate-containing output material;

$RM_{k,i}$ = Annual quantity of output material *k* containing carbonate *i*, in metric tons;

$CC_{k,i}$ = Average annual content of carbonate *i* in output material *k*, in metric tons of carbonate per metric ton of material;

EF_i = Emission factor for carbonate *i* as specified in Table 25-1 in QC.25.6, in metric tons of CO_2 per metric ton of output carbonate.

QC.25.4. Sampling, analysis and measurement requirements

An emitter who operates a facility or establishment that uses carbonate-based raw materials must

(1) determine annually the calcination fraction for each carbonate consumed by sampling and chemical analysis, using an industry-recognized method such as ASTM, ASME or API, an x-ray fluorescence method, or the value 1.0;

(2) determine annually the average carbonate content by calculating the arithmetic average of the monthly data obtained from raw material suppliers, by conducting sampling and chemical analysis, or using the value 1.0;

(3) determine the annual quantity of each input carbonate and each input carbonate-based raw material, and of each carbonate-based output material, by direct weight measurement once a month using the same plant instruments used for inventory purposes, such as weigh hoppers or belt weigh feeders, or using calculations based on data from the process control system.

QC.25.5. Methods for estimating missing data

When sampling or measurement data required by this Regulation for the calculation of emissions is missing, the emitter must use replacement data determined as follows:

(1) when emissions are calculated using a continuous emission monitoring and recording system, the method in paragraph 2 of QC.1.6 must be used;

(2) when the missing data concerns the monthly quantity of input or output carbonate-based raw materials, the missing data must be estimated using all the data relating to the processes used or the data used for inventory purposes;

(3) when the missing data concerns the carbonate content of raw materials or of output carbonate-based materials, the replacement value must be the default value 1.0.

QC.25.6. Tables

Table 25-1. CO_2 emission factors for various carbonates

(QC.25.3.2, QC.25.3.3)

Mineral name – Carbonate	**CO_2 emission factor (metric tons of CO_2 per metric ton of carbonat(e)**
Limestone– $CaCO_3$	0.43971
Magnesite – $MgCO_3$	0.52197
Dolomite – $CaMg(CO_3)_2$	0.47732
Siderite – $FeCO_3$	0.37987
Ankerite – $Ca(Fe,Mg,Mn)(CO_3)_2$	0.47572
Rhodochrosite – $MnCO_3$	0.38286
Sodium carbonate/Soda ash – Na_2CO_3	0.41492
Strontium carbonate – $SrCO_3$	0.29811
Others	Facility specific factor to be determined through analysis or supplier information

QC.26. GLASS PRODUCTION

QC.26.1. Covered sources

The covered sources are glass melting furnaces used to produce flat glass, container glass, pressed and blown glass or wool fibreglass.

QC.26.2. Greenhouse gas reporting requirements.

The greenhouse gas emissions report referred to in section 6.2 must include the following information:

(1) the annual CO_2 emissions attributable to glass production, in metric tons;

(2) the annual CO_2 emissions attributable to the use of carbonate-containing raw materials for glass production, calculated in accordance with QC.25, in metric tons;

(3) the annual CO_2, CH_4 and N_2O emissions attributable to the combustion of fuels in glass melting furnaces, calculated in accordance with QC.1, in metric tons;

(4) the annual CO_2, CH_4 and N_2O emissions attributable to the use of fixed combustion units, except glass melting furnaces, calculated in accordance with QC.1, in metric tons;

(5) the annual consumption of each carbonate-containing raw material used in a furnace, in metric tons;

(6) the average annual carbonate content of each carbonate-based raw material used in a furnace, in metric tons of carbonate per metric ton of raw material;

(7) the calcination fraction of the carbonates contained in raw materials, in metric tons of carbonate obtained per metric ton of carbonate in the raw material;

(8) the annual quantity of glass produced, in metric tons;

(9) the number of times that the methods for estimating missing data in QC.26.5 were used;

(10) the total greenhouse gas emissions for each type of emissions, namely:

(a) the annual fixed process emissions corresponding to the emissions referred to in subparagraph 2, in metric tons CO_2 equivalent;

(b) the annual combustion emissions corresponding to the total of the emissions referred to in subparagraphs 3 and 4, in metric tons CO_2 equivalent.

Subparagraphs 2, 3, 5, 6 and 7 of the first paragraph do not apply to the CO_2 emissions of an emitter who calculates emissions using data from a continuous emission monitoring and recording system.

QC.26.3. Calculation methods for annual CO_2 emissions

For each glass melting furnace, the annual CO_2 emissions attributable to glass production must be calculated using one of the calculation methods in QC.26.3.1 and QC.26.3.2.

QC.26.3.1. Use of a continuous emission monitoring and recording system

The annual CO_2 emissions may be calculated using data from a continuous emission monitoring and recording system in accordance with QC.1.3.4.

QC.26.3.2. Calculation method for annual CO_2 emissions

The annual CO_2 emissions attributable to the use of carbonate-containing raw materials may be calculated using equation 26-1:

Equation 26-1

$$CO_2 = \sum_{i=1}^{n} CO_{2,i}$$

Where:

CO_2 = Annual CO_2 emissions attributable to the use of carbonate-containing raw materials for glass production in all glass melting furnaces, in metric tons;

n = Number of glass melting furnaces;

i = Glass melting furnace;

$CO_{2,i}$ = Annual CO_2 emissions attributable to the use of carbonate-containing raw materials for glass production in glass melting furnace *i*, calculated in accordance with QC.25.3.2, in metric tons.

QC.26.4. Sampling, analysis and measurement requirements

An emitter who operates a facility or establishment that produces glass must determine annually, in accordance with QC.25.4,

(1) the average carbonate content of each raw material, or use the value 1.0;

(2) the calcination fraction of each carbonate, or use the value 1.0;

(3) the quantity of each carbonate-containing raw material.

QC.26.5. Methods for estimating missing data

When sampling or measurement data required by this Regulation for the calculation of emissions is missing, the emitter must use replacement data determined as follows:

(1) when emissions are calculated using a continuous emission monitoring and recording system, the method in paragraph 2 of QC.1.6 must be used;

(2) when the missing data concerns the monthly quantity of carbonate-based raw materials, the missing data must be estimated using all the data relating to the processes used or the data used for inventory purposes;

(3) when the missing data concerns the carbonate content of carbonate-based raw materials, the replacement value must be the value 1.0.

QC.27. MOBILE EQUIPMENT

QC.27.1. Covered sources

The covered sources are all mobile equipment used at a facility or establishment for the on-site transportation or movement of substances, materials or products, and any other mobile equipment such as tractors, mobile cranes, log transfer equipment, mining machinery, graders, backhoes and bulldozers, and other mobile industrial equipment. All mobile equipment used by subcontractors for the purposes of normal activities at the facility or establishment is also covered.

Road vehicles within the meaning of the Highway Safety Code (R.S.Q., c. C-24.2), aircraft and ships are excluded.

QC.27.2. Greenhouse gas reporting requirements

The greenhouse gas emissions report referred to in section 6.2 must include the following information:

(1) the annual greenhouse gas emissions attributable the combustion of fossil fuels and biomass fuels, in metric tons, specifying, by fuel type,

(a) CO_2 emissions;

(b) CH_4 emissions;

(c) N_2O emissions;

(2) annual and quarterly consumption of each fuel type, in litres.

QC.27.3. Calculation methods for CO_2 emissions

The annual CO_2 emissions attributable to mobile equipment must be calculated in accordance with the calculation methods in QC.27.3.1 to QC.27.3.3.

For mixtures of biomass fuels and fossil fuels, the CO_2 emissions attributable to the biomass fuel portion and to the fossil fuel portion must be calculated separately.

QC.27.3.1. Calculation method for CO_2 emissions based on the quantity of fuel used

When the quantity of fuel used is known, the annual CO_2 emissions attributable to mobile equipment used on-site at a facility or establishment must be calculated using equation 27-1:

Equation 27-1

$$CO_2 = \sum_{i=1}^{4} \left[Fuel_i \times EF \right] \times 0.001$$

Where:

CO_2 = Annual CO_2 emissions attributable to each fuel type used by the mobile equipment, in metric tons;

i = Quarter;

$Fuel_i$ = Volume of fuel used by the mobile equipment during quarter *i*, in litres;

EF = CO_2 emission factor for the fuel as specified in Table 1-2 in QC.1.7 or Table 27-1 in QC.27.6, in kilograms per litre;

0.001 = Conversion factor, kilograms to metric tons.

QC.27.3.2. Calculation method for CO_2 emissions based on operating conditions of the mobile equipment

When the quantity of fuel used cannot be determined, the annual CO_2 emissions attributable to mobile equipment used on-site at a facility or establishment must be calculated using equation 27-2:

Equation 27-2

$$CO_2 = \sum_{i=1}^{4}\left[\sum_{j=1}^{n}\left(H_j \times P_j \times LF_j \times SFC_j\right)\times EF\right]_i \times 0.001$$

Where:

CO_2 = Annual CO_2 emissions attributable to each fuel type used by the mobile equipment, in metric tons;

i = Quarter;

n = Number of mobile equipment units;

j = Mobile equipment;

H_j = Quarterly hours of operation of mobile equipment *j*, in hours;

P_j = Rated power of mobile equipment *j*, in kilowatts;

LF_j = Load factor for mobile equipment *j*, determined by the emitter;

SFC_j = Specific consumption of each fuel type by mobile equipment *j*, in litres per kilowatt-hour;

EF = CO_2 emission factor for the fuel, as specified in Table 1-2 in QC.1.7 or Table 27-1 in QC.27.6, in kilograms per litre;

0.001 = Conversion factor, kilograms to metric tons.

QC.27.3.3. Calculation method for CO_2 emissions based on emission factors determined by the emitter according to operating conditions

When the quantity of fuel used cannot be determined and the information needed to calculate CO_2 emissions using the method in QC.27.3.2 is not available, the annual CO_2 emissions attributable to mobile equipment used on-site at a facility or establishment must be calculated using equation 27-3:

Equation 27-3

$$CO_2 = \sum_{j=1}^{n} \left(H_j \times AFC_j \times EF_j\right) \times 0.001$$

Where:

CO_2 = Annual CO_2 emissions attributable to mobile equipment, in metric tons;

n = Number of mobile equipment operating conditions;

j = Operating condition;

H_j = Annual hours of use of mobile equipment in operating condition *j*, in hours;

AFC_j = Average fuel consumption of mobile equipment in operating condition *j*, in litres per hour;

EF_j = CO_2 emission factor for mobile equipment operating condition *j*, determined by the emitter, in kilograms per litre;

0.001 = Conversion factor, kilograms to metric tons.

QC.27.4. Calculation methods for CH_4 and N_2O emissions

The annual CH_4 and N_2O emissions attributable to mobile equipment must be calculated using the calculation methods in QC.27.4.1 to QC.27.4.3.

For mixtures of biomass fuels and fossil fuels, the CH_4 and N_2O emissions attributable to the biomass fuel portion and to the fossil fuel portion must be calculated separately.

QC.27.4.1. Calculation method for annual CH_4 and N_2O emissions based on the quantity of fuel consumed

When the quantity of fuel is known, the annual CH_4 and N_2O emissions attributable to mobile equipment used on-site at a facility or establishment must be calculated using equation 27-4:

Equation 27-4

$$CH_4 \ or \ N_2O = \sum_{i=1}^{4} \left[Fuel_i \times EF \right] \times 0.000001$$

Where:

CH_4 or N_2O = Annual CH_4 or N_2O emissions attributable to each fuel type used by the mobile equipment, in metric tons;

i = Quarter;

$Fuel_i$ = Volume of fuel used by mobile equipment during quarter *i*, in litres;

EF = CH_4 or N_2O emission factor for the fuel, as specified in Table 1-3 in QC.1.7 or Table 27-1 in QC.27.6, in grams per litre;

0.000001 = Conversion factor, grams to metric tons.

