Draft Methodological tool

"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"

(Version 01)

I. DEFINITIONS, SCOPE, APPLICABILITY AND PARAMETERS

Definitions

For the purpose of this tool, the following definitions apply:

Dry gas. The dry gas is a mixture of gaseous components (except H_2O) that are present in a gaseous stream. The gaseous stream may contain different fractions of N_2, CO_2, O_2, CO, H_2, CH_4, N_2O, NO, NO_2, SO_2, SF_6 and PFCs. Other gases may be present (e.g., hydrocarbons) provided their total concentration represents less than 1% (v/v) of the total.

Absolute humidity or mass fraction of water. The absolute humidity of a gas is the ratio between the mass of H_2O (vapor phase) in the gas and the mass of the dry gas.

Saturation (absolute) humidity. The saturation (absolute) humidity is the maximum amount of H_2O (vapor phase) that the gas can contain at a given temperature and pressure, expressed as mass of H_2O per mass of the dry gas.

Moisture content. The moisture content of a gas is the H_2O concentration of water in mass of H_2O (vapor phase) per volume of dry gas at normal conditions (NPT), expressed in mg H_2O/m^3 dry gas.

Relative humidity. The relative humidity of a gas is the ratio between the partial pressure of H_2O in the gas and the saturation pressure at a given temperature.

"Wet basis" means that a parameter accounts for the H_2O present in the gas.

"Dry basis" means that a parameter does not account for the H_2O present in the gas.

"Normal conditions" is defined as 0^oC (273.15 K, 32^oF) and 1 atm (101.325 kN/m^2, 101.325 kPa, 14.69 psia, 29.92 in Hg, 760 torr).

Scope and applicability

This tool provides procedures to determine the mass flow of a greenhouse gas in a gaseous stream. The tool can be used to determine the mass flow of the following gases: **CO_2, CH_4, N_2O, SF_6 and/or PFCs**.

The mass flow of a particular greenhouse gas is calculated based on measurements of (a) the total volume or mass flow of the gas stream and (b) the volumetric fraction of the gas in the gas stream. The volume flow, mass flow and volumetric fraction may be measured on a **dry basis or wet basis**. The tool covers most of the possible measurement combinations, providing eight different options to determine the mass flow of a particular gas (options A to H below). Typical applications of this tool are methodologies where the flow and composition of residual or flared gases or exhaust gases are measured for the determination of baseline or project emissions.

When no measurement of the moisture content in the gaseous stream is performed, a simplified conservative approach is used by assuming that the gas is saturated with H_2O or that no H_2O is in the gas, whichever is more conservative in the context of the underlying methodology.[1]

This tool is applicable under the followings conditions:

- The tool is only applicable to gaseous streams consisting of at least 99% or a larger volumetric fraction of the following gases: N_2, CO_2, O_2, CO, H_2, CH_4, N_2O, NO, NO_2, SO_2, SF_6 and PFCs and H_2O in vapor phase.[2] Other gases may be present (e.g., hydrocarbons) provided their total concentration represents less than 1% (v/v) of the total.[3]
- The absolute pressure of the gas must be below 10 atm or 1.013 MPa.[4]

The underlying methodology should specify to which gaseous stream the tool should be applied, for which greenhouse gases the mass flow should be determined, and in which time intervals the mass flow of the gaseous stream should be measured.

Parameters

This tool provides procedures to determine the following parameter:

Parameter	SI Unit	Description
$F_{i,t}$	kg / h	Mass flow of greenhouse gas *i* (CO_2, CH_4, N_2O, SF_6 or a PFC) in the gaseous stream in time interval *t*

[1] For example, in the case that (1) the greenhouse gas in the gaseous stream is emitted as project emission source, (2) the mass or volume flow of the gas stream is measured on a wet basis and (3) the volumetric fraction of the greenhouse gas is measured on a dry basis, it is a conservative simplification to assume that no H_2O is present in the gas stream.

