CLEAN DEVELOPMENT MECHANISM

CDM-MP85-A01

Draft Large-scale Methodology

AM00XX: Recovery of methane-rich vapours from hydrocarbon storage tanks

Version 01.0

Sectoral scope(s): 10

United Nations
Framework Convention on
Climate Change

COVER NOTE

1. Procedural background

1. This methodology is based on the following proposed new methodology: NM0380: Recovery of methane-rich vapours from hydrocarbon storage tanks, separators or stabilization containers.

2. Purpose

2. To present a new methodology in the oil and gas sector aiming to reduce methane emissions from the oil storage tanks where, in the absence of the proposed project, the methane-rich vapours would be vented into the atmosphere.

3. Key issues and proposed solutions

3.1. Applicability

3. The methodology is applicable to project activities that recover methane-rich vapours that were previously vented into the atmosphere from hydrocarbon storage tanks located within existing (prior to 31 December 2020) oil production facilities, oil and gas pre-treatment facilities, gas processing plants, oil treatment facilities, and liquid hydrocarbon storage tanks and loading stations. Stabilization containers are not eligible under this methodology. The recovered gas may be flared or utilized to generate energy.

3.2. Baseline scenario, baseline emissions and project emissions

4. The identification of baseline scenario and demonstration of additionality shall follow TOOL02.

5. Venting of the methane-rich vapours takes place at facilities where hydrocarbon storage tanks are located, either directly from the vent points on the storage tanks or from a dedicated vent stack.

6. The baseline emissions are determined based on real measurements of the recovered flow of methane-containing gas multiplied by the methane fraction. The methodology provides several methods for *ex-ante* estimation of baseline emissions at validation. The temperature and pressure data at the last stage immediately prior to the storage tanks are required to be monitored in order to avoid process manipulation to gain emission reductions.

7. The project emissions are determined based on the consumption of fossil fuel, electricity and the combustion of the methane through flaring. No leakage is anticipated under this methodology.

8. The main monitoring parameters will include the quantity of the recovered methane (i.e. gas flow and the methane fraction), pressure and temperature in the separator, as well as the quantity of electricity and fossil fuels consumed by the project activity.

4. Impacts

9. This methodology, if approved, is expected to facilitate the development of new projects in the oil and gas sector.

5. Subsequent work and timelines

10. The proposed methodology was recommended by the Methodologies Panel at its 85th meeting for approval by the Executive Board at its 111th meeting. No further work is envisaged.

6. Recommendations to the Board

11. The Methodologies Panel recommends that the Board adopt this new methodology, to be effective from the time of the Board's approval.

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1. Introduction

1.1. Background

12. The following table describes the key elements of the methodology:

Table 1. Methodology key elements

Typical project(s)	Recovery and destruction of the methane-rich vapours that were previously vented into the atmosphere from the hydrocarbon storage tanks. The destruction can take place in flares or by utilizing the gas for energy generation purposes.
Type of greenhouse gas (GHG) emissions mitigation action	GHG emission avoidance: Recovery and destruction of methane.

2. Scope, applicability, and entry into force

2.1. Scope

13. This methodology applies to project activities that recover and destroy the methane in the methane-rich vapours from hydrocarbon storage tanks within existing[1] (prior to 31 December 2020) oil production facilities, oil and gas pre-treatment facilities, gas processing plants, oil treatment facilities, and liquid hydrocarbon storage tanks and loading stations, by use of vapour recovery units.

2.2. Applicability

14. The methodology is applicable to project activities that recover the methane-rich vapours that were previously vented into the atmosphere from the hydrocarbon storage tanks located within existing (prior to 31 December 2020) oil production facilities, oil and gas pre-treatment facilities, gas processing plants, oil treatment facilities, and liquid hydrocarbon storage tanks and loading stations. Stabilization containers are not eligible under this methodology. The recovered methane may be flared or utilized to generate energy.

15. The methodology is applicable under the following conditions:

(a) Under the project activity, the recovered gas is further transported for at least one of the following purposes:

(i) on-site heat generation;

(ii) on-site electricity generation;

(iii) a gas pipeline;

[1] New oil production and storage facilities that are installed after 2020 are not eligible under this methodology.

(iv) a large compressor within the facility that leads to the gas being utilized through combustion;

(v) a flare system.

(b) The pressure and temperature of the last stage of separation from which the liquids are sent to the project storage tanks remain the same before and after the project implementation.

(c) The applicability conditions included in the tools referred to below apply.

(d) The methodology is only applicable if the application of the procedure to identify the baseline scenario results in continuation of venting of the vapours from the storage tanks as the most plausible baseline scenario.

(e) All of the recovered gas originates from hydrocarbon production facilities that have been in operation and are producing liquid hydrocarbons at the time of implementing the recovery of the vapours. Storage tanks that started operation after 31 December 2020 are not eligible under this methodology.

(f) All of the methane-containing vapours originate from existing hydrocarbon production facilities upstream of the project activity. The project activity is implemented in storage tanks at locations such as oil/condensate storage terminals, tank batteries, and centralized tank farms that receive oil from existing fields.

