Draft revision to the methodological tool

"Project emissions from flaring"

(Version 02.0.0)

I. DEFINITIONS, SCOPE, APPLICABILITY AND PARAMETERS

Definitions

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

Enclosed flare. Devices where the residual gas is burned in a vertical cylindrical or rectilinear enclosure that includes a burning system and a damper where air for the combustion reaction is admitted.

Exhaust gas (EG). Gas emitted from the flare, following the flaring of residual gas as part of the project activity.

Flare efficiency. Methane destruction efficiency of the flare, defined as the ratio between the mass flow rate of methane in the exhaust gas and the mass flow rate of methane in residual gas to be flared (both referred to in dry basis and reference conditions).

Manufacturer. The original manufacturer of the flare, or their authorized agent for undertaking the manufacture of the flare.

Flare Specification. The flare manufacturer's design specification of the flare, which include: the minimum and maximum flow rate and/or heat flux; minimum and maximum operating temperature; and, location(s) of temperature sensors.

Open flare. Device where the residual gas is burned in an open air tip with or without any auxiliary fluid assistance or an enclosed flare, whose flame enclosure is less than 2 times the diameter of the enclosure.

Maintenance schedule. The flare manufacturer's specification for the schedule of routine maintenance that is required to maintain the flare in good working order. This is typically expressed as the desirable time between maintenance events.

Reference conditions. Reference conditions are defined as $0^{o}C$ (273.15 K, 32ºF) and 1 atm (101.325 kN/m2, 101.325 kPa, 14.69 psia, 29.92 in Hg, 760 torr).

Residual gas (RG). Gas containing methane that is to be flared as part of the project activity.

Residual gas component. Chemical species composing the residual gas (CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3, N_2).

Low height flare. The flame enclosure of a flare has a height between 10 and 2 times the diameter of the enclosure.

Auxiliary fuel. Additional fuel added to the residual gas to increase the calorific value to the point where the mixture will sustain continuous combustion. Auxiliary fuel where needed is normally propane supplied from cylinders of gas or methane from a gas main.

Scope and applicability

This tool provides procedures to calculate project emissions from flaring of a residual gas. The tool is applicable to enclosed or open flares and project participants should document in the CDM-PDD the type of flare used in the project activity.

This tool is applicable to flaring flammable greenhouse gases where methane is the flammable gas with the higher concentration, and that the source of the gas is coal mine methane or biogenic (e.g. biogas, landfill gas or wastewater treatment gas). The tool is not applicable to the use of auxiliary fuels and therefore the residual gas must have sufficient flammable gas present to sustain combustion. For the case of an enclosed flare, there shall be operating specifications provided by the manufacturer of the flare.

This methodology refers to the latest approved version of the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream". The applicability conditions of this tool also apply.

Parameters

This tool provides procedures to determine the following parameter:

Parameter	SI Unit	Description
$PE_{flare,y}$	t CO_2 e	Project emissions from flaring of the residual gas in year *y*

II. BASELINE METHODOLOGY PROCEDURE

The calculation procedure in this tool determines the project emissions from flaring the residual gas ($PE_{flare,y}$) based on the flare efficiency ($\eta_{flare,m}$) and the flow rate of methane to the flare ($F_{CH4,RG,m}$). The flare efficiency is determined for each minute *m* of year *y* based either on monitored data or default values.

The project emissions calculation procedure is given in the following steps:

STEP 1: Determination of methane mass flow rate of the residual gas;

STEP 2: Determination of the flare efficiency;

STEP 3: Calculate of project emissions from flaring.

Step 1: Determination of methane mass flow rate in the residual gas on a dry basis

The "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" shall be used to determine the following parameter:

Parameter	SI Unit	Description
$F_{CH4,m}$	kg / h	Mass flow of methane in the residual gaseous stream in the minute *m*

The following requirements apply:

- The gaseous stream tool shall be applied to the residual gas;
- The flow of the gaseous stream shall be measured continuously;
- CH_4 is the greenhouse gas *i* for which the mass flow should be determined;
- The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations 3 and 17 in the tool); and
- The time interval *t* for which mass flow should be calculated is every minute *m*.