[2] This condition is required because it is assumed in the calculations that the gas stream behaves as an ideal binary mixture of water vapor and an ideal gas. If the gaseous stream contains larger fractions of other gases, such as hydrocarbons other than methane or HFCs, the gas cannot be considered to be an ideal gas mixture.

[3] For the cases of landfill gas and exhaust gases from thermal oxidation N_2O, SF_6 or PFCs using natural gas, it will be assumed that this applicability condition is fulfilled.

[4] Moderate pressures will assure that gases behave as ideal gases and the tool applies.

II. PROCEDURE

The mass flow of a greenhouse gas *i* in a gaseous stream ($F_{i,t}$) is determined through measurement of the volume or mass flow of the gaseous stream and measurement of the volumetric fraction of the gas. Measurements may occur on a dry basis or wet basis. The following options for measurement may be used:

Option	Volume flow of gaseous stream	Mass flow of gaseous stream	Volumetric fraction
A	dry basis	-	dry basis
B	dry basis	-	wet basis
C	wet basis	-	dry basis
D	wet basis	-	wet basis
E	-	dry basis	dry basis
F	-	dry basis	wet basis
G	-	wet basis	dry basis
H	-	wet basis	wet basis

Project participants should document in the CDM-PDD which option is applied. $F_{i,t}$ should be calculated following the steps/guidance described for each option below.

Option A

The mass flow of greenhouse gas *i* ($F_{i,t}$) is determined as follows:

$$F_{i,t} = V_{t,db} \times v_{i,t,db} \times \rho_{i,t} \qquad \textbf{(1)}$$

with

$$\rho_{i,t} = \frac{P_t * MM_i}{R_u * T_t} \qquad \textbf{(2)}$$

Where:

$F_{i,t}$	=	Mass flow of greenhouse gas *i* in the gaseous stream in time interval *t* (kg gas/h)
$V_{t,db}$	=	Volumetric flow of the gaseous stream in actual conditions (P_t, T_t) in time interval *t* on a dry basis (m^3 dry gas/h)
$\rho_{i,t}$	=	Density of greenhouse gas *i* in the gaseous stream in actual conditions (P_t, T_t) in time interval *t* (kg gas *i*/m^3 dry gas)
$v_{i,t,db}$	=	Volumetric fraction of greenhouse gas *i* in the gaseous stream in a time interval *t* on a dry basis (m^3 gas *i*/m^3 dry gas)
P_t	=	Absolute pressure of the gaseous stream in time interval *t* (Pa)
MM_i	=	Molecular mass of greenhouse gas *i* (kg/kmol)
R_u	=	Universal ideal gases constant (8314 Pa.m^3/kmol.K)
T_t	=	Temperature of the gaseous stream in time interval *t* (K)

Option B

The mass flow of greenhouse gas *i* ($F_{i,t}$) is determined using equations (1) and (2). The volumetric fraction of greenhouse gas *i* in the gaseous stream in time interval *t* on a dry basis ($v_{i,t,db}$) is determined by converting the volumetric fraction from wet basis to dry basis as follows:

$$v_{i,t,db} = v_{i,t,wb} * \left(1 + v_{H2O,t,db}\right) \qquad \textbf{(3)}$$

with

$$v_{H2O,t,db} = \frac{m_{H2O,t,db} * MM_{t,db}}{MM_{H2O}} \qquad \textbf{(4)}$$

Where:

$v_{i,t,db}$	=	Volumetric fraction of greenhouse gas *i* in the gaseous stream in time interval *t* on a dry basis (m^3 gas *i*/m^3 dry gas)
$v_{i,t,wb}$	=	Volumetric fraction of greenhouse gas *i* in the gaseous stream in time interval *t* on a wet basis (m^3 gas *i*/m^3 wet gas)
$v_{H2O,t,db}$	=	Volumetric fraction of H_2O in the gaseous stream in time interval *t* on a dry basis (m^3 H_2O / m^3 dry gas)
$m_{H2O,t,db}$	=	Mass fraction of H_2O in the gaseous stream in time interval *t* on a dry basis (kg H_2O / kg dry gas)
$MM_{t,db}$	=	Molecular mass of the gaseous stream in time interval *t* on a dry basis (kg dry gas / kmol dry gas)
MM_{H2O}	=	Molecular mass of H_2O (kg H_2O/kmol H_2O)