QC.27.4.2. Calculation method for CH_4 and N_2O emissions based on use of the mobile equipment

When the quantity of fuel used cannot be determined, the annual CH_4 and N_2O emissions attributable to mobile equipment used on-site at a facility or establishment must be calculated using equation 27-5:

Equation 27-5

$$CH_4 \ or \ N_2O = \sum_{i=1}^{4}\left[\sum_{j=1}^{n}\left(H_j \times P_j \times LF_j \times SFC_j\right) \times EF\right]_i \times 0.000001$$

Where:

CH_4 or N_2O = Annual CH_4 or N_2O emissions attributable to each fuel type used by the mobile equipment, in metric tons;

i = Quarter;

n = Number of mobile equipment units;

j = Mobile equipment;

H_j = Quarterly hours of operation of mobile equipment *j*, in hours;

P_j = Rated power of mobile equipment *j*, in kilowatts;

LF_j = Load factor for mobile equipment *j*, determined by the emitter;

SFC_j = Specific consumption of each fuel type by mobile equipment *j*, in litres per kilowatt-hour;

EF = CH_4 or N_2O emission factor for the fuel, as specified in Table 1-3 in QC.1.7 or Table 27-1 in QC.27.6, in grams per litre;

0.000001 = Conversion factor, grams to metric tons.

QC.27.4.3. Calculation method for CH_4 or N_2O emissions based on emission factors determined by the emitter according to operating conditions

When the quantity of fuel used cannot be determined and the information needed to calculate CH_4 or N_2O emissions using the method in QC.27.4.2 is not available, the annual CH_4 or N_2O emissions attributable to mobile equipment used on-site at a facility or establishment must be calculated using equation 27-6:

Equation 27-6

$$CH_4 \ or \ N_2O = \sum_{j=1}^{n} \left(H_j \times AFC_i \times EF_j \right) \times 0.001$$

Where:

CH_4 or N_2O = Annual CH_4 or N_2O emissions attributable to mobile equipment, in metric tons;

n = Number of mobile equipment operating conditions;

j = Operating condition;

H_j = Annual hours of use of mobile equipment in operating condition *j*, in hours;

AFC_j = Average fuel consumption of mobile equipment in operating condition *j*, in litres per hour;

EF_j = CH_4 or N_2O emission factor for mobile equipment operating condition *j*, determined by the emitter, in kilograms per litre;

0.001 = Conversion factor, kilograms to metric tons.

QC.27.5. Sampling, analysis and measurement requirements

An emitter who uses mobile equipment on-site at a facility or establishment must

(1) for a mixture of biomass fuels and fossil fuels, determine during each delivery the portion of biomass fuels and the portion of fossil fuels based on the data indicated by the supplier;

(2) determine quarterly the volumes of fuel used, using the same plant instruments as those used for inventory purposes, such as purchase invoices or a gauge reading for each unit of mobile equipment;

(3) determine annually the operating conditions during which mobile equipment is used when the calculation methods in QC.27.3.3 and QC.27.4.3 are used.

QC.27.6. Tables

Table 27-1. Emission factors by fuel type

(QC.27.3.1, QC.27.3.2, QC.27.3.3, QC.27.4.1, QC.27.4.2)

Mobile equipment	**CO_2 (kg/(L)**	**CH_4 (g/(L)**	**N_2O (g/(L)**
Light-duty gasoline vehicle			
- tier 1	2.289	0.12	0.16
- tier 0	2.289	0.32	0.66
- oxidation catalyst	2.289	0.52	0.20
- non-catalytic controlled	2.289	0.46	0.028
Light-duty gasoline truck			
- tier 1	2.289	0.13	0.25
- tier 0	2.289	0.21	0.66
- oxidation catalyst	2.289	0.43	0.20
- non-catalytic controlled	2.289	0.56	0.028
Heavy-duty gasoline vehicle			
- three-way catalyst	2.289	0.068	0.20
- non-catalytic controlled	2.289	0.29	0.047
- uncontrolled	2.289	0.49	0.084
Light-duty diesel vehicle			
- advance control	2.663	0.051	0.22
- moderate control	2.663	0.068	0.21
- uncontrolled	2.663	0.10	0.16
Light-duty diesel truck			
- advance control	2.663	0.068	0.22
- moderate control	2.663	0.068	0.21
- uncontrolled	2.663	0.085	0.16
Heavy-duty diesel vehicle			
- advance control	2.663	0.12	0.082
- moderate control	2.663	0.14	0.082
- uncontrolled	2.663	0.15	0.075
Natural gas vehicle	0.00189	0.009	0.00006
Propane vehicle	1,510	0.64	0.028

Off-road gasoline	2.289	2.7	0.05
Off-road diesel	2.663	0.15	1.1
Diesel train	2.663	0.15	1.1
Biodiesel vehicle	2.449	-[1]	-[1]
Ethanol vehicle	1.494	-[2]	-[2]

[1] Diesel CH_4 and N_2O emission factors (by vehicle type) are used for biodiesel.

[2] Gasoline CH_4 and N_2O emission factors (by vehicle type) are used for ethanol.

QC.28. Electronics manufacturing

QC.28.1. Covered sources

The covered sources are all facilities or establishments that manufacture semiconductors, liquid crystal displays, micro-electro-mechanical systems and photovoltaic cells. The following manufacturing processes are also targeted:

(1) plasma etching, in other words the process in which plasma-generated fluorine atoms and other reactive fluorine-containing fragments chemically react with exposed thin-films constituted of dielectric materials and metals, and in contact with silicon;

(2) the periodical cleaning of the chambers used for depositing thin films using plasma-generated fluorine atoms and other reactive fluorine-containing fragments from fluorinated and other gases;

(3) the cleaning of semiconductor wafers using plasma-generated fluorine atoms or other reactive fluorine-containing fragments to remove residual material from wafer surfaces;

(4) the transformation of fluorinated compounds, in other words the process by which fluorinated compounds can be transformed into different fluorinated compounds which are then exhausted, unless abated, into the atmosphere;

(5) chemical vapour deposition processes or any other electronics manufacturing processes using N_2O;

(6) equipment cooling, in other words the process in which fluorinated gases are used as heat transfer fluids to cool process equipment, control temperature during device testing, and solder semiconductor devices to circuit boards.

QC.28.2. Greenhouse gas reporting requirements

The greenhouse gas emissions report referred to in section 6.2 must include the following information:

(1) the annual greenhouse gas emissions attributable to electronics manufacturing processes, in metric tons;

(2) the annual CO_2, CH_4 and N_2O emissions attributable to the use of stationary combustion equipment, calculated in accordance with QC.1, in metric tons;

(3) the greenhouse gas calculations methods used pursuant to QC.28.3;

(4) production in terms of substrate surface area, such as silica, photovoltaic cells and liquid crystal displays, in square metres;

(5) the emission factors used to determine process utilization and by-product formation rates and the source for each factor;

(6) a description of each calculation method used, when different from the methods in QC.28.3;

(7) the annual consumption of each greenhouse gas and the quantity of gas remaining in the container after use, in metric tons;

(8) the apportioning factors for the production processes, in other words the quantity of each gas fed into each individual process used;

(9) a description of the engineering model used to apportion the consumption of fluorinated bases;

(10) the annual consumption of each greenhouse gas, calculated in accordance with the method used to determine the apportioning factors when that method allows an estimate that is independent of the estimate obtained using equation 28-6 in QC.28.3.4, in metric tons;

(11) the data used to calculate the mass balance of each greenhouse gas for any heat transfer fluid used, using equation 28-5 provided for in QC.28.3.3;

(12) the annual greenhouse gas emissions for each type of emissions, namely:

(a) the annual greenhouse gas emissions attributable to combustion, corresponding to the total emissions referred to in paragraph 2, in metric tons CO_2 equivalent;

(b) the annual greenhouse gas emissions in the "other" category, corresponding to the total emissions referred to in paragraph 1, in metric tons CO_2 equivalent.

QC.28.3. Greenhouse gas calculation methods

The annual greenhouse gas emissions attributable to all electronics manufacturing processes must be calculated using equation 28-1:

Equation 28-1

$$GHG = \sum_{i=1}^{n} \left(GHG_{P,i} + GHG_{B,i} + GHG_{TF,i} \right) + N_2O$$

Where:

GHG = Annual greenhouse gas emissions attributable to all electronics manufacturing processes, in metric tons;

n = Total number of input gases;

i = Type of input gas;

$GHG_{P,j}$ = Annual greenhouse gas emissions of input gas *i* from individual process or process category *j*, calculated in accordance with QC.28.3.1, in metric tons;

$GHG_{B,i}$ = Annual emissions of by-product gas formed from input gas *i* during individual process or process category *j*, calculated in accordance with QC.28.3.1, in metric tons;

$GHG_{TF,i}$ = Annual greenhouse gas emissions attributable to the use of heat transfer fluid *i*, calculated in accordance with QC.28.3.3, in metric tons;

N_2O = Annual N_2O emissions attributable to each electronics manufacturing process, calculated in accordance with QC.28.3.2, in metric tons;

j = Individual process or process category.

QC.28.3.1. Calculation method for fluorinated gas emissions

The annual fluorinated gas emissions attributable to all electronics manufacturing processes must be calculated using equations 28-2 and 28-3 and in accordance with the second paragraph.

Equation 28-2

$$GHG_{P,i} = \sum_{j=1}^{m} \left[C_j \times \left(1 - U_j\right) \times \left(1 - a_j \times d_j\right) \right]_i \times 0.001$$

Where:

$GHG_{P,j}$ = Annual greenhouse gas emissions of input gas *i* from individual process or process category *j*, in metric tons;

m = Total number of individual processes or process categories;

j = Individual process or process category;

C_j = Consumption of input gas *i* in individual process or process category *j*, calculated using equation 28-6 and apportioned in accordance with QC.28.4.2, in kilograms;

U_j = Process utilization for input gas *i* during individual process or process category *j*;

a_j = Volumetric fraction of input gas *i* used in individual process or process category *j* with antipollution systems, in percentage expressed in the form of a decimal;

d_j = Volumetric fraction of input gas *i* destroyed by the antipollution system connected to individual process or process category *j*, during process use time, determined in accordance with paragraph 2 of QC.28.4.4, in percentage expressed in the form of a decimal, or a default value of 0;

0.001 = Conversion factor, kilograms to metric tons;

i = Input gas;

Equation 28-3

$$GHG_{D,i} = \sum_{j=1}^{m}\sum_{k=1}^{p}\left[P_{jk} \times C_j \times \left(1 - a_j \times d_{jk}\right)\right]_i \times 0.001$$

Where:

$GHG_{D,i}$ = Annual emissions of by-product gas *k* formed from input gas *i* during individual process or process category *j*, in metric tons;

m = Total number of individual processes or process categories;

j = Individual process or process category;

p = Total number of by-product gases;

k = By-product gas;

P_{jk} = Rate of production of by-product gas *k* from consumption of input gas *i* during individual process or process category *j*;

C_j = Consumption of input gas *i* during process *j*, calculated using equation 28-6 and apportioned in accordance with QC.28.4.2, in kilograms;

a_j = Volumetric fraction of input gas *i* used in individual process or process category *j* with antipollution systems, in percentage expressed in the form of a decimal;

d_{jk} = Volumetric fraction of input gas *i* destroyed by the antipollution system connected to individual process or process category *j*, during process use time, determined in accordance with paragraph 2 of QC.28.4.4, in percentage expressed in the form of a decimal, or a default value of 0;

0.001 = Conversion factor, kilograms to metric tons;

i = Input gas.

For the purpose of calculating emissions, the emitter must determine the rate of use of the input gas during the individual process or process category and the rate of production of the by-product gas from consumption of the input gas during the individual process or process category using the following methods:

(1) for a facility that manufactures semiconductors on wafers 300 mm or less in diameter:

(*a)* using the rates indicated in Tables 28-1, 28-2 and 28-3 in QC.28.6;

(*b)* by measuring the rates in accordance with QC.28.4.3;

(2) for a facility that manufactures semiconductors on wafers measuring more than 300 mm in diameter, by measuring the rates in accordance with QC.28.4.3;

(3) for all other electronics manufacturing facilities, using the rates indicated in Tables 28-4, 28-5 and 28-6 in QC.28.6.

QC.28.3.2. Calculation method for N_2O emissions

The annual N_2O emissions attributable to all electronics manufacturing processes must be calculated using equation 28-4 and in accordance with the second paragraph.