$F_{CH4,m}$, which is measured as the mass flow rate (kg / h) during minute *m*, shall then be used to determine mass of methane in kilograms fed to the flare in minute *m* ($F_{CH4,RG,m}$).

Step 2: Determination of flare efficiency

The flare efficiency depends on the efficiency of combustion in the flare and the time that the flare is operating. For determining the efficiency of combustion of enclosed flares there is the option to apply a default value or determine the efficiency based on monitored data. For open flares a default value must be applied. The time the flare is operating is determined by monitoring the flame using a flame detector, and for the case of enclosed flares, the additional monitoring that manufacturer's specifications for operating conditions are met.

Open flare

In case of open flares, the flare efficiency in the minute *m* ($\eta_{flare,m}$) is 50% when the flame is detected in the minute *m* ($Flame_m$), otherwise $\eta_{flare,m}$ is 0%.

Enclosed flare

In case of enclosed flares, project participants may choose between the following two options to determine the flare efficiency for minute *m* ($\eta_{flare,m}$), and shall document in the CDM-PDD, which option is selected. Option A is applying a default value for flare efficiency, provided that the flare is operating correctly, and Option B is to measure the flare efficiency.

For enclosed flares that are defined as low height flares, then the flare efficiency in the minute *m* ($\eta_{flare,m}$) shall be discounted by 10%. For example, the default value applied would be 80%, rather than 90%, and if for example the measured value was 99%, then the value would be discounted to 89%.

Option A: Default value

The flare efficiency for the minute *m* ($\eta_{flare,m}$) is 90% when the following two conditions are met to demonstrate that the flare is operating:

(1) The temperature of the flare ($T_{EG,m}$) and the flow rate of residual gas to the flare ($F_{RG,m}$) is within manufacturer's specification ($SPEC_{flare}$) in minute *m*; and

(2) The flame is detected in minute *m* ($Flame_m$).

Otherwise $\eta_{flare,m}$ is 0%.

Option B: Measured flare efficiency

The flare efficiency in the minute *m* is a measured value ($\eta_{flare,m} = \eta_{flare,calc,m}$) when the following three conditions are met to demonstrate that the flare is operating:

(1) The temperature of the flare ($T_{EG.m}$) and the flow rate of residual gas to the flare ($F_{RG,m}$) is within manufacturer's specification ($SPEC_{flare}$) in minute *m*;

(2) The flame is detected in minute *m* ($Flame_m$); and

(3) The time between the completion of the maintenance event to minute *m* ($Maintenance_y$) and the minute *m*, does not exceed the manufacturer's maintenance schedule ($SPEC_{flare}$).

Otherwise $\eta_{flare,m}$ is 0%.

The project participant may choose to determine $\eta_{flare,calc,m}$ using either option B.1 or option B.2. Option B.1 is to have the measurement conducted by an accredited entity on a biannual basis and option B.2 is to measure the flare efficiency each minute.

Option B.1: Biannual measurement of flare efficiency

The calculated flare efficiency $\eta_{flare,calc,m}$ is determined as the average of two measurements of flare efficiency made in year *y* ($\eta_{flare,calc,y}$) as follows:

$$\eta_{flare,calc,y} = 1 - \frac{1}{2}\sum_{t=1}^{2}\left(\frac{F_{CH4,EG,t}}{F_{CH4,RG,t}}\right) \qquad \textbf{(1)}$$

Where:

$\eta_{flare,calc,y}$	=	Flare efficiency in the year *y*
$F_{CH4,EG,t}$	=	Mass flow of methane in the exhaust gas in the time period *t* (kg / t)
$F_{CH4,RG,t}$	=	Mass flow of methane in the residual gas in the time period *t* (kg / t)
t	=	The two time periods in year *y* during which $F_{CH4,EG,m}$ is measured, each a minimum of one hour and separated by at least 6 months

$F_{CH4,EG,t}$ is measured according to an appropriate national or international standard. $F_{CH4,RG,t}$ is calculated according to Step 1, and consists of the sum of methane flow in the minutes *m* that make up the time period *t*.