And $MM_{t,db}$ is determined as follows:

$$MM_{t,db} = \sum_{k} (v_{k,t,db} * MM_k) \qquad \textbf{(5)}$$

Where:

$MM_{t,db}$	=	Molecular mass of the gaseous stream in time interval *t* on a dry basis (kg dry gas / kmol dry gas)
$v_{k,t,db}$	=	Volumetric fraction of gas *k* in the gaseous stream in time interval *t* on a dry basis (m^3 gas k / m^3 dry gas)
MM_k	=	Molecular mass of gas *k* (kg / kmol)
k	=	All gases contained in the gaseous stream (e.g. N2, CO_2, O2, CO, H2, CH_4, N_2O, NO, NO2, SO_2, SF_6 and PFCs and H2O in vapor phase)

The mass fraction of water in time interval *t* on a dry basis ($m_{H2O,t,db}$) can be determined using one of the following two options. Project participants should document in the CDM-PDD which option they apply.

Option 1: Measurement of the moisture content

This option provides a procedure to determine the mass fraction of H_2O in the gaseous stream from measurements of the moisture content of the gas. The moisture content in the gaseous stream should be measured according to the USEPA CF42 method 4 and then converted to the mass fraction of H_2O in the gaseous stream in time interval *t* on a dry basis ($m_{H2O,t,db}$) as follows:

$$m_{H2O,t,db} = \frac{C_{H2O,t,db,n}}{10^6 * \rho_{t,db,n}} \quad \textbf{(6)}$$

Where:

$m_{H2O,t,db}$	=	Mass fraction of H_2O in the gaseous stream in time interval *t* on a dry basis (kg H_2O / kg dry gas)
$C_{H2O,t,db,n}$	=	Moisture content of the gaseous stream, according to the USEPA CF42 method 4, at normal conditions in time interval *t* (mg H_2O/m^3 dry gas)
$\rho_{t,db,n}$	=	Density of the gaseous stream in time interval *t* on a dry basis at normal conditions (kg dry gas / m^3 dry gas)

The moisture content at normal conditions is determined as follows:

$$C_{H2O,t,db,n} = \frac{10^6 * M_{H2O,t}}{V_{t,db,n}} \quad \textbf{(7)}$$

Where:

$C_{H2O,t,db,n}$	=	Moisture content of the gaseous stream, according to the USEPA CF42 method 4, at normal conditions in a time interval *t* (mg H_2O/ m^3 dry gas)
$M_{H2O,t}$	=	Mass flow of H_2O in the gaseous stream in time interval *t* (kg H_2O / h)
$V_{t,db,n}$	=	Volumetric flow of the gaseous stream in a time interval *t* at normal conditions on a dry basis (m^3 dry gas / h)

The density of the gaseous stream on a dry basis at normal conditions ($\rho_{t,db,n}$) is determined as follows:

$$\rho_{t,db,n} = \frac{P_n * MM_{t,db}}{R_u * T_n} \quad \textbf{(8)}$$

Where:

$\rho_{t,db,n}$	=	Density of the gaseous stream in time interval *t* on a dry basis at normal conditions (kg dry gas / m^3 dry gas)
P_n	=	Absolute pressure at normal conditions (101325 Pa)
T_n	=	Temperature at normal conditions (273.15 K)
$MM_{t,db}$	=	Molecular mass of the gaseous stream in a time interval *t* on a dry basis (kg dry gas / kmol dry gas)
R_u	=	Universal ideal gases constant (8314 Pa.m^3/kmol.K)

And $MM_{t,db}$ is estimated as per equation (5).