Equation 28-4

$$N_2O = \sum_{j=1}^{m} \left[C_j \times \left(1 - U_j\right) \times \left(1 - a_j \times d_j\right) \right] \times 0.001$$

Where:

N_2O = Annual emissions of N_2O attributable to each electronics manufacturing process, in metric tons;

m = Total number of processes used;

j = Type of process used;

C_j = Consumption of N_2O during process *j*, calculated using equation 28-6 and apportioned to N_2O-using process *j*, in kilograms;

U_j = Rate of utilization of N_2O during process *j*;

a_j = Volumetric fraction of N_2O used in N_2O-using process *j* with an antipollution system, in percentage expressed in the form of a decimal;

d_j = Volumetric fraction of N_2O destroyed by the antipollution systems connected to process *j*, during process use time, determined in accordance with paragraph 2 of QC.28.4.4, or a default value of 0;

0.001 = Conversion factor, kilograms to metric tons.

For the purpose of calculating emissions, the emitter must:

(1) determine the N_2O utilization rate by measuring it in accordance with QC.28.4.3 or, when the rate cannot be measured, using a default value of 20% for chemical vapour deposition processes and a value of 0% for all other manufacturing processes;

(2) for a facility equipped with antipollution systems, calculate the reduction in N_2O emissions attributable to the use of such systems, in accordance with QC.28.4.4.

QC.28.3.3. Calculation method for fluorinated gas emissions attributable to heat transfer fluids

The annual fluorinated gas emissions attributable to the use of each heat transfer fluid must be calculated using equation 28-5:

Equation 28-5

$$GHG_{HT,i} = \rho_i \times \left[\left(I_{D,i} - I_{F,i} \right) + \left(NC_{R,i} - NC_{N,i} \right) + \left(TF_{A,i} - TF_{T,i} \right) \right] \times 0.001$$

Where:

$GHG_{HT,i}$ = Annual greenhouse gas emissions attributable to the use of heat transfer fluid *i*, in metric tons;

ρ_i = Density of heat transfer fluid *i*, in kilograms per litre;

$I_{D,i}$ = Quantity of heat transfer fluid *i* in inventory in containers at the beginning of the year, in litres;

$I_{F,i}$ = Quantity of heat transfer fluid *i* in inventory in containers at the end of the year, in litres;

$NC_{R,i}$ = Total nameplate capacity of equipment that uses heat transfer fluid *i* and that is removed from the facility during the year, in litres;

$NC_{N,i}$ = Total nameplate capacity of equipment that uses heat transfer fluid *i* and that is newly installed during the year, in litres;

$TF_{A,i}$ = Quantity of heat transfer fluid *i* acquired during the year, including amounts obtained from chemical suppliers and equipment suppliers and amounts of fluid returned to the facility after recycling, in litres;

$TF_{T,i}$ = Quantity of heat transfer fluid *i* transferred or sold during the year, including amounts returned to chemical suppliers, sent off-site for recycling or destroyed, in litres;

0.001 = Conversion factor, kilograms to metric tons;

i = Heat transfer fluid.

QC.28.3.4. Calculation method for the consumption of fluorinated gases and N_2O

The annual consumption of fluorinated gases and N_2O used in electronics manufacturing processes must be calculated in accordance with QC.28.4.1 using equations 28-6 and 28-7:

Equation 28-6

$$C_i = (I_{Di} - I_{Fi} + A_i - S_i) \times 0.001$$

Where:

Ci = Annual consumption of input gas *i*, in metric tons;

I_{Di} = Quantity of gas *i* in inventory in all containers at the beginning of the year, including heels, in kilograms;

I_{Fj} = Quantity of gas *i* in inventory in all containers at the end of the year, including heels, in kilograms;

A_i = Quantity of gas *i* acquired during the year, including heels in containers returned to the establishment or facility, in kilograms;

S_i = Quantity of gas *i* sold or transferred during the year, including heels in containers returned to the gas supplier, calculated using equation 28-7, in kilograms;

0.001 = Conversion factor, kilograms to metric tons;

i = Input gas;

Equation 28-7

$$S_i = \sum_{l=1}^{q} \left(f_{i,l} \times N_{i,l} \times NC_{i,l} \right) + X_i$$

Where:

S_i = Quantity of gas *i* sold or transferred during the year, including heels in containers returned to the gas supplier, in kilograms;

q = Total number of types of container;

l = Type of container;

$f_{i,l}$ = Fraction of gas *i* remaining in container of type *l*, determined in accordance with QC.28.4.1;

$N_{i,l}$ = Number of containers of type *l* returned to the gas supplier containing the heel of gas *i* calculated in accordance with paragraph 2 of QC.28.4.1;

$NC_{i,l}$ = Total nameplate capacity of containers of type *l* containing gas *i*, in kilograms;

X_i = Any other quantity of gas *i* sold or transferred during the year, calculated in accordance with paragraph 3 of QC.28.4.1, in kilograms;

i = Gas sold or transferred.

QC.28.4. Sampling, analysis and measurement requirements

QC.28.4.1. Determination of gas heel remaining in a container

An emitter operating an electronics manufacturing facility or establishment must determine the gas heel remaining in a container, for each type of gas and type of container, using the following methods:

(1) by determining the fraction of gas heel remaining in a container using equation 28-8:

Equation 28-8

$$f_{i,j} = \frac{w_{r,i}}{m_{initial,i}}$$

Where:

$f_{i,j}$ = Gas heel *i* remaining in a container of type *j*;

$w_{r,i}$ = Residual weight of gas *i*, calculated in accordance with paragraph 2, in grams;

$m_{initial,i}$ = Initial mass of gas *i*, determined by measuring or based on the weight of the gas indicated by the supplier, in grams;

(2) by measuring the residual weight or pressure of a container when replacing it and, when the pressure is measured, by determining the residual weight using equation 28-9:

Equation 28-9

$$w_{r,i} = \frac{M_i \times p_i \times V_i}{Z_i \times R \times T_i}$$

Where:

$w_{r,i}$ = Residual weight of gas *i*, in grams;

M_i = Molar weight of gas *i*, in grams per mole;

p_i = Absolute pressure of gas *i*, in pascals;

V_i = Volume of gas *i*, in cubic metres;

Z_i = Compressibility factor of gas *i*;

R = Perfect gas constant of 8.314 joules per kelvin-mole;

T_i = Absolute temperature of gas *i*, in kelvins;

(3) if a container is replaced when the residual weight or pressure of the gas is over 20% higher than the weight or pressure used to calculate the gas heel remaining in the container, by weighing the container or by measuring the pressure using a pressure gauge and using either value to replace the gas heel calculated previously;

(4) by recalculating the gas heel remaining in the container calculated previously when the residual weight or pressure of gas determined when the container is replaced differs by more than 1% from the initial value used to calculate the gas heel remaining in the container.

QC.28.4.2. Apportionment of the consumption of fluorinated gases by process category

The emitter must apportion the consumption of fluorinated gases by process category, as defined in the tables in QC.28.6, or by individual process, using an engineering model based on the number of wafer passes.

QC.28.4.3. Determination of the utilization rates for fluorinated gases and N_2O and the formation rates for by-product gases

The utilization rates for fluorinated gases and N_2O and the formation rates for by-product gases determined by the emitter or by the equipment manufacturer must comply with the "International SEMATECH Manufacturing Initiative's Guideline for Environmental Characterization of Semiconductor Process Equipment – Revision 2".

QC.28.4.4. Calculation of N_2O emissions reductions attributable to the use of an antipollution system

An emitter who calculates reductions in fluorinated gases and N_2O emissions attributable to the use of an antipollution system must

(1) ensure that the antipollution system is designed to reduce fluorinated gas and N_2O emissions and is installed, operated and maintained according to the manufacturer's instructions, and keep the certification;

(2) determine the time of use of the antipollution system when using an destruction factor to calculate the reduction in fluorinated gas and N_2O emissions, and calculate the use factor by adding together the system's operational productive, standby, and stoppage times and dividing the result by the total operations time of its associated manufacturing equipment, in accordance with SEMI E-10-0304E "Specification for Definition and Measurement of Equipment Reliability, Availability, and Maintainability" published by the Semiconductor Equipment and Materials International (SEMI);

(3) use a default destruction factor of 60%, or determine the destruction factor using the following methods:

(a) in accordance with EPA 430-R-10-003 "Protocol for Measuring Destruction or Removal Efficiency of Fluorinated Greenhouse Gas Abatement Equipment in Electronics Manufacturing" published by the U.S. Environmental Protection Agency (USEPA);

(b) by selecting annually a random sample of antipollution systems and measuring their destruction factor using the following methods:

i. the random sample must come from 3 antipollution systems or 20% of the total number of installed antipollution systems, whichever is greater, for each category of antipollution system. When the percentage does not equate to a whole number, it must be rounded up to the nearest whole number;

ii. all the antipollution systems in each category must be subject to a random sampling at least once every 5 years;

(c) for each antipollution system whose destruction factor has been measured during the previous 2 years, by calculating the reduction in emissions using that factor;

d) for each antipollution system whose destruction factor has not been measured during the previous 2 years, by using the average destruction factor of the systems in the same category;

(e) when an emergency antipollution system is utilized, the utilization time may be included in the total utilization time for the antipollution systems, calculated annually.

QC.28.4.5. Instrument calibration and accuracy

The emitter must calibrate all the instruments used to determine the concentration of fluorinated gases and N_2O in process streams immediately before measuring the destruction factor, gas utilization factor for the process, or by-product gas formation factor. The calibration must be based on representative samples with known concentrations, for which the fractions by mass of the same gases are similar to those of the process samples. The emitter may also use high-concentration fluorinated gases or N_2O certified representative samples using a gas dilution system that meets the requirements specified in Method 205, 40 CFR part 51, Appendix M of the Code of Federal Regulations "Verification of Gas Dilution Systems for Field Instrument Calibrations".

When the emitter uses flow meters, weigh scales, pressure gauges or thermometers, their minimum accuracy must be 1% of full scale.

QC.28.5. Methods for estimating missing data

When one or more values used to calculate the fluorinated gas emissions attributable to heat transfer fluids using equation 28-5 are missing, the emitter must estimate greenhouse gas emissions using the arithmetic average of the emissions rates for the previous year and for 2 months following the missing data period. When those emission rates cannot be obtained, the emitter must estimate the greenhouse gas emissions using data from the suppliers of the heat transfer fluids.

QC.28.6. Tables

Table 28-1. Default greenhouse gas emission factors for fluorinated compounds for process categories for semiconductor manufacturing for 150 mm wafer size

(QC.28.3.1, QC.28.4.2)

Refined process category	**Gas *i***										
	CF_4	C_2F_6	CHF_3	CH_2F_2	C_3F_8	c-C_4F_8	NF_3	SF_6	C_4F_6	C_5F_8	C_4F_8O
PATTERNING/ETCHING											
Oxide etch											
$1-U_i$	0.2-0.8	0.2-0.7	0.2-0.7	0.02-0.3	N/A	0.1-0.3	0.1-0.4	0.1-0.4	0.05-0.2	0.05-0.3	N/A
PCF_4	N/A	0.05-0.5	0.01-0.8	0.05-0.1	N/A	0.01-0.3	N/A	N/A	0.02-0.4	0.02-0.4	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	0.01-0.3	N/A	N/A	0.02-0.3	0.02-0.3	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitride etch											
$1-U_i$	0.2-0.8	0.2-0.7	0.2-0.7	0.02-0.3	N/A	0.1-0.3	0.1-0.4	0.1-0.4	0.05-0.2	0.05-0.3	N/A
PCF_4	N/A	0.05-0.5	0.01-0.8	0.05-0.1	N/A	0.01-0.3	N/A	N/A	0.02-0.4	0.02-0.4	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	0.01-0.3	N/A	N/A	0.02-0.3	0.02-0.3	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Silicon etch											
$1-U_i$	0.2-0.8	0.2-0.7	0.2-0.7	0.02-0.3	N/A	0.1-0.3	0.1-0.4	0.1-0.4	0.05-0.2	0.05-0.3	N/A
PCF_4	N/A	0.05-0.5	0.01-0.8	0.05-0.1	N/A	0.01-0.3	N/A	N/A	0.02-0.4	0.02-0.4	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	0.01-0.3	N/A	N/A	0.02-0.3	0.02-0.3	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Metal etch											
1-U_i	0.2-0.8	0.2-0.7	0.2-0.7	0.02-0.3	N/A	0.1-0.3	0.1-0.4	0.1-0.4	0.05-0.2	0.05-0.3	N/A
PCF_4	N/A	0.05-0.5	0.01-0.8	0.05-0.1	N/A	0.01-0.3	N/A	N/A	0.02-0.4	0.02-0.4	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	0.01-0.3	N/A	N/A	0.02-0.3	0.02-0.3	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CHAMBER CLEANING											
In situ plasma cleaning											
1-U_i	0.8-0.95	0.4-0.8	N/A	N/A	0.2-0.6	0.05-0.3	0.05-0.3	N/A	N/A	0.05-0.2	0.05-0.2
PCF_4	N/A	0.05-0.2	N/A	N/A	0.05-0.2	0.05-0.2	0.05-0.2	N/A	N/A	0.05-0.2	0.05-0.2
PC_2F_6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.02-0.08
Remote plasma cleaning											
1-U_i	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PCF_4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
In situ thermal cleaning											
1-U_i	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PCF_4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WAFER CLEANING											
Bevel cleaning											
1-U_i	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PCF_4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ashing											
1-U_i	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PCF_4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 28-2. Default greenhouse gas emission factors for fluorinated compounds for process categories for semiconductor manufacturing for 200 mm wafer size