Option B.2: Measurement of flare efficiency each minute $\eta_{flare,calc,m}$

Measurement of flare efficiency each minute ($\eta_{flare,calc,m}$) is determined based on monitoring methane content in the exhaust gas and residual gas, and the air used in the combustion process during the minute *m* in year *y,* as follows:

$$\eta_{flare,calc,m} = 1 - \frac{F_{CH4,EG,m}}{F_{CH4,RG,m}} \qquad \textbf{(2)}$$

Where:

$\eta_{flare,calc,y}$	=	Flare efficiency in the year *y*
$F_{CH4,EG,m}$	=	Cumulative mass flow of methane in the exhaust gas in the minute *m* (kg)
$F_{CH4,RG,m}$	=	Cumulative mass flow of methane in the residual gas in the minute *m* (kg)

$F_{CH4,RG,m}$ is calculated according to Step 1: Determine $F_{CH4,EG,m}$ according to Steps 2.1 - 2.4 below:

Step 2.1: Determine methane mass flow rate in the exhaust gas on a dry basis

The mass flow of methane in the exhaust gas is based on the volumetric flow of the exhaust gas and the measured concentration of methane in the exhaust gas, as follows:

$$F_{CH4,EG,m} = V_{EG,m} \times fc_{CH4,EG,m} \times 10^{-6} \quad \textbf{(3)}$$

Where:

$F_{CH4,EG,m}$	=	Cumulative mass flow of methane in the exhaust gas of the flare in dry basis at normal conditions in the minute *m* (kg)
$V_{EG,m}$	=	Volumetric flow rate of the exhaust gas in dry basis at reference conditions in minute *m* (m^3 / m)
$fc_{CH4,EG,m}$	=	Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in minute *m* (mg / m^3)

Step 2.2: Determine volumetric flow rate of the exhaust gas on a dry basis ($V_{EG,m}$)

Determine the average volume flow of the exhaust gas in minute *m* based on a stoichiometric calculation of the combustion process. This depends on the chemical composition of the residual gas, the amount of air supplied to combust it and the composition of the exhaust gas. It is calculated as follows:

$$V_{EG,m} = Q_{EG,m} \times M_{RG,m} \quad \textbf{(4)}$$

Where:

$V_{EG,m}$	=	Volumetric flow rate of the exhaust gas in dry basis at reference conditions in minute *m* (m^3 / m)
$Q_{EG,m}$	=	Volume of the exhaust gas in dry basis at reference conditions per kilogram of residual gas in minute *m* (m^3 / kg residual gas)
$M_{RG,m}$	=	Mass flow rate of the residual gas in the minute *m* (kg / m)

Step 2.3: Determine mass flow rate of the residual gas ($M_{RG,m}$)

Project participants may select to monitor the mass flow rate of the residual gas in minute *m* directly (see monitored parameter $M_{RG,m}$), or according to the procedure given in this step, calculate $M_{RG,m}$ based on the volumetric flow rate and the density of the residual gas. The density of the residual gas is determined based on the volumetric fraction of all components in the gas.

$$M_{RG,m} = \rho_{RG,ref,m} \times V_{RG,m} \quad \textbf{(5)}$$

Where:

$M_{RG,m}$	=	Mass flow of the residual gas in minute m (kg)
$\rho_{RG,ref,m}$	=	Density of the residual gas at reference conditions in minute *m* (kg / m^3)
$V_{RG,m}$	=	Volumetric flow rate of the residual gas in dry basis at reference conditions in the minute *m* (m^3 / m)

and:

$$\rho_{RG,ref,m} = \frac{P_{ref}}{\frac{R_u}{MM_{RG,m}} \times T_{ref}} \quad \textbf{(6)}$$

Where:

$\rho_{RG,ref,m}$	=	Density of the residual gas at reference conditions in minute *m* (kg / m^3)
P_{ref}	=	Atmospheric pressure at reference conditions (Pa)
R_u	=	Universal ideal gas constant (Pa.m^3/kmol.K)
$MM_{RG,m}$	=	Molecular mass of the residual gas in minute *m* (kg / kmol)
T_{ref}	=	Temperature at reference conditions (K)