The following equation should be used to convert the volumetric flow of the gaseous stream from actual conditions to normal conditions of temperature and pressure:

$$V_{t,db,n} = V_{t,db} * (273.15/T_t) * (P_t/101{,}325) \qquad \textbf{(9)}$$

Where:

P_t	=	Absolute pressure of the gaseous stream in time interval *t* (Pa)
T_t	=	Temperature of the gaseous stream in time interval *t* (K)
$V_{t,db,n}$	=	Volumetric flow of the gaseous stream in a time interval *t* at normal conditions on a dry basis (m^3 dry gas/h)
$V_{t,db}$	=	Volumetric flow of the gaseous stream in time interval *t* at actual conditions on a dry basis (m^3/h)

Option 2: Simplified calculation without any measurements of the moisture content

This option does not require measuring the moisture content of the gas but provides a simple and conservative approach to determine the absolute humidity of the gaseous stream. It is assumed that the gas is saturated with H_2O or that no H_2O is in the gas, whichever is more conservative in the context of the underlying methodology.

If it is conservative to assume that no H_2O in vapor phase is in the gaseous stream, assume $m_{H2O,t,db} = 0$. If it is conservative to assume that the gaseous stream is saturated with H_2O, determine $m_{H2O,t,db}$ as follows:

$$m_{H2O,t,db,Sat} = \frac{p_{H2O,t,Sat} * MM_{H2O}}{(P_t - p_{H2O,t,Sat}) * MM_{t,db}} \qquad \textbf{(10)}$$

Where:

$m_{H2O,t,db,sat}$	=	Saturation absolute humidity in time interval *t* on a dry basis (kg H_2O/kg dry gas)
$p_{H20,t,Sat}$	=	Saturation pressure of H_2O at temperature T_t (Pa)
T_t	=	Temperature of the gaseous stream in time interval *t* (K)
P_t	=	Absolute pressure of the gaseous stream in time interval *t* (Pa)
MM_{H2O}	=	Molecular mass of H_2O (kg H_2O/kmol H_2O)
$MM_{t,db}$	=	Molecular mass of the gaseous stream in a time interval *t* on a dry basis (kg dry gas / kmol dry gas)

Option C

The mass flow of greenhouse gas *i* ($F_{i,t}$) is determined using equations (1) and (2). The volumetric flow of the gaseous stream in time interval *t* on a dry basis ($V_{t,db}$) is determined by converting the volumetric flow from wet basis to dry basis as follows:

$$V_{t,db} = V_{t,wb} / \left(1 + v_{H2O,t,db}\right) \qquad \textbf{(11)}$$

Where:

$V_{t,db}$	=	Volumetric flow of the gaseous stream in time interval *t* on a dry basis (m^3 dry gas/h)
$V_{t,wb}$	=	Volumetric flow of the gaseous stream in time interval *t* on a wet basis (m^3 wet gas/h)
$v_{H2O,t,db}$	=	Volumetric fraction of H_2O in the gaseous stream in time interval *t* on a dry basis (m^3 H_2O/m^3 dry gas)

The volumetric fraction of H_2O in time interval *t* on a dry basis ($v_{H2O,t,db}$) should be estimated as per the procedure provided in **Option B**.

Option D

The mass flow of greenhouse gas *i* ($F_{i,t}$) is determined as follows:

$$F_{i,t} = V_{t,wb,n} \times v_{i,t,wb,n} \times \rho_{i,n} \quad \textbf{(12)}$$

with

$$\rho_{i,n} = \frac{P_n * MM_i}{R_u * T_n} \quad \textbf{(13)}$$

Where:

$V_{t,wb}$	=	Volumetric flow of the gaseous stream in time interval *t* on a wet basis (m^3 wet gas/h)
$v_{i,t,wb,n}$	=	Volumetric fraction of greenhouse gas *i* in the gaseous stream in time interval *t* on a wet basis (m^3 gas *i*/m^3 wet gas)
$\rho_{i,n}$	=	Density of greenhouse gas *i* in the gaseous stream at normal conditions (kg gas *i*/m^3 dry gas)
P_n	=	Absolute pressure at normal conditions (101325 Pa)
T_n	=	Temperature at normal conditions (273.15 K)
MM_i	=	Molecular mass of greenhouse gas *i* (kg/kmol)
R_u	=	Universal ideal gases constant (8314 Pa.m^3/kmol.K)