(QC.28.3.1, QC.28.4.2)

Refined process category	**Gas *i***										
	CF_4	C_2F_6	CHF_3	CH_2F_2	C_3F_8	c-C_4F_8	NF_3	SF_6	C_4F_6	C_5F_8	C_4F_8O
PATERNING/ETCHING											
Oxide etch											
1-U_i	0.2-0.8	0.2-0.7	0.2-0.7	0.02-0.3	N/A	0.1-0.3	0.1-0.4	0.1-0.4	0.05-0.5	0.05-0.3	N/A
PCF_4	N/A	0.05-0.5	0.01-0.8	0.05-0.1	N/A	0.01-0.3	N/A	N/A	0.02-0.4	0.02-0.4	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	0.01-0.3	N/A	N/A	0.02-0.3	0.02-0.3	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitride etch											
1-U_i	0.2-0.8	0.2-0.7	0.1-0.7	0.02-0.3	N/A	0.05-0.3	0.1-0.4	0.1-0.4	0.05-0.2	0.05-0.3	N/A
PCF_4	N/A	0.05-0.5	0.01-0.8	0.05-0.1	N/A	0.02-0.3	N/A	N/A	0.02-0.4	0.02-0.4	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	0.005-0.3	N/A	N/A	0.02-0.3	0.02-0.3	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Silicon etch											
1-U_i	0.2-0.8	0.2-0.7	0.2-0.7	0.02-0.3	N/A	0.1-0.3	0.1-0.4	0.1-0.4	0.05-0.2	0.05-0.3	N/A
PCF_4	N/A	0.05-0.5	0.01-0.8	0.05-0.1	N/A	0.01-0.3	N/A	N/A	0.02-0.4	0.02-0.4	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	0.01-0.3	N/A	N/A	0.02-0.3	0.02-0.3	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Metal etch											
1-U_i	0.2-0.8	0.2-0.7	0.2-0.7	0.02-0.3	N/A	0.1-0.3	0.1-0.4	0.1-0.4	0.05-0.2	0.05-0.3	N/A
PCF_4	N/A	0.05-0.5	0.01-0.8	0.05-0.1	N/A	0.01-0.3	N/A	N/A	0.02-0.4	0.02-0.4	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	0.01-0.3	N/A	N/A	0.02-0.3	0.02-0.3	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CHAMBER CLEANING											
In situ plasma cleaning											
1-U_i	0.8-0.95	0.4-0.8	N/A	N/A	0.2-0.6	005-0.3	0.05-0.2	N/A	N/A	0.05-0.2	0.05-0.2
PCF_4	N/A	0.05-0.2	N/A	N/A	0.05-0.2	0.05-0.2	0.05-0.1	N/A	N/A	0.05-0.2	0.05-0.2
PC_2F_6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.02-0.08

Remote plasma cleaning											
$1-U_i$	N/A	N/A	N/A	N/A	N/A	N/A	0.005-0.03	N/A	N/A	N/A	N/A
PCF_4	N/A	N/A	N/A	N/A	N/A	N/A	0.0001-0.2	N/A	N/A	N/A	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
In situ thermal cleaning											
$1-U_i$	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PCF_4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WAFER CLEANING											
Bevel cleaning											
$1-U_i$	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PCF_4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ashing											
$1-U_i$	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PCF_4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 28-3. Default emission factors for process categories for semiconductor manufacturing for semiconductor manufacturing for 300 mm wafer size

(QC.28.3.1, QC.28.4.2)

Refined process category	**Gas *i***										
	CF_4	C_2F_6	CHF_3	CH_2F_2	C_3F_8	$c\text{-}C_4F_8$	NF_3	SF_6	C_4F_6	C_5F_8	C_4F_8O
PATERNING/ETCHING											
Oxide etch											
$1-U_i$	0.2-0.8	0.2-0.7	0.2-0.4	0.1-0.8	N/A	0.05-0.3	0.1-0.4	0.1-0.4	0.05-0.3	0.05-0.3	N/A
PCF_4	N/A	0.05-0.5	0.005-0.03	0.001-0.01	N/A	0.005-0.1	N/A	N/A	0.02-0.4	0.02-0.4	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	0.005-0.1	N/A	N/A	0.02-0.3	0.02-0.3	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Nitride etch											
$1-U_i$	0.2-0.8	0.2-0.7	0.2-0.4	0.1-0.8	N/A	0.08-0.3	0.1-0.4	0.1-0.4	0.05-0.2	0.05-0.3	N/A
PCF_4	N/A	0.05-0.5	0.003-0.1	0.01-0.1	N/A	0.02-0.3	N/A	N/A	0.05-0.4	0.05-0.4	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	0.02-0.3	N/A	N/A	0.05-0.4	0.05-0.4	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Silicon etch											
$1-U_i$	0.2-0.8	0.2-0.7	0.2-0.7	0.02-0.3	N/A	0.1-0.3	0.1-0.4	0.1-0.4	0.05-0.2	0.05-0.3	N/A
PCF_4	N/A	0.05-0.5	0.01-0.8	0.05-0.1	N/A	0.01-0.3	N/A	N/A	0.02-0.4	0.02-0.4	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	0.01-0.3	N/A	N/A	0.02-0.3	0.02-0.3	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Metal etch											
$1-U_i$	0.2-0.8	0.2-0.7	0.2-0.7	0.02-0.3	N/A	0.1-0.3	0.1-0.4	0.1-0.4	0.05-0.2	0.05-0.3	N/A
PCF_4	N/A	0.05-0.5	0.01-0.8	0.05-0.1	N/A	0.01-0.3	N/A	N/A	0.02-0.4	0.02-0.4	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	0.01-0.3	N/A	N/A	0.02-0.3	0.02-0.3	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CHAMBER CLEANING											
In situ plasma cleaning											
$1-U_i$	N/A	N/A	N/A	N/A	N/A	N/A	0.1-0.4	N/A	N/A	N/A	N/A
PCF_4	N/A	N/A	N/A	N/A	N/A	N/A	0.001-0.6	N/A	N/A	N/A	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Remote plasma cleaning											
$1-U_i$	N/A	N/A	N/A	N/A	N/A	N/A	0.002-0.03	N/A	N/A	N/A	N/A
PCF_4	N/A	N/A	N/A	N/A	N/A	N/A	0.001-0.05	N/A	N/A	N/A	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
In situ thermal cleaning											
$1-U_i$	N/A	N/A	N/A	N/A	N/A	N/A	0.1-0.4	N/A	N/A	N/A	N/A
PCF_4	N/A	N/A	N/A	N/A	N/A	N/A	0.005-0.05	N/A	N/A	N/A	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WAFER CLEANING											
Bevel cleaning											
$1-U_i$	0.3-0.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PCF_4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Ashing										
1-U_i	0.3-0.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PCF_4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_2F_6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 28-4. Default emission factors for micro-electrical-mechanical systems manufacturing

(QC.28.3.1, QC.28.4.2)

Process type factors	**Gas *i***										
	CF_4	C_2F_6	CHF_3	CH_2F_2	C_3F_8	c-C_4F_8	NF_3 remote	NF_3	SF_6	C_4F_6[a]	C_5F_8[a]	C_4F_8O[a]
Etch 1-U_i	0.7	0.4[1]	0.4[1]	0.06[1]	N/A	0.2[1]	N/A	0.2	0.2	0.1	0.2	N/A
Etch PCF_4	N/A	0.4[1]	0.07[1]	0.08[1]	N/A	0.2	N/A	N/A	N/A	0.3[1]	0.2	N/A
Etch PC_2F_6	N/A	N/A	N/A	N/A	N/A	0.2	N/A	N/A	N/A	0.2[1]	0.2	N/A
CVD 1-U_i	0.9	0.6	N/A	N/A	0.4	0.1	0.02	0.2	N/A	N/A	0.1	0.1
CVD PCF_4	N/A	0.1	N/A	N/A	0.1	0.1	0.02[2]	0.1[2]	N/A	N/A	0.1	0.1
CVD PC_3F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.4

[1] Estimate includes multi-gas etch processes.

[2] Estimate reflects presence of low-k, carbide and multi-gas etch processes that may contain a fluorinated GHG greenhouse gas additive.

Table 28-5. Default emission factors for LCD screen manufacturing

(QC.28.3.1, QC.28.4.2)

Process type factors	**Gas *i***								
	CF_4	C_2F_6	CHF_3	CH_2F_2	C_3F_8	c-C_4F_8	NF_3 remote	NF_3	SF_6
Etch 1-U_i	0.6	N/A	0.2	N/A	N/A	0.1	N/A	N/A	0.3
Etch PCF_4	N/A	N/A	0.07	N/A	N/A	0.009	N/A	N/A	N/A
Etch $PCHF_3$	N/A	N/A	N/A	N/A	N/A	0.02	N/A	N/A	N/A
Etch PC_2F_6	N/A	N/A	0.05	N/A	N/A	N/A	N/A	N/A	N/A
CVD 1-U_i	N/A	N/A	N/A	N/A	N/A	N/A	0.03	0.3	0.9

Table 28-6. Default emission factors for photovoltaic cell manufacturing

(QC.28.3.1, QC.28.4.2)

Process type factors	**Process gas *i***								
	CF_4	C_2F_6	CHF_3	CH_2F_2	C_3F_8	c-C_4F_8	NF_3 remote	NF_3	SF_6
Etch 1-U_i	0.7	0.4	0.4	N/A	N/A	0.2	N/A	N/A	0.4
Etch PCF_4	N/A	0.2	N/A	N/A	N/A	0.1	N/A	N/A	N/A
Etch PC_2F_6	N/A	N/A	N/A	N/A	N/A	0.1	N/A	N/A	N/A
CVD 1-U_i	N/A	0.6	N/A	N/A	0.1	0.1	N/A	0.3	0.4
CVD PCF_4	N/A	0.2	N/A	N/A	0.2	0.1	N/A	N/A	N/A

QC.29. NATURAL GAS TRANSMISSION AND DISTRIBUTION

QC.29.1. Covered sources

The covered sources are the processes and equipment used for the transmission and distribution of natural gas:

(1) onshore natural gas transmission compression, which includes any stationary combination of compressors that move natural gas at elevated pressure from production fields or natural gas processing facilities in transmission pipelines to natural gas distribution pipelines or into storage, and any equipment required for liquids separation, natural gas dehydration, and tanks for the storage of water and hydrocarbon liquids;

(2) underground natural gas storage, which includes depleted gas or oil reservoirs and salt dome caverns that store natural gas that has been transferred from its original location for the primary purpose of load balancing, natural gas underground storage processes and operations, including compression, dehydration and flow measurement, and all the wellheads connected to the compression units that inject and recover natural gas into and from the underground reservoirs;

(3) liquefied natural gas (LNG) storage, which includes LNG storage vessels located above ground, equipment for liquefying natural gas, compressors to capture and re-liquefy boil-off-gas, and vaporization units for re-gasification of the liquefied natural gas;

(4) LNG import and export equipment, which includes, in the case of LNG import equipment, all onshore or offshore equipment that receives imported LNG via ocean transport, stores LNG, re-gasifies LNG, and delivers re-gasified natural gas to a natural gas transmission or distribution system and, in the case of LNG export equipment, all onshore or offshore equipment that receives natural gas, liquefies natural gas, stores LNG, and transfers the LNG via ocean transportation to its destination;

(5) natural gas transmission pipelines, which include high pressure pipelines and associated equipment transporting sellable quality natural gas from production or natural gas processing to natural gas distribution stations before delivery to customers;

(6) natural gas distribution, which includes all natural gas equipment downstream of the station yard inlet shut-off valves of natural gas transmission pipelines at stations where pressure reduction and/or measuring first occurs for eventual delivery of natural gas to consumers.