2.3. Entry into force

16. The date of entry into force is the date of the publication of the EB XX meeting report on DD Month 2021.

2.4. Applicability of sectoral scopes

17. For validation and verification of clean development mechanism (CDM) projects and programmes of activities by a designated operational entity (DOE) using this methodology, application of sectoral scope 10 is mandatory.

3. Normative references

18. This baseline and monitoring methodology is based on the following proposed new methodology and approved methodologies:

(a) “NM0380: Recovery of methane-rich vapours from hydrocarbon storage tanks, separators and stabilization containers”;

(b) “AM0009: Recovery and utilization of gas from oil fields that would otherwise be flared or vented”;

(c) “AM0023: Leak detection and repair in gas production, processing, transmission, storage and distribution”.

19. This methodology also refers to the latest approved versions of the following tools:

(a) “TOOL02: Combined tool to identify the baseline scenario and demonstrate additionality” (hereinafter referred as “TOOL02”);

(b) “TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion” (hereinafter referred as “TOOL03”);

(c) “TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” (hereinafter referred as “TOOL05”);

(d) “TOOL06: Project emissions from flaring” (hereinafter referred as “TOOL06”);

(e) “TOOL07: Tool to calculate the emission factor for an electricity system” (hereinafter referred as “TOOL07”);

(f) “TOOL11: Assessment of the validity of the original/current baseline and to update of the baseline at the renewal of the crediting period” (hereinafter referred as “TOOL11”).

20. For more information regarding the proposed new methodologies and the tools as well as their consideration by the Executive Board, please refer to <http://cdm.unfccc.int/goto/MPappmeth>.

3.1. Selected approach from paragraph 48 of the CDM modalities and procedures

21. “Existing actual or historical emissions, as applicable”.

4. Definitions

22. The definitions contained in the Glossary of CDM terms shall apply.

23. For the purpose of this methodology, the following definitions apply:

(a) **Flaring –** combustion of gas at a flare stack.

(b) **Hydrocarbons (HCs) –** under this methodology, HCs refer to compounds that have a low boiling point and a high vapour pressure, resulting in their easy evaporation from the liquid state and release into the atmosphere. In hydrocarbon products of the oil and gas industry, alkanes (such as methane, ethane and propane, butane, pentane and hexane) are considered as part of the HCs, in addition to alkenes (such as ethylene and propylene) and aromatics (such as benzene and toluene).

(c) **Hydrocarbon storage tanks –** vessels used in oil and natural gas facilities for holding liquid hydrocarbon products (mainly crude oil, condensates and produced water) for a period of time until they are further transported by pipelines, trucks or floating vessels. In many cases, storage tanks are operated at atmospheric pressure with fixed roofs, allowing light HCs dissolved in the crude oil or condensate (e.g. unstabilized hydrocarbon liquids), including methane and other HCs, to vaporize out from the liquids stored in the tank. These typically methane-rich vapours may be vented to the atmosphere. Under this methodology, storage tanks are the only eligible source where the recovery of methane-rich vapours takes place under the project activity.

(d) **Liquid dropouts –** products of the Vapour Recovery Unit (VRU) in liquid phase consisting mostly of heavier components (natural gas liquids) which are typically pumped back into the hydrocarbon storage tank after separation from the gaseous compounds.

(e) **Loading facilities –** also called loading terminals, are facilities designed to store and subsequently load HCs to vessels or vehicles for further transportation, both onshore and offshore.

(f) **Non-methane hydrocarbons (NMHCs) –** under this methodology, NMHCs refers to any compounds of HCs (such as ethane, ethene, propane, propene, and isoprene) that constitute the flash gas emitted from the storage tanks, excluding methane.

(g) **Oil field –** the area of land or seabed containing reserves of petroleum deposits, secured under concession for the purpose of extracting oil.

(h) **Recovered gas –** the product of the VRU in gas phase consisting mostly of methane which is transferred further to a utilization point (typically compressed) or to a flare, after the liquid dropouts are removed.

(i) **Storage facilities –** also referred to as tank farms, tank batteries, or storage tank complexes, which include hydrocarbon storage tanks, stabilization containers (if installed), as well as other ancillary facilities required to handle the temporary storage of liquid HCs. Storage facilities may be standalone facilities or may be units within larger hydrocarbon production or treatment facilities.

(j) **Venting –** engineered or intentional releases of gases into the atmosphere, such as the venting of vapours (including methane and NMHCs) from storage tanks.

(k) **Vapour recovery units (VRUs) –** systems which are used to collect vented HCs from storage tanks. They separate heavier components (natural gas liquids mostly consisting of NMHCs) and transfer the recovered gas (mostly consisting of methane) to the point of utilization (e.g. injection into the suction of a larger compressor, a local fuel gas system, directly into a gas gathering line) or route the recovered gas to a flare.