The following equation should be used to convert the volumetric flow of the gaseous stream from actual conditions to normal conditions of temperature and pressure:

$$V_{t,wb,n} = V_{t,wb} * [(273.15/T_t) * (P_t/101,325)] \quad \textbf{(14)}$$

Where:

P_t	=	Pressure of the gaseous stream in time interval *t* (Pa)
T_t	=	Temperature of the gaseous stream in time interval *t* (K)
$V_{t,wb,n}$	=	Volumetric flow of the gaseous stream in a time interval *t* at normal conditions on a wet basis (m^3 wet gas / h)
$V_{t,wb}$	=	Volumetric flow of the gaseous stream in time interval *t* at actual conditions on a wet basis (m^3 wet gas/h)

Option E

The mass flow of greenhouse gas *i* ($F_{i,t}$) is determined using equations (1) and (2). The volumetric flow of the gaseous stream in time interval *t* on a dry basis at actual conditions ($V_{t,db}$) is determined by converting the mass flow of the gaseous stream to a volumetric flow as follows:

$$V_{t,db} = M_{t,db} / \rho_{t,db} \quad \textbf{(15)}$$

Where:

$V_{t,db}$	=	Volumetric flow of the gaseous stream in a time interval *t* at actual conditions on a dry basis (m^3 dry gas/h)
$M_{t,db}$	=	Mass flow of the gaseous stream in time interval *t* on a dry basis (kg/h)
$\rho_{t,db}$	=	Density of the gaseous stream in time interval *t* on a dry basis at actual conditions (kg dry gas / m^3 dry gas)

$\rho_{t,db}$ should be determined as per equation (2).

Option F

The mass flow of greenhouse gas *i* ($F_{i,t}$) is determined using equations (1) and (2). The volumetric flow of the gaseous stream in time interval *t* on a dry basis ($V_{t,db}$) is determined by converting the mass flow of the gaseous stream in time interval *t* on a dry basis ($M_{t,db}$) to a volumetric basis as per **Option E**. The volumetric fraction of the greenhouse gas *i* on a dry basis ($v_{i,t,db}$) is determined by converting the volumetric fraction on wet basis ($v_{i,t,wb}$) to a dry basis as per **Option B**.

Option G

The mass flow of greenhouse gas *i* ($F_{i,t}$) is determined using equations (1) and (2). The volumetric flow of the gaseous stream in time interval *t* on a dry basis ($V_{t,db}$) is determined in two steps. First the mass flow of the gaseous stream in time interval t on a wet basis ($M_{t,wb}$) is converted from wet basis to dry basis as follows:

$$M_{t,db} = M_{t,wb} / \left(1 + m_{H2O,t,db}\right) \quad \textbf{(16)}$$

Where:

$M_{t,db}$	=	Mass flow of the gaseous stream in time interval *t* on a dry basis (kg/h)
$M_{t,wb}$	=	Mass flow of the gaseous stream in time interval *t* on a wet basis (kg/h)
$m_{H2O,t,db}$	=	Mass fraction of H_2O in the gaseous stream in a time interval *t* on a dry basis (kg H_2O / kg dry gas)

Then, the mass flow of the gaseous stream in time interval *t* on a dry basis ($M_{t,db}$) is converted to the volumetric flow of the gaseous stream in time interval *t* on a dry basis ($V_{t,db}$) following the procedure in **Option E**.