QC.29.2. Greenhouse gas reporting requirements

The greenhouse gas emissions report referred to in section 6.2 must include the following information:

(1) the annual CO_2, CH_4 and N_2O emissions, in metric tons;

(2) the annual CO_2, CH_4 and N_2O emissions attributable to the use of stationary combustion equipment, calculated in accordance with QC.1, in metric tons;

(3) the annual CO_2 and CH_4 emissions attributable to the compression of natural gas for onshore pipeline transmission, in metric tons, specifying:

(a) compressor venting, including:

i. emissions from natural gas pneumatic high bleed devices and pumps, calculated in accordance with QC.29.3.1;

ii. emissions from natural gas low bleed and intermittent bleed devices, calculated in accordance with QC.29.3.2;

iii. emissions from blowdown vent stacks, calculated in accordance with QC.29.3.3;

iv. emissions from centrifugal compressors, calculated in accordance with QC.29.3.5;

v. emissions from reciprocating compressors, calculated in accordance with QC.29.3.6;

vi. emissions from other fugitive emissions or venting emissions sources, calculated in accordance with QC.29.3.9;

(b) annual fugitive CO_2 and CH_4 emissions from compressor equipment, such as valves, connectors, open ended lines, pressure relief valves and meters, calculated in accordance with QC.29.3.7;

(c) annual CO_2, CH_4 and N_2O emissions from compressor station flaring, calculated in accordance with QC.29.3.4;

(d) other annual fugitive CO_2 and CH_4 emissions from compressor stations, calculated in accordance with QC.29.3.9;

(e) annual fugitive CO_2 and CH_4 emissions from pipeline above ground meters and regulators at custody transfer gate stations, and fugitive equipment leaks from connectors, block valves, control valves, pressure relief valves, orifice meters, regulators, and open ended lines, calculated in accordance with QC.29.3.7;

(f) annual fugitive CO_2 and CH_4 emissions from above ground meters and regulators at non-custody transfer gate stations, including station equipment leaks, calculated in accordance with QC.29.3.8, but excluding fugitive emissions from customer meters;

(g) annual CO_2, CH_4 and N_2O emissions from pipeline flaring, calculated in accordance with QC.29.3.4;

(h) annual fugitive CO_2 and CH_4 emissions from below ground meters and regulators, calculated in accordance with QC.29.3.8;

(i) other annual fugitive CO_2 and CH_4 emissions from the pipeline system not covered in subparagraphs *e* to *h*, including third party hits, farm taps, tubing systems less than 2.54 cm diameter and customer meter sets, calculated in accordance with QC.29.3.9;

(j) annual CO_2 and CH_4 emissions other than pipeline venting emissions, calculated in accordance with QC.29.3.9;

(k) annual CO_2 and CH_4 emissions from natural gas transmission storage tanks, calculated in accordance with QC.29.3.9;

(4) the annual CO_2 and CH_4 emissions from underground natural gas storage, in metric tons, specifying:

(a) annual emissions from venting, including:

i. emissions from natural gas pneumatic continuous high bleed devices and pumps, calculated in accordance with QC.29.3.1;

ii. emissions from pneumatic low bleed and intermittent bleed devices, calculated in accordance with QC.29.3.2;

iii. emissions from centrifugal compressors, calculated in accordance with QC.29.3.5;

iv. emissions from reciprocating compressors, calculated in accordance with QC.29.3.6;

v. fugitive emissions from other sources, calculated in accordance with QC.29.3.9;

(b) annual fugitive CO_2 and CH_4 emissions from equipment components such as valves, connectors, open ended lines, pressure relief valves and meters, calculated in accordance with QC.29.3.7 or QC.29.3.8;

(c) annual CO_2, CH_4 and N_2O emissions from flares, calculated in accordance with QC.29.3.4;

(d) fugitive emissions from other sources, calculated in accordance with QC.29.3.9;

(5) annual CO_2 and CH_4 emissions from LNG storage, in metric tons, specifying:

(a) venting emissions, including:

i. emissions from centrifugal compressors, calculated in accordance with QC.29.3.5;

ii. emissions from reciprocating compressors, calculated in accordance with QC.29.3.6;

iii. emissions from other venting sources, calculated in accordance with QC.29.3.9;

(b) annual fugitive CO_2 and CH_4 emissions from equipment components, such as valves, pump seals, connectors and vapour recovery compressors, calculated in accordance with QC.29.3.7 or QC.29.3.8;

(c) annual CO_2, CH_4 and N_2O emissions from flares, calculated in accordance with QC.29.3.4;

(d) fugitive emissions from other emissions sources, calculated in accordance with QC.29.3.9;

(6) annual CO_2, CH_4 and N_2O emissions from LNG import and export equipment, in metric tons, specifying:

(a) venting emissions, including:

i. emissions from blowdown vent stacks, calculated in accordance with QC.29.3.3;

ii. emissions from centrifugal compressors, calculated in accordance with QC.29.3.5;

iii. emissions from reciprocating compressors, calculated in accordance with QC.29.3.6;

iv. emissions from other venting sources, calculated in accordance with QC.29.3.9;

(b) annual fugitive CO_2 and CH_4 emissions from equipment components, such as valves, pump seals, connectors and vapour recovery compressors, calculated in accordance with QC.29.3.7 or QC.29.3.8;

(c) annual CO_2, CH_4 and N_2O emissions from flares, calculated in accordance with QC.29.3.4;

(d) fugitive emissions from other emissions sources, calculated in accordance with QC.29.3.9;

(7) annual CO_2, CH_4 and N_2O emissions attributable to natural gas distribution, in metric tons, specifying:

(a) annual CO_2 and CH_4 fugitive emissions from above ground meters and regulators at custody transfer gate stations, including leaks from station equipment such as connectors, block valves, control valves, pressure relief valves, orifice meters, regulators and open ended lines, calculated in accordance with QC.29.3.7, but excluding fugitive emissions from customer meters;

(b) annual CO_2 and CH_4 fugitive emissions from above ground meters and regulators at non-custody transfer gate stations, including station equipment leaks, calculated in accordance with QC.29.3.8, but excluding fugitive emissions from customer meters;

(c) annual fugitive CO_2 and CH_4 emissions from below ground meters and regulators and other underground station equipment, calculated in accordance with QC.29.3.8;

(d) annual fugitive CO_2 and CH_4 emissions from transmission system equipment, calculated in accordance with QC.29.3.8;

(e) annual fugitive CO_2 and CH_4 emissions from distribution system equipment, calculated in accordance with QC.29.3.8;

(f) annual CO_2, CH_4 and N_2O emissions from transmission and distribution system flares, calculated in accordance with QC.29.3.4;

(g) emissions from other venting sources, calculated in accordance with QC.29.3.9;

(h) other annual CO_2 and CH_4 fugitive missions from pipelines, including emissions attributable to third party hits, farm taps, tubing systems less than 2.54 cm diameter, and customer meter sets, calculated in accordance with QC.29.3.9;

(8) annual CO_2, CH_4 and N_2O emissions attributable to the use of portable combustion equipment, calculated using the methods for stationary combustion equipment in QC.1, in metric tons;

(9) the following data for each emissions source in subparagraphs 3 to 7:

(a) the number of natural gas pneumatic devices used by type, namely high bleed, low bleed and intermittent bleed;

(b) the number of natural gas driven pneumatic pumps;

(c) total pipeline length;

(d) if glycol dehydrators are used, the number of dehydrators, specifying

i. the number of dehydrators with a capacity of less than 11,328 m^3 per day at standard conditions;

ii. the number of dehydrators with a capacity greater than 11,328 m^3 per day at standard conditions;

(e) if dehydrators other than glycol hydrators are used, the number of dehydrators used;

(f) for each compressor used:

i. compressor type;

ii. compressor capacity in horsepower;

iii. number of blowdowns per year;

iv. operating mode during the year, as determined in QC.29.4.6;

(g) when the calculation methods in QC.29.3.7 and QC.29.3.8 are used:

i. the component count for each source for which an emission factor is provided in Tables 29-1 to 29-5 in QC.29.6;

ii. the total number of leaks found in annual leak detection surveys by type of leak for which an emission factor is provided;

(h) for natural gas distribution :

i. the number of custody transfer gate stations;

ii. the number of non-custody transfer gate stations;

(10) the number of times that the methods for estimating missing data provided for in QC.29.5 were used;

(11) total emissions of greenhouse gas for each type of emissions, namely,

(a) annual greenhouse gas emissions attributable to combustion corresponding to the emissions referred to in paragraphs 2 and 8, in metric tons CO_2 equivalent;

(b) annual greenhouse gas emissions of the "other" category corresponding to the total of the emissions referred to in paragraphs 3 to 7, in metric tons CO_2equivalent.

Emissions attributable to venting or other sources of fugitive emissions referred to in subparagraph *vi* of subparagraph *a* and subparagraphs *d*, *i*, *j* and *k* of subparagraph 3, subparagraph *v* of subparagraph *a* and subparagraph *d* of subparagraph 4, subparagraph *iii* of subparagraph *a* and subparagraph *d* of subparagraph 5, subparagraph *iv* of subparagraph *a* and subparagraph *d* of subparagraph 6 and subparagraphs *g* and *h* of subparagraph 7 of the first paragraph are not required to be reported if the emissions from that source are below 0.5% of the emitter's total emissions and total emissions not reported under this paragraph do not exceed 1% of the emitter's total emissions.

QC.29.3. Calculation methods for CO_2, CH_4 and N_2O emissions

The annual CO_2, CH_4 and N_2O emissions attributable to natural gas transmission and distribution must be calculated in accordance with one of the calculation methods in QC.29.3.1 to QC.29.3.9.

When no calculation method for an emissions source, the emitter must use industry inventory practices. In addition, when a calculation method provides for the use of temperature and pressure as parameters, the emitter must use average atmospheric conditions or typical operating conditions for the equipment.