Use the equation below to calculate $MM_{RG,m}$. When applying this equation, then project participants may choose to either a) use the measured volumetric fraction of each component *i* of the residual gas, or b) as a simplification, measure the volumetric fraction of methane and consider the difference to 100% as being nitrogen (N_2). The same equation applies, irrespective of which option is selected.

$$MM_{RG,m} = \sum_i (v_{i,RG,m} \cdot MM_i) \quad \textbf{(7)}$$

Where:

$MM_{RG,m}$	=	Molecular mass of the residual gas in minute *m* (kg / kmol)
MM_i	=	Molecular mass of residual gas component *i* (kg / kmol)
$v_{i,RG,m}$	=	Volumetric fraction of component *i* in the residual gas in the minute *m*
i	=	Component of residual gas. If option a) is selected to measure the volumetric fraction, then i = CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3, N_2 or if option b) is selected then i= CH_4 and N_2

Step 2.4: Determine volume of the exhaust gas in dry basis at reference conditions per kilogram of residual gas $Q_{EG,m}$

$$Q_{EG,h} = Q_{CO_2,EG,h} + Q_{O_2,EG,h} + Q_{N_2,EG,h} \quad \textbf{(8)}$$

Where:

$Q_{EG,m}$	=	Volume of the exhaust gas in dry basis at reference conditions per kg of residual gas in the minute *m* (m^3 / kg residual gas)
$Q_{CO2,EG,m}$	=	Quantity of CO_2 volume in the exhaust gas at reference conditions per kg of residual gas in the minute m (m^3 / kg residual gas)
$Q_{N2,EG,m}$	=	Quantity of N_2 volume in the exhaust gas at reference conditions per kg of residual gas in the minute m (m^3 / kg residual gas)
$Q_{O2,EG,m}$	=	Quantity of O_2 volume in the exhaust gas at reference conditions per kg of residual gas in the minute *m* (m^3 / kg residual gas)

$$Q_{O_2,EG,m} = n_{O2,EG,m} \times VM_{ref} \quad \textbf{(9)}$$

Where:

$Q_{O2,EG,m}$	=	Quantity of O_2 volume in the exhaust gas at reference conditions per kg of residual gas in the minute *m* (m^3 / kg residual gas)
$n_{O2,EG,m}$	=	Quantity of O_2 moles in the exhaust gas per kg residual gas flared in minute *m* (kmol / kg residual gas)
VM_{ref}	=	Volume of one mole of any ideal gas at reference temperature and pressure (m^3 / kmol)

164 $$Q_{N2,EG,m} = VM_{ref} \times \left\{ \frac{MF_{N,RG,m}}{200AM_{N}} + \left(\frac{1 - v_{O2,air}}{v_{O_2,air}} \right) \times \left[F_{O2,RG,m} + n_{O2,EG,m} \right] \right\} \quad \textbf{(10)}$$

165 Where:

$Q_{N2,EG,m}$	=	Quantity of N_2 volume in the exhaust gas at reference conditions per kg of residual gas in the minute m (m^3 / kg residual gas)
VM_{ref}	=	Volume of one mole of any ideal gas at reference temperature and pressure (m^3 / kmol)
$MF_{N,RG,m}$	=	Mass fraction of nitrogen in the residual gas in the minute m
AM_N	=	Atomic mass of nitrogen (kg/kmol)
$v_{O2,air}$	=	Volumetric fraction of O_2 in air
$F_{O2,RG,m}$	=	Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in minute *m* (kmol / kg residual gas)
$n_{O2,EG,m}$	=	Quantity of O_2 moles in the exhaust gas per kg residual gas flared in minute *m* (kmol / kg residual gas)

166 $$Q_{CO_2,EG,m} = \frac{MF_{C,RG,m}}{AM_{C}} \times VM_{ref} \quad \textbf{(11)}$$