Option H

The mass flow of greenhouse gas *i* ($F_{i,t}$) is determined as follows:

$$F_{i,t} = V_{t,wb,n} \times v_{i,t,wb} \times \rho_{i,n} \quad \textbf{(17)}$$

with

$$V_{t,wb,n} = M_{t,wb} / \rho_{t,wb,n} \quad \textbf{(18)}$$

and

$$\rho_{t,wb,n} = \frac{P_n * MM_{t,wb}}{R_u * T_n} \quad \textbf{(19)}$$

Where:

$F_{i,t}$	=	Mass flow of greenhouse gas *i* in the gaseous stream in time interval *t* (kg gas/h)
$V_{t,wb,n}$	=	Volumetric flow of the gaseous stream in time interval *t* at normal conditions on a wet basis (m^3 dry gas/h)
$v_{i,t,wb}$	=	Volumetric fraction of greenhouse gas *i* in the gaseous stream in time interval *t* on a wet basis (m^3 gas *i*/m^3 wet gas)
$M_{t,wb}$	=	Mass flow of the gaseous stream in time interval *t* on a wet basis (kg/h)
$\rho_{t,wb,n}$	=	Density of the gaseous stream in a time interval *t* at normal conditions on a wet basis (kg wet gas/m^3 wet gas)
P_n	=	Absolute pressure at normal conditions (101325 Pa)
T_n	=	Temperature at normal conditions (273.15 K)
$MM_{t,wb}$	=	Molecular mass of the gaseous stream in a time interval *t* on a wet basis (kg wet gas / kmol wet gas)
R_u	=	Universal ideal gases constant (8314 Pa.m3/kmol.K)
$\rho_{i,n}$	=	Density of greenhouse gas *i* in the gaseous stream at normal conditions (kg gas *i*/m^3 dry gas)

$\rho_{i,n}$ is determined as per equation (13) above.

And,

$$MM_{t,wb} = \sum_k (v_{k,t,wb} * MM_k) \quad \textbf{(20)}$$

Where:

$MM_{t,wb}$	=	Molecular mass of the gaseous stream in time interval *t* on a wet basis (kg dry gas / kmol wet gas)
$v_{k,t,wb}$	=	Volumetric fraction of gas *k* in the gaseous stream in time interval *t* on a wet basis (m³ gas *k*/m³ wet gas)
MM_k	=	Molecular mass of gas *k* (kg / kmol)
k	=	Gas in the gaseous stream (e.g. N_2, CO_2, O_2, CO, H_2, CH_4, N_2O, NO, NO_2, SO_2, SF_6 and PFCs and H_2O in vapor phase)

Data and parameters not monitored

Data / Parameter:	R_u
Data unit:	$Pa.m^3/kmol.K$
Description:	Universal ideal gases constant
Value to be applied:	8314
Any comment:	

Data / Parameter:	MM_i
Data unit:	kg/kmol
Description:	Molecular mass of greenhouse gas *i*
Value to be applied:	(see table below)
Any comment:	

Compound	Structure	Molecular mass (kg / kmol)
Carbon dioxide	CO_2	44
Methane	CH_4	16
Nitrous oxide	N_2O	44
Sulfur hexafluoride	SF_6	146
Perfluoromethane	CF_4	88
Perfluoroethane	C_2F_6	138
Perfluoropropane	C_3F_8	188
Perfluorobutane	C_4F_{10}	238
Perfluorocyclobutane	$c\text{-}C_4F_8$	200
Perfluoropentane	C_5F_{12}	288
Perfluorohexane	C_6F_{14}	338

Data / Parameter:	MM_k
Data unit:	kg/kmol
Description:	Molecular mass of gas *k*
Value to be applied:	For greenhouse gases applied values for MM_i.
Any comment:	

Compound	Structure	Molecular mass (kg / kmol)
Nitrogen	N_2	28
Oxygen	O_2	32
Carbon monoxide	CO	28
Hydrogen	H_2	2
Nitric oxide	NO	30
Nitrogen dioxide	NO_2	46
Sulfur dioxide	SO_2	64

Data / Parameter:	MM_{H2O}
Data unit:	kg/kmol
Description:	Molecular mass of water
Value to be applied:	18 kg/kmol
Any comment:	

Data / Parameter:	P_n
Data unit:	P_n
Description:	Total pressure at normal conditions
Value to be applied:	101325 Pa
Any comment:	

Data / Parameter:	T_n
Data unit:	K
Description:	Temperature at normal conditions
Value to be applied:	273.15 K
Any comment:	

III. MONITORING METHODOLOGY PROCEDURE

Data and parameters to be monitored

All monitored data must be linked in time, i.e., calculations shall be performed considering only a set of data acquired in the same time interval. As noted above, project participants may use an hour or a smaller discrete time interval. When performing the water concentration measurement (discrete measurement) the resulting absolute humidity will be used during the whole period between two consecutive measurements. Measurements of moisture content shall be performed at least every 6 months.