QC.29.3.1. Calculation of CO_2 and CH_4 emissions attributable to high bleed pneumatic device venting and natural gas driven pneumatic pump venting

The annual CO_2 and CH_4 emissions attributable to high bleed pneumatic device venting and natural gas driven pneumatic pump venting must be calculated in accordance with equations 29-1 to 29-4:

Equation 29-1

$$GHG_i = GHG_{dv,i} + GHG_{pv,i}$$

Where:

GHG_i = Emissions of greenhouse gas *i* attributable to high bleed pneumatic device venting and pneumatic pump venting, in metric tons;

$GHG_{dv,i}$ = Emissions of greenhouse gas *i* attributable to high bleed pneumatic device venting, calculated using equation 29-2 or 29-3, in metric tons;

$GHG_{pv,i}$ = Emissions of greenhouse gas *i* attributable to pneumatic pump venting, calculated using equation 29-4, in metric tons;

i = CO_2 or CH_4;

Equation 29-2

$$GHG_{dv,i} = V_{NG} \times MF_i \times \frac{MW_i}{MVC} \times 0.001$$

Where:

$GHG_{dv,i}$ = Emissions of greenhouse gas *i* attributable to high bleed pneumatic device venting, in metric tons;

V_{NG} = Annual volume of natural gas consumed by high bleed pneumatic devices, determined in accordance with paragraph 1 of QC.29.4.1, in cubic metres at standard conditions;

MF_i = Mole fraction of gas *i* in natural gas, determined in accordance with paragraph 3 of QC.29.4;

MW_i = Molecular weight of gas *i*, in kilograms per kilomole;

MVC = Molar volume conversion factor of 24.06 m^3 per kilomole at standard conditions;

0.001 = Conversion factor, kilograms to metric tons;

i = CO_2 or CH_4;

Equation 29-3

$$GHG_{ev,i} = \sum_{j=1}^{n} \left[F_j \times t_j \right] \times MF_i \times \rho_i \times 0.001$$

Where:

$GHG_{ev,i}$ = Emissions of greenhouse gas *i* attributable to high bleed pneumatic device venting, in metric tons;

n = Total number of high bleed pneumatic devices;

j = High bleed pneumatic device;

F_j = Natural gas flow for pneumatic device *j*, determined in accordance with paragraph 2 of QC.29.4.1, in cubic metres per minute at standard conditions;

t_j = Annual operating time for pneumatic device *j*, in minutes;

MF_i = Mole fraction of greenhouse gas *i* in natural gas, determined in accordance with paragraph 3 of QC.29.4;

ρ_i = Density of greenhouse gas *i* that is 1.893 kg per cubic metre for CO_2 and 0.690 kg per cubic metre for CH_4 at standard conditions;

0.001 = Conversion factor, kilograms to metric tons;

i = CO_2 or CH_4;

Equation 29-4

$$GHG_{PV,i} = \sum_{k=1}^{m} \left[Q_{NG,k} \times V_k \right] \times MF_i \times \rho_i \times 0.001$$

Where:

$GHG_{PV,i}$ = Emissions of greenhouse gas *i* attributable to pneumatic pump venting, in metric tons;

m = Total number of pneumatic pumps;

k = Pneumatic pump;

$Q_{NG,k}$ = Quantity of natural gas consumed by pneumatic pump *k*, determined in accordance with paragraph 3 of QC.29.4.1, in cubic metres per litre of liquid pumped at standard conditions;

V_k = Annual volume of liquid pumped, in litres;

MF_i = Mole fraction of greenhouse gas *i* in natural gas, determined in accordance with paragraph 3 of QC.29.4;

ρ_i = Density of greenhouse gas *i* that is 1.893 kg per cubic metre for CO_2 and 0.690 kg per cubic metre for CH_4 at standard conditions;

0.001 = Conversion factor, kilograms to metric tons;

i = CO_2 or CH_4.

QC.29.3.2. Calculation of CO_2 and CH_4 emissions attributable to low bleed or intermittent bleed natural gas pneumatic device venting

The annual CO_2 and CH_4 emissions attributable to low bleed or intermittent bleed natural gas pneumatic device venting must be calculated separately using equation 29-5:

Equation 29-5

$$GHG_i = \sum_j \left[N_j \times EF_j \times t_j \right] \times \rho_i \times 0.001$$

Where:

GHG_i = Annual emissions of greenhouse gas *i* attributable to low bleed or intermittent bleed natural gas pneumatic device venting, in metric tons;

j = Type of low bleed or intermittent bleed natural gas pneumatic device;

N_j = Number of pneumatic devices *j* determined in accordance with QC.29.4.2;

EF_j = Emission factor for pneumatic device *j* as specified in Tables 29-1 and 29-2 in QC.29.6, in cubic metres per hour;

t_j = Annual operating time for pneumatic device *j*, in hours;

ρ_i = Density of greenhouse gas *i*, of 1.893 kg per cubic metre for CO_2 and 0.690 kg per cubic metre for CH_4 at standard conditions;

0.001 = Conversion factor, kilograms to metric tons;

i = CO_2 or CH_4.

QC.29.3.3. Calculation of CO_2 and CH_4 emissions attributable to natural gas emissions to the atmosphere from equipment blowdown vent stacks

The CO_2 and CH_4 emissions attributable natural gas emissions to the atmosphere from equipment blowdown vent stacks, except equipment depressurizing to a flare, over-pressure relief and operaint pressure vent controls, must be calculated using equation 29-6:

Equation 29-6

$$GHG_i = \sum_{j=1}^{n} \left[N_j \times V_j \times \left(\frac{T_{SC} \times P_B}{T_B \times P_{SC}} \right) - \left(V_j \times PF_j \right) \right] \times MF_i \times \rho_i \times 0.001$$

Where:

GHG_i = Emissions of greenhouse gas *i* attributable to natural gas emissions to the atmosphere from equipment blowdown vent stacks, in metric tons;

n = Total number of types of equipment;

j = Type of equipment with the same gas volume in the blowdown equipment chambers between isolation valves;

N_j = Annual number of blowdowns for each equipment type *j*, determined in accordance with QC.29.4.3;

V_j = Total volume of gas in blowdown equipment chambers, between isolation valves, for equipment type *j*, determined in accordance with QC.29.4.3, in cubic metres;

T_{SC} = Temperature at standard conditions of 293.15 kelvin;

T_B = Temperature at blowdown conditions, in kelvin;

P_B = Pressure at blowdown conditions, in kilopascals;

P_{SC} = Pressure at standard conditions of 101.325 kilopascals;

PF_j = Purge factor that is 1 if the equipment of type *j* is not purged or 0 if the equipment of type *j* is purged using a gas other than a greenhouse gas;

MF_i = Mole fraction of greenhouse gas *i* in natural gas, determined in accordance with paragraph 3 of QC.29.4;

ρ_i = Density of greenhouse gas *i*, of 1.893 kg per cubic metre for CO_2 and 0.690 kg per cubic metre for CH_4 at standard conditions;

0.001 = Conversion factor, kilograms to metric tons;

i = CO_2 or CH_4.

QC.29.3.4. Calculation of CO_2, CH_4 and N_2O emissions attributable to flares

Annual CO_2, CH_4 and N_2O emissions attributable to flares must be calculated in accordance with the following methods:

(1) annual CO_2 emissions attributable to flares must be calculated using equation 29-7:

Equation 29-7

$$CO_2 = \left[\left(V_G \times MF_{CO2} \right) + \left(\sum_{k=1}^{m} \left(MF_k \times CA_k \right) \times V_G \times eff_t \right) \right] \times \left[\frac{T_{SC} \times P_t}{T_t \times P_{SC}} \right] \times \rho_{CO2} \times 0.001$$

Where:

CO_2 = Annual CO_2 emissions attributable to flares, in metric tons;

V_G = Annual volume of gas directed to flares, determined in accordance with QC.29.4.4, in cubic metres;

MF_{CO2} = Mole fraction of CO_2 in the gas directed to flares, determined in accordance with QC.29.4.4;

m = Total number of hydrocarbon gas constituents;

k = Hydrocarbon gas constituent;

MF_k = Mole fraction of hydrocarbon gas constituent *k*, determined in accordance with QC.29.4.4;

CA_k = Number of carbon atoms in hydrocarbon gas constituent *k*, that is 1 for methane, 2 for ethane, 3 for propane, 4 for butane and 5 for pentanes plus;

eff_t= Flare combustion efficiency from manufacturer or a default value of 0.98;

T_{SC} = Temperature at standard conditions of 293.15 kelvin;

T_t = Temperature during flaring, in kelvin;

P_t = Pressure during flaring, in kilopascals;

P_{SC} = Pressure at standard conditions of 101.325 kPa;

ρ_{CO2} = Density of CO_2, of 1.893 kg per cubic metre at standard conditions;

0.001 = Conversion factor, kilograms to metric tons;

(2) annual CH_4 emissions attributable to flares must be calculated using equation 29-8:

Equation 29-8

$$CH_4 = \left[V_G \times MF_{CH4} \times (1 - eff_t)\right] \times \left[\frac{T_{SC} \times P_t}{T_t \times P_{SC}}\right] \times \rho_{CH4} \times 0.001$$

Where:

CH_4 = Annual CH_4 emissions attributable to flares, in metric tons;

V_G = Annual volume of gas directed to flares, determined in accordance with QC.29.4.4, in cubic metres;

MF_{CH4} = Mole fraction of CH_4 in the gas directed to flares, determined in accordance with QC.29.4.4;

eff_t = Flare combustion efficiency from manufacturer or a default value of 0.98;

T_{SC} = Temperature at standard conditions of 293.15 kelvin;

T_t = Temperature during flaring, in kelvin;

P_t = Pressure during flaring, in kilopascals;

P_{SC} = Pressure at standard conditions of 101.325 kPa;

ρ_{CH4} = Density of CH_4 of 0.690 kg per cubic metre at standard conditions;

0.001 = Conversion factor, kilograms to metric tons;

(3) annual N_2O emissions attributable to flares must be calculated using equation 29-9:

Equation 29-9

$$N_2O = V_G \times HHV \times EF_{N2O} \times 0.001$$

Where:

N_2O = Annual N_2O emissions attributable to flares, in metric tons;

V_G = Annual volume of gas directed to flares, determined in accordance with QC.29.4.4, in cubic metres;

HHV = High heat value of gas as specified in Tables 1-1 and 1-2 in QC.1.7 or high heat value of 4.579×10^{-2} GJ per cubic metre for gas emissions from equipment venting or determined in accordance with QC.1.5.4, in gigajoules per cubic metre;

EF_{N2O} = Emission factor for N_2O of 9.52×10^{-5} kg per gigajoule;

0.001 = Conversion factor, kilograms to metric tons.

QC.29.3.5. Calculation of CO_2, CH_4 and N_2O emissions attributable to centrifugal compressor venting

The annual CO_2, CH_4 and N_2O emissions attributable to centrifugal compressor venting must be calculated in accordance with the following methods:

(1) for each centrifugal compressor, the emitter must determine, in accordance with AC.29.4.5, the volume of vapours from a wet seal oil degassing tank sent to an atmospheric vent and the volume of gas sent to a flare;

(2) the annual CO_2 and CH_4 emissions attributable to vapours sent to an atmospheric centrifugal compressor vent must be calculated using equation 29-10:

Equation 29-10

$$GHG_i = \sum_{j=1}^{n} \left[F_{G,i} \times t_j \times \left(1 - FG_j\right) \right] \times MF_i \times \left[\frac{T_{SC} \times P_{cc}}{T_{cc} \times P_{SC}} \right] \times \rho_i \times 0.001$$

Where:

GHG_i = Annual greenhouse gas *i* emissions attributable to atmospheric centrifugal compressor vents, in metric tons;

n = Total number of centrifugal compressors;

j = Centrifugal compressor;

$F_{G,i}$ = Gas flow from the atmospheric vent of centrifugal compressor *j* determined in accordance with QC.29.4.5, in cubic metres per hour;

t_j = Annual operating time of centrifugal compressor *j* equipped with a wet seal oil degassing tank, in hours;

FG_j = Quantity of the gas from the atmospheric vent of centrifugal compressor *j* that is recovered using a vapour recovery system or destined for another use, determined in accordance with QC.29.4.5, expressed in percentage;

MF_i = Mole fraction of greenhouse gas *i* in the gas from atmospheric vents, determined in accordance with paragraph 3 of QC.29.4;

T_{SC} = Temperature at standard conditions of 293.15 kelvin;

T_{cc} = Temperature at the atmospheric vent of the centrifugal compressor, in kelvin;

P_{cc} = Pression at the atmospheric vent of the centrifugal compressor, in kilopascals;

P_{SC} = Pressure at standard conditions of 101.325 kPa;

ρ_i = Density of greenhouse gas *i*, of 1.893 kg per cubic metre for CO_2 and 0.690 kg per cubic metre for CH_4 at standard conditions;

0.001 = Conversion factor, kilograms in metric tons;

i = CO_2 or CH_4.

(3) the annual CO_2, CH_4 and N_2O emissions attributable to gas sent to a flare must be calculated in accordance with the calculation methods in QC.29.3.4.