167 Where:

$Q_{CO2,EG,m}$	=	Quantity of CO_2 volume in the exhaust gas at reference conditions per kg of residual gas in the minute m (m^3 / kg residual gas)
$MF_{C,RG,m}$	=	Mass fraction of carbon in the residual gas in the minute m
AM_C	=	Atomic mass of carbon (kg / kmol)
VM_{ref}	=	Volume of one mole of any ideal gas at reference temperature and pressure (m^3 / kmol)

168 $$n_{O2,EG,m} = \frac{v_{O_2,EG,m}}{\left(1 - (v_{O_2,EG,m} / v_{O_2,air})\right)} \cdot \left[\frac{MF_{C,RG,m}}{AM_{C}} + \frac{MF_{N,EG,m}}{2AM_{N}} + \left(\frac{1 - v_{O_2,air}}{v_{O_2,air}} \right) \cdot F_{O2,RG,m} \right] \quad \textbf{(12)}$$

169 Where:

$n_{O2,EG,m}$	=	Quantity of O_2 moles in the exhaust gas per kg residual gas flared in minute *m* (kmol / kg residual gas)
$v_{O2,EG,m}$	=	Volumetric fraction of O_2 in the exhaust gas in the minute *m*
$v_{O2,air}$	=	Volumetric fraction of O_2 in the air (0.21)
$MF_{C,RG,m}$	=	Mass fraction of carbon in the residual gas in the minute *m*
AM_C	=	Atomic mass of carbon (kg / kmol)
$MF_{N,RG,m}$	=	Mass fraction of nitrogen in the residual gas in the minute *m*
AM_N	=	Atomic mass of nitrogen (kg / kmol)
$F_{O2,RG,m}$	=	Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in minute *m* (kmol / kg residual gas)

170 $$F_{O2,RG,m} = \frac{MF_{C,RG,m}}{AM_{C}} + \frac{MF_{H,RG,m}}{4AM_{H}} - \frac{MF_{O,RG,m}}{2AM_{O}} \quad \textbf{(13)}$$

Where:

$F_{O2,RG,m}$	=	Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in minute *m* (kmol / kg residual gas)
$MF_{C,RG,m}$	=	Mass fraction of carbon in the residual gas in the minute *m*
AM_C	=	Atomic mass of carbon (kg / kmol)
$MF_{N,RG,m}$	=	Mass fraction of nitrogen in the residual gas in the minute *m*
AM_N	=	Atomic mass of nitrogen (kg / kmol)
$MF_{H,RG,m}$	=	Mass fraction of hydrogen in the residual gas in the minute *m*
AM_H	=	Atomic mass of hydrogen (kg / kmol)

Determine the mass fractions of carbon, hydrogen, oxygen and nitrogen in the residual gas, using the volumetric fraction of component *i* in the residual gas using the equation below. When applying this equation, then project participants may choose to either a) use the measured volumetric fraction of each component *i* of the residual gas, or b) as a simplification, measure the volumetric fraction of methane and consider the difference to 100% as being nitrogen (N_2). The same equation applies, irrespective of which option is selected.

$$MF_{j,RG,m} = \frac{\sum_{i} v_{i,RG,m} \times AM_j \times NA_{j,i}}{MM_{RG,m}} \qquad \textbf{(14)}$$

Where:

$MF_{j,RG,m}$	=	Mass fraction of element *j* in the residual gas in minute *m*
$v_{i,RG,m}$	=	Volumetric fraction of component *i* in the residual gas in the minute *m*
AM_j	=	Atomic mass of element *j* (kg / kmol)
$NA_{j,i}$	=	Number of atoms of element *j* in component *i*
$MM_{RG,m}$	=	Molecular mass of the residual gas in minute *m* (kg / kmol)
j	=	elements C, O_2,H_2, N_2
i	=	Component of residual gas. If option a) is selected to measure the volumetric fraction, then i = CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3, N_2 or if option b) is selected then i= CH_4 and N_2