Data / Parameter:	$V_{t,wb}$
Data unit:	m³ wet gas/h
Description:	Volumetric flow of the gaseous stream in time interval *t* on a wet basis
Source of data:	
Measurement procedures (if any):	Volumetric flow measurement should always refer to the actual pressure and temperature. Instruments with recordable electronic signal (analogical or digital) are required
Monitoring frequency:	Continuous if not specified in the underlying methodology
QA/QC procedures:	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory
Any comment:	This parameter will be monitored in options C and D

Data / Parameter:	$V_{t,db}$
Data unit:	m³ dry gas/h
Description:	Volumetric flow of the gaseous stream in time interval *t* on a dry basis
Source of data:	
Measurement procedures (if any):	Calculated based on the wet basis flow measurement plus water concentration measurement
Monitoring frequency:	Continuous if not specified in the underlying methodology
QA/QC procedures:	
Any comment:	This parameter will be monitored in options A and B

Data / Parameter:	$v_{i,t,db}$
Data unit:	m³ gas *i*/m³ dry gas
Description:	Volumetric fraction of greenhouse gas *i* in a time interval *t* on a dry basis
Source of data:	
Measurement procedures (if any):	Continuous gas analyser operating in dry-basis
Monitoring frequency:	Continuous if not specified in the underlying methodology
QA/QC procedures:	Calibration should include zero verification with an inert gas (e.g., N_2) and at least one reading verification with a standard gas (single calibration gas or mixture calibration gas). All calibration gases must have a certificate provided by the manufacturer and must be under their validity period
Any comment:	This parameter will be monitored in options A, C, E and G

Data / Parameter:	$v_{i,t,wb}$
Data unit:	m^3 gas *i*/m^3 wet gas
Description:	Volumetric fraction of greenhouse gas *i* in a time interval *t* on a wet basis
Source of data:	
Measurement procedures (if any):	Calculated based on the dry basis analysis plus water concentration measurement or continuous in-situ analyzers if not specified in the underlying methodology
Monitoring frequency:	Continuous if not specified in the underlying methodology
QA/QC procedures:	Calibration should include zero verification with an inert gas (e.g., N_2) and at least one reading verification with a standard gas (single calibration gas or mixture calibration gas). All calibration gases must have a certificate provided by the manufacturer and must be under their validity period.
Any comment:	This parameter will be monitored in options B, D, F and H

Data / Parameter:	$M_{t,wb}$
Data unit:	kg/h
Description:	Mass flow of the gaseous stream in time interval *t* on a wet basis
Source of data:	
Measurement procedures (if any):	Instruments with recordable electronic signal (analogical or digital) are required
Monitoring frequency:	Continuous if not specified in the underlying methodology
QA/QC procedures:	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory
Any comment:	This parameter will be monitored in options G and H

Data / Parameter:	$M_{t,db}$
Data unit:	kg/h
Description:	Mass flow of the gaseous stream in time interval *t* on a dry basis
Source of data:	
Measurement procedures (if any):	Calculated based on the wet basis flow measurement plus water concentration measurement
Monitoring frequency:	Continuous if not specified in the underlying methodology
QA/QC procedures:	
Any comment:	This parameter will be monitored in Options E and F