QC.29.3.6. Calculation of CO_2 and CH_4 emissions attributable to reciprocating compressor vents

The annual CO_2 and CH_4 emissions attributable to reciprocating compressor vents must be calculated using equation 29-11, except emissions attributable to gas sent to a common flare, which must be calculated in accordance with QC.29.3.4:

Equation 29-11

$$GHG_i = \sum_{j=1}^{n} \left[F_{G,i} \times t_j \times \left(1 - FG_j\right) \right] \times MF_i \times \left[\frac{T_{SC} \times P_{ca}}{T_{ca} \times P_{SC}} \right] \times \rho_i \times 0.001$$

Where:

GHG_i = Annual greenhouse gas *i* attributable to reciprocating compressor vents, in metric tons;

n = Total number of reciprocating compressors;

j = Reciprocating compressor;

$F_{G,i}$ = Gas flow from the vent of reciprocating compressor *j* determined in accordance with QC.29.4.6, in cubic metres per hour;

t_j = Annual operating time of reciprocating compressor *j* in the mode determined in QC.29.4.6, in hours;

FG_j = Quantity of gas from the vent of reciprocating compressor *j* that is recovered using a vapour recovery system, determined in accordance with paragraph 4 of QC.29.4.5, expressed in percentage;

MF_i = Mole fraction of greenhouse gas *i* in the gas from reciprocating compressor vents, determined in accordance with paragraph 3 of QC.29.4;

T_{SC} = Temperature at standard conditions of 293.15 kelvin;

T_{ca} = Temperature at the reciprocating compressor vent, in kelvin;

P_{ca} = Pressure at the reciprocating compressor vent, in kilopascals;

P_{SC} = Pressure at standard conditions of 101.325 kPa;

ρ_i = Density of greenhouse gas *i*, of 1.893 kg per cubic metre for CO_2 and 0.690 kg per cubic metre for CH_4 at standard conditions;

0.001 = Conversion factor, kilograms in metric tons;

i = CO_2 or CH_4.

QC.29.3.7. Calculation of the CO_2 and CH_4 emissions attributable to leaks identified following a leak detection survey

Except for emissions from emissions sources for which the total weight of CO_2 and CH_4 in the natural gas is below 10%, which do not have to be calculated, and emission leaks from pipelines with a diameter of 1.27 cm or less, which must be calculated in accordance with QC.29.3.9, the annual fugitive CO_2 and CH_4 emissions attributable to leaks identified following a leak detection survey must be calculated in accordance with the following methods:

(1) the leak detection survey must be carried out in accordance with paragraph 2 of QC.29.4 for each of the following sources:

(a) fugitive emissions from equipment components during:

i. underground natural gas storage;

ii. liquid natural gas storage;

iii. liquid natural gas imports and exports;

(b) fugitive emissions leaks from compressor components during the compression of natural gas for onshore pipeline transmission;

(c) fugitive emissions from above ground meters and regulators at custody transfer gate stations during

i. the compression of natural gas for onshore pipeline transmission;

ii. natural gas distribution;

(2) for each source where leaks have been detected, the fugitive emissions must be calculated using equation 29-12 or 29-13, depending on the unit of the leaker emission factor used:

Equation 29-12

$$GHG_i = \sum_{j=1}^{n} \left[N_j \times EF_j \times t_j \right] \times C_i \times \rho_i \times 0.001$$

Where:

GHG_i = Annual greenhouse gas ,*i*, for each source of fugitive emissions, in metric tons;

n = Total number of component types, for each source of fugitive emissions;

j = Component type;

N_j = Total number of components for each component type *j*;

EF_j = Emission factor for leaks from component type *j*, determined in accordance with QC.29.4.7, in cubic metres per hour;

t_j = Time during which component type *j* was leaking, determined in accordance with QC.29.4.7, in hours;

C_i = Concentration in natural gas of greenhouse gas *i*, of 0.011 for CO_2 and 1 for CH_4;

ρ_i = Density of greenhouse gas *i*, of 1.893 kg per cubic metre for CO_2 and 0.690 kg per cubic metre for CH_4 at standard conditions;

0.001 = Conversion factor, kilograms to metric tons;

i = CO_2 or CH_4;

Equation 29-13

$$GHG_i = \sum_{j=1}^{n} \left[N_j \times EF_j \times t_j \right] \times C_i$$

Where:

GHG_i = Annual greenhouse gas *i*, for each source of fugitive emissions, in metric tons;

n = Total number of component types, for each source of fugitive emissions;

j = Component type;

N_j = Total number of components for each component type *j*;

EF_j = Emission factor for leaks from component type *j*, determined in accordance with QC.29.4.7, in metric tons per hour;

t_j = Time during which component type *j* was leaking, determined in accordance with QC.29.4.7, in hours;

C_i = Concentration in natural gas of greenhouse gas *i*, determined in accordance with QC.29.4.7;

i = CO_2 or CH_4.

QC.29.3.8. Calculation of fugitive CO_2 and CH_4 emissions attributable to all components

Except for emissions from emissions sources for which the total weight of CO_2 and CH_4 in the natural gas is below 10% that do not have to be calculated and emission leaks from pipelines with a diameter of 1.27 cm or less, which must be calculated in accordance with QC.29.3.9, the annual fugitive CO_2 and CH_4 emissions attributable to all components must be calculated in accordance with the following methods:

(1) the annual fugitive emissions must be calculated for each of the following sources:

(a) fugitive emissions from equipment components during:

i. underground natural gas storage;

ii. liquid natural gas storage;

iii. imports and exports of liquid natural gas;

(b) fugitive emissions from above ground meters and regulators at non-custody transfer gate stations during:

i. the compression of natural gas for onshore pipeline transmission;

ii. natural gas distribution;

(*c*) fugitive emissions from below ground meters and regulators during:

i. the compression of natural gas for onshore pipeline transmission;

ii. natural gas distribution;

(*d*) fugitive emissions from transmission system and distribution system equipment.

(2) the annual fugitive emissions must be calculated using equation 29-14 or 29-15, depending on the emission factor used:

Equation 29-14

$$GHG_i = \sum_{j=1}^{n} \left[N_j \times EF_j \times t_j \right] \times C_i \times \rho_i \times 0.001$$

Where:

GHG$_i$ = Annual greenhouse gas *i*, for each source of fugitive emissions, in metric tons;

n = Total number of component types, for each source of fugitive emissions;

j = Component type;

N$_j$ = Total number of components for each component type *j*, determined in accordance with QC.29.4.8;

EF_j = Emission factor for component type *j*, determined in accordance with QC.29.4.8, in cubic metres per hour;

t_j = Time during which component type *j*, associated with fugitive emissions, was operational, in hours;

C_i = Concentration in natural gas of greenhouse gas *i*, of 0.011 for CO_2 and 1 for CH_4;

ρ_i = Density of greenhouse gas *i*, of 1.893 kg per cubic metre for CO_2 and 0.690 kg per cubic metre for CH_4 at standard conditions;

0.001 = Conversion factor, kilograms to metric tons;

i = CO_2 or CH_4;

Equation 29-15

$$GHG_i = \sum_{j=1}^{n} \left[N_j \times EF_j \times t_j \right] \times C_i$$

Where:

GHG_i = Annual greenhouse gas *i*, for each source of fugitive emissions, in metric tons;

n = Total number of component types, for each source of fugitive emissions;

j = Component type;

N_j = Total number of components for each component type *j*;

EF_j = Emission factor component type *j*, determined in accordance with QC.29.4.8, in metric tons per hour;

t_j = Time during which component type *j*, associated with fugitive emissions, was operational, in hours;

C_i = Concentration in natural gas of greenhouse gas *i*, determined in accordance with QC.29.4.8;

i = CO_2 or CH_4.

QC.29.3.9. Calculation of other fugitive emissions sources

Emissions from fugitive emissions sources that are not calcuated using the methods in QC.29.3.1 to QC.29.3.8 must be calculated in accordance with the following methods:

(1) the methods in "Methodology Manual: Estimation of Air Emissions from the Canadian Natural Gas Transmission, Storage and Distribution System" published in September 2007 by Clearstone Engineering Ltd.;

(2) a sector-specific method published by the Canadian Gas Association.

QC.29.4. Sampling, analysis and measurement requirements

An emitter who operates a natural gas transmission and distribution enterprise must

(1) ensure that all instruments used for sampling, analysis and measurement are calibrated before the first emissions report and annually thereafter, and operate in accordance with the manufacturer's instructions or in accordance with the methods published by the following organizations:

(a) Canadian Standards Association;

(b) Canadian Gas Association;

(c) Canadian Association of Petroleum Producers;

(d) American National Standards Institute;

(e) American Society of Testing and Materials;

(f) American Petroleum Institute;

(g) American Society of Mechanical Engineers;

(h) North American Energy Standards Board;

(2) conduct leak detection surveys and manage transmission and distribution system integrity in accordance with CSA Z662-11 "Oil and gas pipeline systems" published by the Canadian Standards Association in June 2011 and in accordance with the Construction Code (c. B-1.1, r. 0.01.01);

(3) determine the mole fraction of CO_2 and CH_4 in natural gas by calculating the annual average of the following mole fractions:

(a) the mole fraction in natural gas during compression for onshore pipeline transmission;

(b) the mole fraction in natural gas in underground storage facilities;

(c) the mole fraction in natural gas in liquid natural gas storage facilities;

(d) the mole fraction in natural gas in liquid natural gas import and export facilities;

(e) the mole fraction in natural gas for distribution through the system.

QC.29.4.1. High bleed pneumatic device venting and natural gas driven pneumatic pump venting

For high bleed pneumatic device venting and natural gas driven pneumatic pump venting, the emitter must

(1) when using equation 29-2, determine the annual volume of natural gas consumed by high bleed pneumatic devices using statistical data, which must be developed using representative samples of all the high bleed pneumatic devices and revised at least every 3 years;

(2) when using equation 29-3, obtain from the device manufacturer the natural gas flow for each high bleed pneumatic device during normal operating conditions or, when the data are not available, use the flow from a similar device;

(3) when using equation 29-4:

(a) obtain from the manufacturer the quantity of natural gas consumed by volume of liquid pumped for each pneumatic pump model in normal operating conditions or, when the data are not available, use data from a similar device;

(b) keep a log of the quantity of liquid pumped annually by each pneumatic pump.

QC.29.4.2. Natural gas low bleed or intermittent bleed pneumatic device venting

For low bleed or intermittent bleed natural gas pneumatic device venting, the emitter must determine the number of natural gas low bleed pneumatic devices and the number of natural gas intermittent bleed pneumatic devices in the following manner:

(1) for the first emission report year, by counting all the devices according to type or estimating the total number of devices and apportion that number according to the estimated percentage of each type of device;

(2) for subsequent years, by updating the number of low bleed pneumatic devices and the number of intermittent bleed pneumatic devices to take annual changes into account.

QC.29.4.3. Equipment blowdown vent stacks

For equipment blowdown vent stacks, the emitter must

(1) calculate the volume of gas in blowdown equipment chambers, between isolation valves, for each equipment type;

(2) if the volume is greater than or equal to 1.42 m^3 at standard conditions, log the annual number of blowdowns for each equipment type;

(3) calculate the total volume of gas for which the volume in the blowdown equipment chamber, between isolation valves, is the same.

QC.29.4.4. Flares

For flares, the emitter must

(1) determine the volume of gas directed to flares, using one of the following methods:

(a) using the volumetric gas flow when the flare is equipped with a continuous flow monitoring and recording system or, when part of the gas is not measured by such a system, estimating the unmeasured gas flow must be estimated using a sector-recognized method;

(b) using a sector-recognized method;

(2) determine the gas composition using one of the following methods:

(*a*) using a continuous gas composition monitoring and recording system;

(*b*) when the flare is not equipped with a continuous gas composition monitoring and recording system, by determining, using a sector-recognized method:

i. the mole fraction of CO_2 and CH_4 in the gas when the stream going to the flare is natural gas;

ii. the mole fraction of the methane, ethane, propane, butane and pentane-plus when the stream going to the flare is a hydrocarbon product stream.

QC.29.4.5. Centrifugal compressors venting

For centrifugal compressors, the emitter must

(1) determine the volume of gas from a wet seal oil degassing tank sent to an atmospheric vent or the volume of gas sent to a flare, using a temporary or permanent flow meter;

(2) when a centrifugal compressor is isolated and used for peaking purposes and is not equipped with a flow meter, determine the volume of gas using data from flow meters installed on similar devices;

(3) calibrate the flow meters in accordance with the methods in paragraph 1 of QC.29.4;

(4) determine the quantity of the gas that is recovered using a vapour recovery system or destined for another use, expressed in percentage, based on the number of hours of operation of the recovery system and the quantity of gas sent to the fuel gas system.