Step 3: Calculate annual project emissions from flaring

Project emissions from flaring are calculated as the sum of emissions for each minute *m* in year *y,* based on the methane flow rate in the residual gas ($F_{CH4,RG,m}$) and the flare efficiency ($\eta_{flare,m}$), as follows:

$$PE_{flare,y} = GWP_{CH4} \times \sum_{m=1}^{525600} F_{CH4,RG,m} \times \left(1 - \eta_{flare,m}\right) \times 10^{-3} \qquad \textbf{(15)}$$

Where:

$PE_{flare,y}$	=	Project emissions from flaring of the residual gas in year *y* (t CO_2e)
GWP_{CH4}	=	Global Warming Potential of methane valid for the commitment period (t CO_2e / t CH_4)
$F_{CH4,RG,m}$	=	Cumulative mass flow of methane in the residual gas in the minute *m* (kg)
$\eta_{flare,m}$	=	Flare efficiency in minute *m*

Data and parameters not monitored

Parameters and data that are not monitored include the constants used in equations, as listed in Table 1 below.

Table 1: Constants used in equations

Parameter	SI Unit	Description	Value
MM_{CH4}	kg/kmol	Molecular mass of methane	16.04
MM_{CO}	kg/kmol	Molecular mass of carbon monoxide	28.01
MM_{CO2}	kg/kmol	Molecular mass of carbon dioxide	44.01
MM_{O2}	kg/kmol	Molecular mass of oxygen	32.00
MM_{H2}	kg/kmol	Molecular mass of hydrogen	2.02
MM_{N2}	kg/kmol	Molecular mass of nitrogen	28.02
AM_{C}	kg/kmol (g/mol)	Atomic mass of carbon	12.00
AM_{H}	kg/kmol (g/mol)	Atomic mass of hydrogen	1.01
AM_{O}	kg/kmol (g/mol)	Atomic mass of oxygen	16.00
AM_{N}	kg/kmol (g/mol)	Atomic mass of nitrogen	14.01
P_{ref}	Pa	Atmospheric pressure at reference conditions	101 325
R_{u}	$Pa.m^3/kmol.K$	Universal ideal gas constant	0.008314472
T_{ref}	K	Temperature at reference conditions	273.15
$v_{O2,air}$	Dimensionless	O_2 volumetric fraction of air	0.21
GWP_{CH4}	tCO_2/tCH_4	Global warming potential of methane	21
MV_{n}	$m^3/Kmol$	Volume of one mole of any ideal gas at reference conditions	22.414
$\rho_{CH4,\ n}$	kg/m^3	Density of methane gas at reference conditions	0.716
$NA_{i,j}$	Dimensionless	Number of atoms of element j in component i, depending on molecular structure	
VM_{ref}	m^3 / kmol	Volume of one mole of any ideal gas at reference temperature and pressure	22.4

Data / Parameter:	GWP_{CH4}
Data unit:	t CO_2e / t CH_4
Description:	Global Warming Potential of CH_4
Source of data:	IPCC
Value to be applied:	21 for the first commitment period. Shall be updated for future commitment periods according to any future COP/MOP decisions
Any comment:	-

Data / Parameter:	$SPEC_{flare}$
Data unit:	Temperature - °C Flow rate or heat flux - kg / h or m^3 / h Maintenance schedule - number of days
Description:	Manufacturer's flare specifications for temperature, flow rate and maintenance schedule
Source of data:	Flare manufacturer
Measurement procedures:	Document in the CDM-PDD the flare specifications set by the manufacturer for the correct operation of the flare for the following parameters: (a) Minimum and maximum inlet flow rate, if necessary converted to flow rate at reference conditions or heat flux; (b) Minimum and maximum operating temperature; and (c) Maximum duration in days between maintenance events
Any comment:	Only applicable in case of enclosed flares. Maintenance schedule is not required if Option A is selected to determine flare efficiency of an enclosed flare

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 in case of continuous monitoring. Project participants shall use one minute or a smaller discrete time interval for reporting purposes.