5. Baseline methodology

5.1. Project boundary

24. The **spatial extent** of the project boundary encompasses:

(a) The project facilities, where the oil is extracted from the oil field and transported to the storage tanks included in the project activity, where the recovery of methane-rich vapours takes place;

(b) The existing (prior to 31 December 2020) storage tanks where the venting of vapours originate from, including the vent stack in cases where the storage tank vapours are routed to an existing vent stack;

(c) The vapour recovery unit (or units where more than one unit is installed under the project activity), including the piping to recover the vapours, the VRU(s) and related infrastructure, including where applicable, the compressors;

(d) The infrastructure laid as part of the project activity to transfer the recovered gas to the point of utilization, tie-in point to a pipeline within the facility or the flare.

25. Emissions from storage tanks may occur due to:

(a) Flash losses: when crude oil or natural gas condensates are transferred from a gas-oil separator at high pressure to a storage tank at lower pressure;

(b) Working losses: when crude or condensate levels change;

(c) Standing losses: with daily and seasonal temperature and barometric pressure changes.

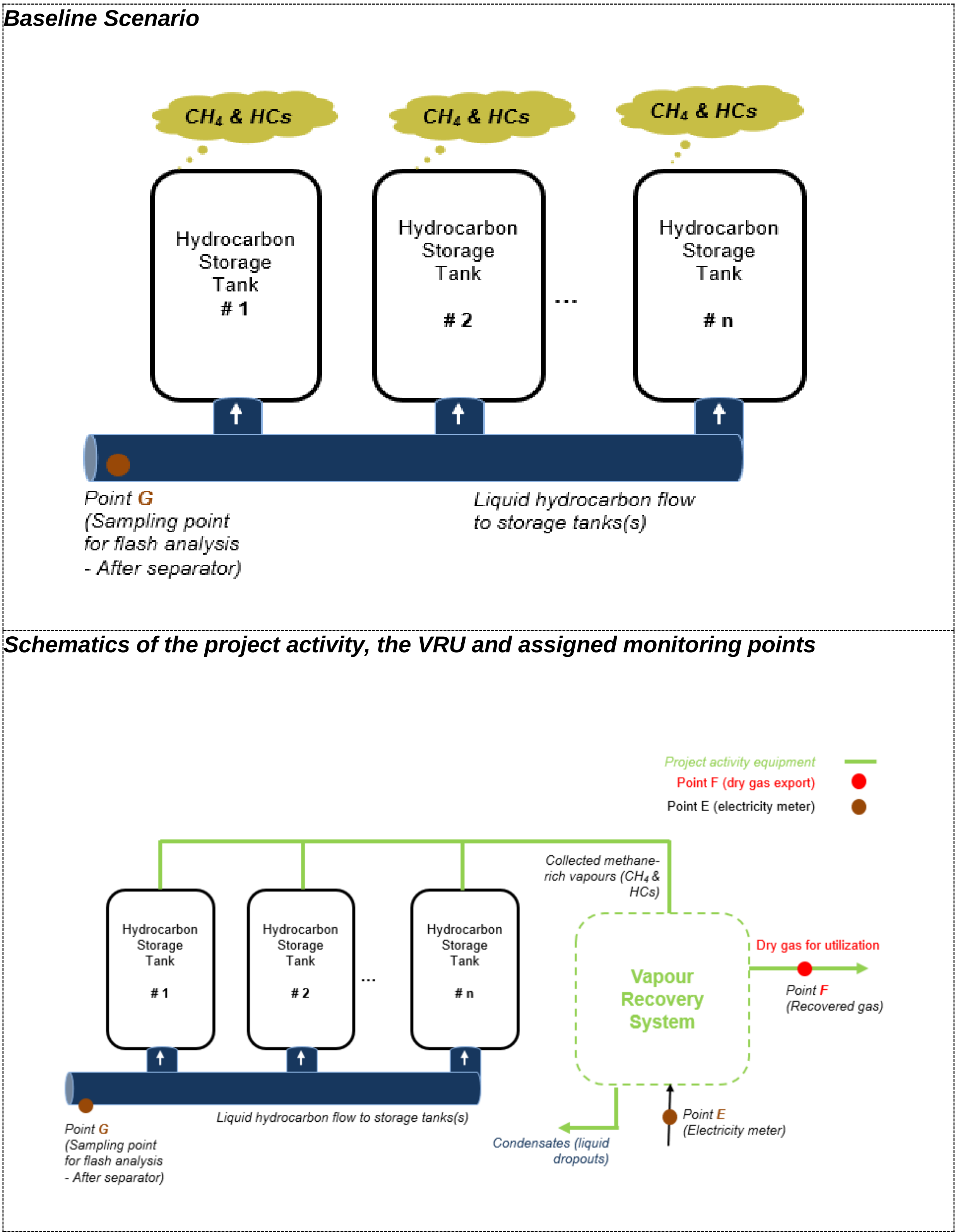
26. The GHGs included in or excluded from the project boundary are shown in table 2.