QC.29.4.6. Reciprocating compressors venting

For reciprocating compressors, the emitter must

(1) determine the gas flow from reciprocating compressor venting using the following methods:

(a) if the reciprocating rod packing and blowdown vent is connected to an open ended vent line, the emitter must use one of the following methods to calculate the gas flow:

i. measuring the flow from all vents, including gas manifolded to common vents, using calibrated bagging in accordance with paragraph 3 or a high volume sampler in accordance with paragraph 4;

ii. measuring the flow from all vents, including gas manifolded to common vents, using a temporary or permanent flow meter in accordance with the methods in paragraph 1 of QC.29.4. In the absence of a permanent flow meter, a port for the insertion of a temporary or permanent flow meter may be installed on the vents;

iii. for through-valve leakage to open ended vents, such as unit isolation valves on not operating, depressurized compressors and blowdown valves on pressurized compressors, using an acoustic detection device in accordance with paragraph 2 of QC.29.4;

(b) when the compressor rod packing case is not equipped with a vent line, the emitter must

i. detect equipment leaks in accordance with paragraph 2 of QC.29.4;

ii. measure the gas flow using calibrated bagging in accordance with paragraph 3, a high volume sampler in accordance with paragraph 4 or a flow meter in accordance with paragraph 1 of QC.29.4;

(2) measure annually the gas flow from rod packing vents, isolation valve vents and reciprocating compressor vents, including gas manifolded to common vents, in the operating mode in which the compressor is used during the measurement period:

(a) the reciprocating compressor is in operating or standby pressurized mode and the gas emitted is from leaks in the blowdown vent stack;

(b) the reciprocating compressor is in operating mode and the gas emitted is from the rod packing;

(c) the compressor is in not operating, depressurized mode; the gas emitted is from isolation valve leakage through the blowdown vent stack. In that case,

i. a reciprocating compressor that is not equipped with blind flanges must be sampled at least once in every 3 consecutive years if no compressor is in this mode during the annual measurement period;

ii. flow measurement is not required when a reciprocating compressor is equipped with blind flanges for the entire 3 consecutive year period;

iii. if a reciprocating compressor is in standby, depressurized mode, is not equipped with blind flanges and is not used for a period of 3 consecutive years, it must be sampled in that mode;

(3) when using calibrated bags to measure the gas flow emitted by the reciprocating compressor vent, use the bags only where the emissions are at a pressure similar to atmospheric pressure and hydrogen sulphide levels are such that it is safe to handle. The calibrated bags must be used according to the manufacturer's instructions and only if the entire emissions volume can be encompassed for measurement. The emitter must also

(a) record the time required to fill the bag and if the bag inflates in less than 1 second, the emitter must round up to 1 second;

(b) perform 3 measurements of the time required to fill the bag, and use the average of the measurements to calculate the gas flow;

(4) when using a high volume sampler, the measurements must be taken in accordance with the manufacturer's instructions. The emitter must also calibrate the sampler, in accordance with the manufacturer's instructions, at 2.5% CH_4 with 97.5% air and 100% CH_4 by using representative samples of known concentrations.

QC.29.4.7. Leaks identified following a detection survey

An emitter who conducts a leak detection survey must

(1) in the first emission reporting year, determine the leaker emission factor for leaks from each component type in accordance with the following methods:

(a) based on specific data for the operation of the enterprise's devices and according to sector-specific methods;

(b) using the data in Tables 29-1 to 29-5 in QC.29.6 depending on the type of activity, namely:

i. for the compression of natural gas for onshore pipeline transmission, the emission factors shown in Table 29-1 for fugitive emissions from connectors, valves, pressure relief valves, meters and open ended lines;

ii. for underground natural gas storage, the emission factors shown in Table 29-2 for fugitive emissions from connectors, valves, pressure relief valves, meters and open ended lines;

iii. for liquefied natural gas storage, the emission factors shown in Table 29-3 for fugitive emissions from valves, pump seals, connectors and all other types of equipment components;

iv. for liquid natural gas imports and exports, the emission factors shown in Table 29-4 for fugitive emissions from valves, pump seals, connectors and all other types of equipment components;

v. for natural gas distribution, for above ground meters and regulators at custody transfer gate stations, the emission factors shown in Table 29-5 for fugitive emissions from connectors, block valves, control valves, pressure relief valves, orifice meters, regulators and open ended lines;

(2) in subsequent emission reporting years, determine the CO_2 and CH_4 concentrations in natural gas using one of the following methods:

(a) based on specific data for the operation of the enterprise’s devices;

(b) using the method specified in "Methodology Manual: Estimation of Air Emissions from the Canadian Natural Gas Transmission, Storage and Distribution System" published in September 2007 by Clearstone Engineering Ltd.;

(3) determine the time during which a component was leaking, using the following methods:

(a) when one leak detection survey is conducted per year, the emitter must assume the component was leaking from the start of the year until the leak was repaired. If the leak was not repaired, the emitter must assume the component was leaking for the entire year;

(b) if multiple leak detection surveys are conducted per year, the emitter must assume that the component found to be leaking has been leaking since the previous survey. If the leak was directed during the previous survey, the emitter must assume the unrepaired component was leaking for the entire year.

QC.29.4.8. Fugitive emissions from all components

For fugitive emissions from all components, the emitter must

(1) determine the total number of components for each component type using one of the following methods:

(a) the method in Appendix E of "Methodology Manual: Estimation of Air Emissions from the Canadian Natural Gas Transmission, Storage and Distribution System" published in September 2007 by Clearstone Engineering Ltd.;

(b) a sector-specific method published by the Canadian Gas Association or Canadian Association of Petroleum Producers;

(c) using enterprise-specific data;

(2) for the first emission reporting year, use the emission factor for each component type depending on the type of activity, namely,

(a) for underground natural gas storage, the emission factors shown in Table 29-2 for fugitive emissions from connectors, valves, pressure relief valves, meters and open ended lines;

(b) for liquefied natural gas storage, the emission factors shown in Table 29-3 for fugitive emissions from vapour recovery compressors;

(c) for imports and exports of liquid natural gas, the emission factors shown in Table 29-4 for fugitive emissions from vapour recovery compressors;

(d) for natural gas distribution:

i. the emission factors shown in Table 29-5 for fugitive emissions from below ground meters and regulators;

ii. the emission factor calculated using equation 29-16 for above ground meters and regulators at non-custody transfer gate stations:

Equation 29-16

$$EF_i = \frac{GHG_i}{N}$$

Where:

EF_i = Enterprise-specific emission factor for above ground meters and regulators at non-custody transfer gate stations, in metric tons per component;

GHG_i = Annual emissions of greenhouse gas *i* from leaks from above ground meters and regulators at custody transfer gate stations, calculated in accordance with equation 29-12, in metric tons;

N = Total number of components, namely above ground meters and regulators, at custody-transfer gate stations;

i = CH_4 or CO_2;

iii. the calculation of fugitive emissions from leaks from the main devices in the transmission and distribution systems may be changed to comply with the methods described in "Methodology Manual: Estimation of Air Emissions from the Canadian Natural Gas Transmission, Storage and Distribution System" published in September 2007 by Clearstone Engineering Ltd.;

(3) in the subsequent emission reporting years, determine the emission factor from leaks from each type of component, in accordance with the following methods:

(a) based on data specific to the operation of the enterprise's equipment and according to the sector-specific methods, in particular methods published by the Canadian Gas Association;

(b) by updating the emission factors at least every 3 years;

(c) when an emission factor specific to the operation of equipment cannot be determined, using the factors provided for in Tables 29-1 to 29-5 in accordance with paragraph 2;

(4) determine the CO_2 and CH_4 concentrations in natural gas in accordance with the methods in "Methodology Manual: Estimation of Air Emissions from the Canadian Natural Gas Transmission, Storage and Distribution System" published in September 2007 by Clearstone Engineering Ltd.

QC.29.5. Methods for estimating missing data

When sampling or measurement data required by this Regulation for the calculation of emissions is missing, the emitter must use replacement data determined as follows:

(1) the measurement or estimate of emissions for each source concerned must be repeated as soon as possible, either during the reporting year or during the following reporting year. In the latter case, the replacement data cannot be re-used to estimate emissions for that reporting year. In addition, at least 30 days must separate emissions estimation or measurements carried out for the previous year emissions and the estimation or measurements of emissions for the current year;

(2) when missing data are temperature, pressure or data estimated using a continuous monitoring and recording system, the replacement data must be estimated in accordance with sector-specific inventory practices.

QC.29.6. Tables

Table 29-1. Emission factors for total organic carbon in natural gas during compression for onshore transmission

(QC.29.3.2, QC.29.3.4 (2), QC.29.4.7 (1))

Leaker emission factor by component type	
Component type	**Total organic carbon (metric tons/hour)**
Connector	4.471×10^{-7}
Block valve	4.131×10^{-6}
Control valve	1.650×10^{-2}
Compressor blowdown valve	3.405×10^{-3}
Pressure relief valve	1.620×10^{-4}
Orifice meter	4.863×10^{-5}
Other meter	9.942×10^{-6}
Regulator	7.945×10^{-6}
Open ended line	9.183×10^{-5}
Fugitive emission factors by component type	
Component type	**Total organic carbon (m^3/hour)**
Low bleed pneumatic device	3.99×10^{-2}
High bleed pneumatic device	5.32×10^{-1}
Intermittent bleed pneumatic device	5.32×10^{-1}

Table 29-2. Emission factors for total organic carbon in natural gas during underground storage

(QC.29.3.2, QC.29.3.4 (2), QC.29.4.7 (1), QC.29.4.8 (2))

Component type	**Total organic carbon m^3/hour**
Leaker emission factor by component type	
Valve	0.4265
Connector	0.1600
Open ended line	0.4964
Pressure relief valve	1.1396
Meter	0.5555

Fugitive emission factors component type	
Connector	2.83 x 10^{-4}
Valve	2.83 x 10^{-3}
Pressure relief valve	4.81 x 10^{-3}
Open ended line	8.49 x 10^{-4}
Low bleed pneumatic device	3.99 x 10^{-2}
High bleed pneumatic device	5.32 x 10^{-1}
Intermittent bleed pneumatic device	5.32 x 10^{-1}

Table 29-3. CH_4 emission factors for liquefied natural gas storage

(QC.29.4.7 (1), QC.29.4.8 (2))

Component type	**CH_4 m^3/hour**
Leaker emission factor by component type	
Valve	3.42 x 10^{-2}
Pump seal	1.15 x 10^{-1}
Connector	9.91 x 10^{-3}
Other	5.09 x 10^{-2}
Fugitive emission factors component type	
Vapour recovery compressor	1.20 x 10^{-1}

Table 29-4. CH_4 emission factors during imports and exports of liquid natural gas

(QC.29.4.7 (1), QC.29.4.8 (2))

Component type	**CH_4 m^3/hour**
Leaker emission factor by component type	
Valve	3.42 x 10^{-2}
Pump seal	1.15 x 10^{-1}
Connector	9.90 x 10^{-3}
Other	5.09 x 10^{-2}
Fugitive emission factors component type	
Vapour recovery compressor	1.20 x 10^{-1}

Table 29-5. Emission factors for total organic carbon and CH_4 in natural gas during distribution

(QC.29.4.7 (1), QC.29.4.8 (2))

Leaker emission factor by component type	
Component type	**Total organic carbon metric tons/hour**
Connector	8.227×10^{-8}
Block valve	5.607×10^{-7}
Control valve	1.949×10^{-5}
Pressure relief valve	3.944×10^{-6}
Orifice meter	3.011×10^{-6}
Regulator	6.549×10^{-7}
Open ended line	6.077×10^{-5}
Fugitive emission factors by component type	
Component type	**CH_4 m^3/hour**
Below ground meter and regulator, inlet pressure >300 psig	3.74×10^{-2}
Below ground meter and regulator, inlet pressure 100 to 300 psig	5.66×10^{-3}
Below ground meter and regulator, inlet pressure <100 psig	2.83×10^{-3}
Fugitive emission factors by type of transmission pipeline	
Type of pipeline	**CH_4 m^3/hour**
Unprotected steel	1.83×10^{-1}
Protected steel	7.22×10^{-2}
Plastic	7.75×10^{-2}
Cast iron	7.83×10^{-1}
Fugitive emission factors by type of distribution pipeline	
Type of pipeline	**CH_4 m^3/hour**
Unprotected steel	7.08×10^{-2}
Protected steel	3.25×10^{-2}
Plastic	1.05×10^{-2}
Copper	2.66×10^{-2}

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11. This Regulation comes into force on the fifteenth day following the date of its publication in the *Gazette officielle du Québec*.

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Abbreviations : **A** : Abrogated, **N** : New, **M** : Modified