Data / Parameter:	$F_{CH4,EG,t}$
Data unit:	kg / t
Description:	Mass flow of methane in the exhaust gas in the time period *t*
Source of data:	Third party accredited entity
Measurement procedures:	Measure the mass flow of methane in the exhaust gas according to an appropriate national or international standard e.g. UKs Technical Guidance LFTGN05 The time period *t* over which the mass flow is measured must be at least one hour The average flow rate to the flare during the time period *t* must be greater than the average flow rate observed for the previous six months
Monitoring frequency:	Biannual
QA/QC procedures	According to the standard applied.
Any comment:	Monitoring of this parameter is required in the case of enclosed flares and the project participant selects Option B.1 to determine flare efficiency

Data / Parameter:	$T_{EG,m}$
Data unit:	°C
Description:	Temperature in the exhaust gas of the enclosed flare in minute *m*
Source of data:	Project participants
Measurement procedures:	Measure the temperature of the exhaust gas in the flare by a Type N thermocouple. Measurements outside the operational temperature specified by the manufacturer may indicate that the flare is not functioning correctly and may require maintenance Flare manufacturers must provide suitable monitoring ports for the monitoring of the temperature of the flare. These would normally be expected to be in the middle third of the flare Where more than one temperature port is fitted to the flare, the flare manufacturer must provide written instructions detailing the conditions under which each location shall be used and the port most suitable for monitoring the operation of the flare according to manufacturers specifications for temperature
Monitoring frequency:	Once per minute
QA/QC procedures	Thermocouples should be replaced or calibrated at least every year in accordance with their maintenance schedule
Any comment:	Unexpected changes such as a sudden increase in temperature can occur for different reasons. These events should be noted in the site records along with any corrective action that was implemented to correct the issue Monitoring of this parameter is applicable in case of enclosed flares. Measurements are required to determine if manufacturer's flare specifications for operating temperature are met

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Data / Parameter:	$v_{i,RG,m}$
Data unit:	-
Description:	Volumetric fraction of component *i* in the residual gas on a dry basis in the hour *h* where *i* = CH_4, CO, CO_2, O_2, H_2, H_2S, NH_4, N_2
Source of data:	Measurements by project participants using a continuous gas analyser
Measurement procedures:	Measurement may be made on either dry or wet basis. If value is made on a wet basis, then it shall be converted to dry basis for reporting
Monitoring frequency:	Continuously. Values to be averaged on a minute basis
QA/QC procedures	Analysers must be periodically calibrated according to the manufacturer's recommendation. A zero check and a typical value check should be performed by comparison with a standard certified gas
Any comment:	As a simplified approach, project participants may only measure the content CH_4, CO and CO_2 of the residual gas and consider the remaining part as N_2. Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency

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Data / Parameter:	$V_{RG,m}$
Data unit:	m^3 / m
Description:	Volumetric flow rate of the residual gas on dry basis at reference conditions in the minute *m*
Source of data:	Measurements by project participants using a flow meter
Measurement procedures:	Instruments with recordable electronic signal (analogical or digital)
Monitoring frequency:	Continuously. Values to be averaged on a minute basis
QA/QC procedures	Flow meters are to be periodically calibrated according to the manufacturer's recommendation
Any comment:	Monitoring of this parameter is applicable in case of enclosed flares and continuous monitoring of the flare efficiency and if project participant selects to calculate $V_{RG,m}$ instead of monitoring directly Monitoring of this parameter may also be necessary for confirming that the manufacturer's specifications for flow rate/heat flux are met. In this case the flow rate should be measured in a m^3 / h basis

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Data / Parameter:	$M_{RG,m}$
Data unit:	kg / m
Description:	Mass flow rate of the residual gas at reference conditions on dry basis in the minute *m*
Source of data:	-
Measurement procedures (if any):	Instruments with recordable electronic signal (analogical or digital)
Monitoring frequency:	Continuous, values to be averaged on a minute basis
QA/QC procedures:	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. Calibration and frequency of calibration is according to manufacturer's specifications
Any comment:	Monitoring of this parameter is applicable in case of enclosed flares and continuous monitoring of the flare efficiency and if project participant selects to monitor $M_{RG,m}$ directly, instead of calculating Monitoring of this parameter may also be necessary for confirming that the manufacturer's specifications for flow rate/heat flux are met. In this case the flow rate should be measured in a kg / h basis