Table 2. Emissions sources included in or excluded from the project boundary

Source		Gas	Included	Justification/Explanation
Baseline	Emissions from the storage tanks included in the project boundary	CO_2	No	The CO_2 content in natural gas is very low. Exclusion is conservative.
		CH_4	Yes	Main source of emissions.
		N_2O	No	The N_2O content in natural gas is very low. Exclusion is conservative.
Project activity	Emissions related to the recovery of vapours, and transfer of productions (e.g. compression of dry gas and/or pumping of condensates and/or flaring of the recovered gas where relevant), as well as emissions from the combustion/flare of the gas.	CO_2	Yes	CO_2 emissions from electricity use or fossil fuel use for vapour recovery comprises project emissions. If the recovered gas (or part of the recovered gas) is flared, CO_2 emissions from gas combustion comprises project emissions.
		CH_4	No	Project activity does not lead to additional emissions of methane.
		N_2O	No	The N_2O content in natural gas is very low. Exclusion is conservative.

27. The figure below outlines the generic schematic of the baseline scenario and the possible schematic of the project activity.

Figure 1. Baseline scenario (top diagram) and project scenario (bottom diagram)



5.2. Identification of the baseline scenario and demonstration of additionality

28. The identification of the baseline scenario and demonstration of additionality shall be conducted by following TOOL02. While identifying the baseline scenarios, the plausible alternative scenarios should be assessed, including, at least, the following alternatives:

    (a) The project activity not implemented as a CDM project;

    (b) Venting of the methane-rich vapours at a facility where hydrocarbon storage tanks are located, either directly from the vent points on the storage tanks or from a dedicated vent stack (B1 scenario);

    (c) Reducing the upstream final pressure, recovery and use of the methane-rich vapours for various purposes (B2 scenario);

    (d) All other plausible and credible alternatives to the project activity.

5.3. Baseline emissions

29. The baseline scenario comprises the emission of methane-rich vapours (methane as well as other HCs) from hydrocarbon storage tanks included as part of the project activity. This methodology provides a method for the *ex-ante* estimation of the baseline emissions (i.e. the amount of methane emissions released into the atmosphere in the absence of the project activity) and a method for the calculation of the actual baseline emissions, i.e. recovered methane emissions as the result of the implementation of the project activity.

30. If a fixed crediting period is chosen, the baseline is determined based on methane venting into the atmosphere for the entire crediting period. If the renewable crediting period is chosen, the baseline emissions are based on methane venting into the atmosphere for the first crediting period and thereafter based on energy displacement, i.e. using the recovered methane to replace a baseline fossil fuel to generate energy for the subsequent crediting periods. This would represent a simplified and conservative approach, assuming that the use of the recovered gas displaces the use of methane – the fossil fuel with the lowest direct CO_2 emissions. Emissions from processing and transportation of fuels to end-users are neglected for both the project activity and the baseline scenario, as it is assumed that these emissions are similar in their magnitude and level out.

31. For projects implemented in oil production facilities, the validating DOE shall confirm that that the associated gas has been separated from the oil stream prior to entering the storage facilities (hydrocarbon storage tanks).

32. At validation, the DOE shall check the pressure and temperature data of the last stage of separation from which the liquids are sent to storage tanks. At verification, the same parameters shall be checked to determine if these process conditions differ significantly[2] as compared to pressure/temperature data prior to the crediting period. If significant differences are observed, it should be checked that this is not intentional to send more gas to the storage tank and that any difference is justified. If there are multiple separators prior to the storage tanks, the DOE shall check the separator pressure and temperature data of all of them.

[2] The process conditions are considered as significantly different if the monitored pressure exceeds the parameter "cap of Psep" (see parameter table 21), or if the monitored temperature falls below the parameter "threshold of Tsep" (see parameter table 22).

5.3.1. Calculation of baseline emissions (*ex-post*)

33. Baseline emissions occur from the hydrocarbon storage tanks that would not be recovered in the absence of a project activity. Baseline emissions (*ex-post*) from hydrocarbon storage tanks will consist of measured methane emissions from the venting of storage tanks.

34. The equation below is used to calculate baseline emissions for the first 7 years' crediting period or 10 years' if fixed crediting period is chosen:

$$BE_y = F_{CH4,y} \times ConvFactor \times GWP_{CH4} \quad \text{Equation (1)}$$

Where:

BE_y	=	Baseline emissions in year *y* (tCO_{2e})
$F_{CH4,y}$	=	Quantity of recovered methane in Point *F* in year *y* (m^3CH_4)
$ConvFactor$	=	Conversion factor to convert m^3CH_4 into tCH_4
GWP_{CH4}	=	Global Warming Potential of CH_4 (tCO_2e/tCH_4)

35. The equation below is used to calculate baseline emissions after the first seven years' crediting period, if renewable crediting period is chosen.

$$BE_y = F_{CH4,y} \times NCV_{CH4} \times EF_{CO2,CH4} \quad \text{Equation (2)}$$

Where:

BE_y	=	Baseline emissions in year *y* (tCO_2e) of the second or third crediting period
$F_{CH4,y}$	=	Quantity of recovered methane in Point *F* in year *y* of the second or third crediting period (m^3CH_4)[3]
$NCV_{CH4,y}$	=	Average net calorific value of recovered gas at point *F* in Figure 2 in year *y* of the second or third crediting period (TJ/m^3)
$EF_{CO2,CH4}$	=	CO_2 emission factor for CH_4 (tCO_2e/TJ)

36. If, during part of the monitoring period, the flow rate of the recovered gas cannot be measured, then emission reductions are conservatively assumed to be zero for that part of the monitoring period.