Data / Parameter:	$C^{db}_{H2O,n,h}$
Data unit:	mg H_2O/m^3 dry gás
Description:	Gas Moisture Content - Concentration of water r in a dry gas stream, as expressed in the USEPA CF42 method 4 at normal conditions, in the time interval *t*
Source of data:	Measurements according to the USEPA CF42 method 4 – Gravimetric determination of water content
Measurement procedures (if any):	Discrete measurement procedure
Monitoring frequency:	The mean value among three consecutive measurements performed in the same day (at least 2 hours each) shall be considered. Maximum time interval between two sets of measurement should be 6 months.
QA/QC procedures:	According to the USEPA CF42 method 4
Any comment:	

Data / Parameter:	T_t
Data unit:	K
Description:	Temperature of the gaseous stream in time interval *t*
Source of data:	
Measurement procedures (if any):	Instruments with recordable electronic signal (analogical or digital) are required. Examples include thermocouples, thermo resistance, etc
Monitoring frequency:	Continuous unless differently specified in the underlying methodology
QA/QC procedures:	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory
Any comment:	

Data / Parameter:	P_t
Data unit:	Pa
Description:	Pressure of the gaseous stream in time interval *t*
Source of data:	
Measurement procedures (if any):	Instruments with recordable electronic signal (analogical or digital) are required. Examples include pressure transducers, etc
Monitoring frequency:	Continuous unless differently specified in the underlying methodology
QA/QC procedures:	Periodic calibration against a primary device must be performed periodically and records of calibration procedures must be kept available as well as the primary device and its calibration certificate. Pressure transducers (either capacitive or resistive) must be calibrated monthly
Any comment:	

Data / Parameter:	$p_{H20,t,Sat}$
Data unit:	Pa
Description:	Saturation pressure of water for a given temperature, T_t in time interval *t*
Source of data:	
Measurement procedures (if any):	This parameter is solely a function of the gas temperature, T_t and can be found at reference [1] for a total pressure equal to 101,325 Pa
Monitoring frequency:	
QA/QC procedures:	
Any comment:	[1] Fundamentals of Classical Thermodynamics; Gordon J. Van Wylen, Richard E. Sonntag and Borgnakke; 4º Edition 1994, John Wiley & Sons, Inc.

Data / Parameter:	$V_{k,t,db}$
Data unit:	m³ gas k/m³ dry gas
Description:	Volumetric fraction of gas *k* in the gaseous stream in time interval *t* on a dry basis
Source of data:	
Measurement procedures (if any):	Continuous gas analyser operating in dry-basis
Monitoring frequency:	Continuous if not specified in the underlying methodology
QA/QC procedures:	Calibration should include zero verification with an inert gas (e.g. N_2) and at least one reading verification with a standard gas (single calibration gas or mixture calibration gas). All calibration gases must have a certificate provided by the manufacturer and must be under their validity period
Any comment:	

Data / Parameter:	$V_{k,t,wb}$
Data unit:	m³ gas *k*/m³ wet gas
Description:	Volumetric fraction of gas *k* in the gaseous stream in time interval *t* on a wet basis
Source of data:	
Measurement procedures (if any):	Calculated based on the dry basis analysis plus water concentration measurement or continuous in-situ analyzers if not specified in the underlying methodology
Monitoring frequency:	Continuous if not specified in the underlying methodology
QA/QC procedures:	Calibration should include zero verification with an inert gas (e.g., N_2) and at least one reading verification with a standard gas (single calibration gas or mixture calibration gas). All calibration gases must have a certificate provided by the manufacturer and must be under their validity period
Any comment:	

IV. REFERENCES

[1] Fundamentals of Classical Thermodynamics; Gordon J. Van Wylen, Richard E. Sonntag and Borgnakke; 4º Edition 1994, John Wiley & Sons, Inc.

[2] Drying: Principles, Applications and Design; Czeslaw Strumillo and Tadeusz Kudra; 1986; Gordon & Breach Science Publisher; Montreaux, Switzerland.

[3] "Tool to determine project emissions from flaring gases containing methane"

- - - - -

History of the document

Version	Date	Nature of revision(s)
01	EB 47, Annex # 28 May 2009	To be considered at EB 47.