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Data / Parameter:	$v_{O2,EG,m}$
Data unit:	-
Description:	Volumetric fraction of O_2 in the exhaust gas in the minute *m*
Source of data:	Measurements by project participants using a continuous gas analyser
Measurement procedures:	Extractive sampling analysers with water and particulates removal devices or in situ analysers for wet basis determination. The point of measurement (sampling point) shall be in the upper section of the flare (80% of total flare height). Sampling shall be conducted with appropriate sampling probes adequate to high temperatures level (e.g. inconel probes)

Monitoring frequency:	Continuously. Values to be averaged on a minute basis
QA/QC procedures	Analysers must be periodically calibrated according to the manufacturer's recommendation. A zero check and a typical value check should be performed by comparison with a standard gas
Any comment:	Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency

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Data / Parameter:	$fc_{CH4,FG,m}$
Data unit:	mg / m^3
Description:	Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in the minute *m*
Source of data:	Measurements by project participants using a continuous gas analyser
Measurement procedures:	Extractive sampling analysers with water and particulates removal devices or in situ analyser for wet basis determination. The point of measurement (sampling point) shall be in the upper section of the flare in order that the sampling is of the gas after consumption has taken place (80% of total flare height). Sampling shall be conducted with appropriate sampling probes adequate to high temperatures level (e.g. inconel probes)
Monitoring frequency:	Continuously. Values to be averaged on a minute basis
QA/QC procedures	Analysers must be periodically calibrated according to manufacturer's recommendation. A zero check and a typical value check should be performed by comparison with a standard gas
Any comment:	Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency Measurement instruments may read ppmv or % values. To convert from ppmv to mg/m^3 simply multiply by 0.716. 1% equals 10 000 ppmv

209

Data / Parameter:	$Flame_m$
Data unit:	Flame on or Flame off
Description:	Flame detection of flare in the minute *m*
Source of data:	Project participants
Measurement procedures:	Measure using a fixed installation optical flame detector: Ultra Violet detector or Infra Red or both
Monitoring frequency:	Once per minute. Detection of flame recorded as a minute that the flame was on, otherwise recorded as a minute that the flame was off
QA/QC procedures	Equipment shall be maintained and calibrated in accordance with manufacturer's recommendations
Any comment:	Applicable to all flares

210

Data / Parameter:	$Maintenance_y$
Data unit:	Calendar dates
Description:	Maintenance events completed in year *y*
Source of data:	Project participants

Measurement procedures:	Record the date that maintenance events were completed in year *y*. Records of maintenance logs must include all aspects of the maintenance including the details of the person(s) undertaking the work, parts replaced, or needing to be replaced, source of replacement parts, serial numbers and calibration certificates
Monitoring frequency:	Annual
QA/QC procedures	Records must be kept in a maintenance log for two years beyond the life of the flare
Any comment:	Monitoring of this parameter is required for the case of enclosed flares and the project participant selects Option B to determine flare efficiency These dates are required so that they can be compared to the maintenance schedule to check that maintenance events were completed within the minimum time between maintenance events specified by the manufacturer ($SPEC_{,flare}$)

IV. REFERENCES

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

Environment Agency Guidance for monitoring enclosed landfill gas flares. LFTGN05 v2 2010

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History of the document

Version	Date	Nature of revision(s)
02.0.0	EB 67, Annex # 11 May 2012	Revision to: • Provide an additional option for determining the methane destruction efficiency of an enclosed flare, using biannual measurements of the efficiency of the flare; • Expand the applicability of the tool to flaring gases that also contain ammonium and hydrogen sulfide; • Define low height flares and specifies how the methane destruction efficiency shall be determined for this type of flares; • Change the title from Methodological “Tool to determine project emissions from flaring gases containing methane” to “Project emissions from flaring”. • Improve the structure and other editorial aspects. Due to the overall modification of the document, no highlights of the changes are provided.
01.0.0	EB 28, Annex 13 15 December 2006	Initial adoption.
Decision Class: Regulatory **Document Type**: Tool **Business Function**: Methodology		