5.3.2. Estimation of baseline emissions (*ex-ante*)

37. The *ex-ante* quantification methods described below shall be applied to estimate the baseline emissions in the project design document or in the component programme activity design documents. The most conservative value among the methods below as selected by the project participants shall be used to estimate the *ex-ante* baseline emissions. Project participants shall apply method A (Direct *ex-ante* quantification) and at least two of the three indirect quantification methods B, C, and D. The project participant shall document and justify in the CDM-PDD the selection of the quantification methods.

[3] All volume units in this methodology in cubic meters (m^3) are in normal conditions.

38. The indirect quantification results from the method B, C, or D shall be applied to cross-check the result from the direct quantification method A. The most conservative estimation should be chosen as the estimation of *ex-ante* baseline emissions.

5.3.2.1. Method A – Direct *ex-ante* quantification

39. Under this method, two cases are presented for the purpose of calculating the *ex-ante* emissions from two types of storage tank vents:

(a) *Case 1:* For tanks that release vapours directly to the atmosphere (e.g. from the hatches on top or on the side of the tank or separator, breathing valves on the tanks, pressure relief valves, or open vent points designed on the storage tank).

(b) *Case 2:* For situations where vented vapours from storage tanks are collected, routed to a vent line and released to the atmosphere through a designated vent stack. (Note: in particular in situations where the vent stack is also used for other vented emissions, or if using Case 2 is technically unfeasible, the project proponent may use Case 1).

5.3.2.1.1. Case 1 – Cases where vapours are directly vented from each individual tank

(a) In order to estimate the amount of methane emissions from tanks where vapours are directly vented to the air, emission points on the tanks shall be detected and their emission rates shall be quantified under conditions of both tank filling and tank not being filled.[4]

(b) Methane emission volumes can be assessed by using high-volume samplers, calibrated volume bags, vane anemometers or other suitable means. For the sake of practicality, where emission sources are elevated and/or unreachable and/or technically infeasible for direct measurement, they may be conservatively estimated through a visualization approach using optical gas-imaging cameras.

(c) The project participant must justify the choice and demonstrate why this approach is deemed as conservative (e.g. the project participant could include third-party expert interpretation and should take into account operational conditions at the time of optical gas-imaging recording).

40. The following Equation 3 is used to estimate baseline emissions from the storage tanks included within the project boundary, prior to the implementation of the VRU(s).

$$BE_{ex-ante,case\ 1,y} = ConvFactor \times GWP_{CH4} \times \sum_{i}^{n} \left[\left(H_{fill,i,y} \times R_{ave,i,fill} \right) + \left(H_{no-fill,i,y} \times R_{ave,i,no-fill} \right) \right]$$

Equation (3)

Where:

$BE_{ex\text{-}ante,case\ 1,y}$	=	*Ex-ante* estimation of the baseline emissions during year y of the crediting period (t CO_2/y)
$ConvFactor$	=	Conversion factor to convert m^3CH_4 into tCH_4

[4] For the purposes of *ex-ante* estimations only. Actual baseline emissions will be measured *ex post*.

GWP_{CH4}	=	Global Warming Potential of CH_4 (tCO_2e/tCH_4)
$H_{fill,i,y}$	=	Average number of hours per year that tank *i* is being filled (h/y)
$H_{no\text{-}fill,i,y}$	=	Average number of hours per year that tank *i* is not being filled (h/y)
$R_{ave,i,fill}$	=	Methane emission rate for tank *i* while being filled (m^3/h)
$R_{ave,i,no\text{-}fill}$	=	Methane emission rate for tank *i* while not being filled (m^3/h)
n	=	Number of tanks

5.3.2.1.2. Case 2 – Cases where vapours are vented through a dedicated vent stack

(a) In order to estimate the amount of emissions (methane-rich vapours) vented from tanks where the vapours are routed to a vent stack and then released to the atmosphere, the vented emissions ($BE_{ex-ante,case2,y}$) could be measured:

(i) either directly by use of vane anemometer, calibrated bag, or other standard measurement device, or

(ii) by existing or temporarily installed flow meters. If various measurements are performed under different operational circumstances (i.e. when the tanks are being filled and when the tanks are not being filled), the same approach as Case 1 can be applied to estimate the total emissions.

41. Under Case 1 or Case 2, the methane fraction in the emitted vapours shall be determined by results of laboratory analysis through gas chromatography based on sampling the vapours emitted. If more than one tank is sampled, the minimum value shall be used. If no reliable analysis can be provided, a default value of 27.4%[5] (volume) can be used for the fraction of methane.

5.3.2.2. Method B – E&P TANKS5 or process engineering calculation

42. The project participant(s) may carry out engineering calculations with programmes such as E&P TANKS5 or similar, or to provide engineering calculations performed by a third-party process engineering entity, or use verifiable empirical equations.

5.3.2.3. Method C – By calculation

43. The project participant(s) may carry out an estimation of the amount of vented gas by applying an emission factor (e.g. $kgCH_4$/year/tank or $kgCH_4$/barrel of oil), if available, or alternatively, by use of the following Vasquez-Beggs equation.

44. The project participant(s) may estimate emissions of HCs (methane and NMHCs) by use of the Vasquez-Beggs equation:

$$GOR = A \times G_{fg} \times (P_{sep} + 14.7)^B \times exp\left(\frac{C \times G_{oil}}{T_{sep} + 460}\right)$$ Equation (4)

[5] American Petroleum Institute. August 2009. Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Natural Gas Industry. Pages 5-43.

Where:

GOR	=	Ratio of flash gas production to standard stock tank barrels of oil produced, in standard cubic feet/barrel (barrels corrected to 60°F/ 15,556°C)
G_{fg}	=	Specific gravity of the tank flash gas, where air = 1. A suggested default value for G_{fg} is 1.22
G_{oil}	=	API gravity of stock tank oil at 60°F (equivalent to 15,556°C)
P_{sep}	=	Pressure in separator (or other vessel directly upstream), in lb/in^2 [1 lbf/in^2 (Psi) = 6,894.757 Pascals (Pa)]
T_{sep}	=	Temperature in separator (or other vessels directly upstream of the tank), °F
A	=	0.0362 for G_{oil} $\leq$ 30°API, or 0.0178 for G_{oil} > 30°API
B	=	1.0937 for G_{oil} $\leq$ 30°API, or 1.187 for G_{oil} > 30°API
C	=	25.724 for G_{oil} $\leq$ 30°API, or 23.931 for G_{oil} > 30°API"

45. The result of this correlation provides an estimate of flashing tank vapours that can be multiplied by the methane fraction to obtain the methane emission rate.

$$BE_{ex-ante,y,C} = GOR \times Q_{oil} \times F_{CH4,y}$$ Equation (5)

Where:

$BE_{ex-ante,y,C}$	=	*Ex-ante* quantification of baseline emissions in the methane-rich vapours emissions under Method C (t CH4/y)
GOR	=	ratio of flash gas production to standard stock tank barrels of oil produced
Q_{oil}	=	Quantity of oil produced and flowed through the storage facility (barrel/y)
$F_{CH4,y}$	=	Fraction of methane in the emitted vapours (%)

5.3.2.4. Method D – Analysis of flash gas

46. Where access to a laboratory is available in the country, the project participant should carry out "flash analysis testing" to determine the emissions of flash gas *ex ante*. Standards such as the "California Code of Regulations, Title 17, Division 3, Chapter 1, Subchapter 10 Climate Change, Article 4", or an equivalent International Organization for Standardization (ISO), national or industrial standard practice, may be used.

5.4. Project emissions

47. Project emissions under this methodology may include emissions from the consumption of electricity, fossil fuels and CO_2 emissions from the flaring.

48. If the recovered gas is utilized for energy purposes (i.e. not destroyed by a flare system), the recovered gas is assumed to substitute an equivalent amount of gas sourced from elsewhere. Therefore, project emissions from combustion are assumed to be zero.

49. Project emissions are calculated as a sum of the project emissions from fossil fuel consumption, electricity consumption, and emissions from methane flaring, if any, as follows:

$$PE_y = PE_{EC,y} + PE_{FC,y} + PE_{flaring,y}$$ Equation (6)

Where:

PE_y	=	Project emissions in year *y* (t CO_2/yr)
$PE_{EC,y}$	=	Project emissions from electricity consumption in year y (t CO_2/yr)
$PE_{FC,y}$	=	Project emissions from fossil fuel consumption in year y (t CO_2/yr)
$PE_{flaring,y}$	=	Project emissions from flaring of the recovered gas in year y (t CO_2yr) if applicable

5.4.1. Determination of project emissions from electricity consumption

50. Project emissions due to the incremental use of electricity for the operation of VRU(s) are calculated applying the latest approved version of TOOL05, where consumption from all sources of electricity consumption (e.g. a compressor, pumps, control system) should be documented transparently in the CDM-PDD and monitoring reports.

$$PE_{EC,y} = EC_y \times EF_{EL,y}$$ Equation (7)

Where:

PE_y	=	Project emissions in year *y* (tCO_2)
EC_y	=	Quantity of electricity consumed by the project activity in year *y* (kWh)
$EF_{EL,y}$	=	Emission factor for electricity generation in year *y* (tCO_2/kWh)

5.4.2. Determination of project emissions from fossil fuel consumption

51. Project emissions from fossil fuel combustion are only relevant in case fossil fuels are consumed by the project activity. If the project activity leads to an incremental use of fossil fuels, the resulting project emissions are calculated by following the latest version of TOOL03.

$$PE_{FC,i,y} = \sum_i FC_{i,y} \times COEF_{i,y}$$ Equation (8)

Where:

$PE_{FC,i,y}$	=	CO_2 emissions from fossil fuel type *i* combustion during the year *y* (tCO_2)
$FC_{i,y}$	=	the incremental quantity of fossil fuel type *i* combusted during the year *y* (mass or volume unit)
$COEF_{i,y}$	=	the CO_2 emission coefficient of the fossil fuel type *i* in year *y* (tCO_2/mass or volume unit)

5.4.3. Determination of project emissions from flaring

52. Project emissions from flaring are only relevant for project activities where a portion or all of the recovered gas is flared. Emissions shall be calculated by following the latest version of TOOL06.

5.5. Leakage

53. No significant leakage is expected to occur in these types of projects. Therefore, leakage is considered as zero under this methodology.

5.6. Emission reductions

54. Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y \qquad \text{Equation (9)}$$

Where:

ER_y	=	Emission reductions in year y (tCO_2)
BE_y	=	Baseline emissions in year y (tCO_2)
PE_y	=	Project emissions in year y (tCO_2)
LE_y	=	Leakage emissions in year y (tCO_2)

5.7. Changes required for methodology implementation in second and third crediting periods

55. Refer to TOOL11: “Assessment of the validity of the original/current baseline and to update of the baseline at the renewal of the crediting period”.

5.8. Data and parameters not monitored

56. In addition to the parameters listed in the tables below, the provisions on data and parameters not monitored in the tools referred to in this methodology apply.

Data / Parameter table 1.

Data / Parameter:	***GWP_{CH4}***
Data unit:	tCO_2e/tCH_4
Description:	Global Warming Potential of CH_4
Source of data:	IPCC
Measurement procedures (if any):	Project participants shall update GWPs according to any decisions by the CMP/EB. A **GWP_{CH4}** = 21 for the first commitment period[6]
Monitoring frequency:	

[6] EB108, para.7. This value will be automatically updated according to latest CMP or EB decisions.

QA/QC procedures:	Baseline emission calculations
Any comment:	The value for the Global Warming Potential of CH_4 shall be updated based on the latest decision of the CMP/EB.

Data / Parameter table 2.

Data / Parameter:	***ConvFactor***
Data unit:	t/m^3
Description:	Conversion factor of methane from volume (m^3) to weight (tonnes)
Source of data:	IPCC
Measurement procedures (if any):	N/A. When applying local industry's "normal conditions", defined as 0 degrees Celsius and 101.3 kPa, a value of 0.000716 t/m^3 (IPCC 2006 Vol.2, p. 4.12) is used to convert from m^3CH_4 into tCH_4 and the flow rate should be determined for reference conditions of 0 degrees Celsius and 101.3 kPa.
Monitoring frequency:	N/A
QA/QC procedures:	The recovered methane flow rate (F_{CH4}) and conversion factor (ConvFactor) should be reduced to the same reference conditions
Any comment:	--

Data / Parameter table 3.

Data / Parameter:	$EF_{CO2,\ CH4}$
Data unit:	tCO_2e/TJ
Description:	CO_2 emission factor for methane
Source of data:	Calculated in line with procedures and data presented in ISO 6976: **Table 3. Carbon content, CO_2 emission factor and net calorific value (NCV) of methane** <table><tr><th>Unit</th><th>Value</th><th>Source</th></tr><tr><td>Carbon Content of Methane</td><td>12,011 kg/kmol</td><td>ISO 6976: Table 1</td></tr><tr><td>CO_2 Emission Factor for Methane</td><td>44.01 kg/kmol</td><td>ISO 6976: Table 1</td></tr><tr><td>NCV of Methane (at 25^0C)</td><td>802.60 kJ/mol</td><td>ISO 6976: Table 3</td></tr></table>
Value to be applied:	54.834 tCO_2/TJ
Any comment:	Used to calculate project emissions in the case of flaring of the recovered gas

Data / Parameter table 4.

Data / Parameter:	***NCV_{CH4}***
Data unit:	TJ/m^3
Description:	Net calorific value of methane at point *F* in Figure 2 in year *y* (TJ/m^3)
Source of data:	Calculated in line with procedures and data presented in ISO 6976: **Carbon content, CO_2 emission factor and NCV of methane** **Unit** / **Value** / **Source**: NCV of Methane (at 25^0C) / 50.029 kJ/kg / ISO 6976: Table 4
Measurement procedures (if any):	The recovered methane flow rate (F_{CH4}) and conversion factor (ConvFactor) should be reduced to the same reference conditions
Monitoring frequency:	-
QA/QC procedures:	-
Any comment:	This parameter is used for baseline emissions after seven years' crediting period

Data / Parameter table 5.

Data / Parameter:	***$H_{fill,i,y}$ and $H_{no\text{-}fill,i,y}$***
Data unit:	h/y
Description:	**$H_{fill,i,y}$**: Average number of hours per year that tank *i* is being filled (h/y) and **$H_{no\text{-}fill,i,y}$**: Average number of hours per year that tank *i* is not being filled (h/y)
Source of data:	Operational data
Measurement procedures (if any):	The value used for "average number of hours per year a tank is being filled" ($H_{fill,i,y}$)" shall be based on the information provided by the site operator or the technical department of the company operating the facility where the project activity is implemented. This value is an annual average of all tanks included under the project activity. The data may be obtained from the technical logs of the facility. Average number of hours per year a tank is not being filled ($H_{no\text{-}fill,y}$) is calculated by subtracting $H_{fill,i,y}$ from the total number of hours in a year.
Monitoring frequency:	Undertaken for the purpose of calculating *ex-ante* estimation of baseline
QA/QC procedures:	Methods B, C and D serve as QA.
Any comment:	Parameters needed to determine emission reductions *ex-ante* under Method A

Data / Parameter table 6.

Data / Parameter:	$R_{ave,i,fill}$
Data unit:	m^3/h
Description:	Methane emission rate for tank *i* while being filled
Source of data:	Directly measured
Measurement procedures (if any):	The value for “methane emission rate for tank *i* while being filled” is calculated as the total of the methane emission rates from all vent points on tank *i* (if there is more than one vent point on the tank) while being filled. Methane emission volumes can be assessed by using high-volume samplers, calibrated vent bags, vane anemometers, hotwire anemometers or other similar quantification technologies. For the sake of practicality, where emission sources are elevated and/or unreachable and/or technically infeasible for direct measurement, they may be conservatively estimated through a visualization approach using optical gas-imaging cameras. Methane fraction in the emitted vapours shall be determined by results of laboratory analysis based on sampling the vapours emitted. If more than one storage tank is sampled, the average shall be used. If no sampling and laboratory analysis has been performed, this value shall be determined by an expert opinion based on observed gas analyser readings during the site visit, or similar observations. If no reliable analysis can be provided, a default value of 27.4% can be used for the volume fraction.
Monitoring frequency:	Undertaken for the purpose of calculating *ex-ante* estimation of baseline
QA/QC procedures:	Methods B, C and D serve as QA.
Any comment:	N/A

Data / Parameter table 7.

Data / Parameter:	$R_{ave,i,no\text{-}fill}$
Data unit:	m^3/h
Description:	Methane emission rate for tank *i* while not being filled
Source of data:	Directly measured

Measurement procedures (if any):	The value for “methane emission rate for tank *i* while not being filled” is calculated as the total of the methane emission rates from all vent points on tank *i* (if there is more than one vent point on the tank) while not being filled. Methane emission volumes can be assessed by using high-volume samplers, calibrated vent bags, vane anemometers, hotwire anemometers or other similar quantification technologies. For the sake of practicality, where emission sources are elevated and/or unreachable and/or technically infeasible for direct measurement, they may be conservatively estimated through a visualization approach using optical gas-imaging cameras. Methane fraction in the emitted vapours shall be determined by results of laboratory analysis based on sampling the vapours emitted. If more than one tank is sampled, the average shall be used. If no sampling and laboratory analysis has been performed, this value shall be determined by an expert opinion based on observed gas analyser readings during the site visit, or similar observations. If no reliable analysis can be provided, a default value of 27.4% can be used for the volume fraction.
Monitoring frequency:	Undertaken for the purpose of calculating *ex-ante* estimation of baseline
QA/QC procedures:	Methods B, C and D serve as QA.
Any comment:	N/A

Data / Parameter table 8.

Data / Parameter:	EF_{CH4}
Data unit:	kgCH4/year/tank or kgCH4/barrel of oil
Description:	Methane emission factor of the baseline scenario without the project activity
Source of data:	Official publication
Measurement procedures (if any):	The emission factor should be a nationally approved emission factor, but if no nationally approved emission factor is available, an international emission factor for comparable tanks should be used (e.g. US EPA’s Natural Gas and Petroleum Systems in the GHG Inventory).
Monitoring frequency:	N/A
QA/QC procedures:	N/A
Any comment:	*Ex-ante* baseline emission calculations – Method C

Data / Parameter table 9.

Data / Parameter:	***A, B, C***
Data unit:	-
Description:	Factors A, B and C in Vasquez-Beggs equation – Method B
Source of data:	Default

Measurement procedures (if any):	*A* 0.0362 for G_{oil} </= 30°API, or 0.0178 for G_{oil} > 30°API *B* 1.0937 for G_{oil} </= 30°API, or 1.187 for G_{oil} > 30°API *C* 25.724 for G_{oil} </= 30°API, or 23.931 for G_{oil} > 30°API
Monitoring frequency:	During *ex-ante* estimation of baseline
QA/QC procedures:	-
Any comment:	*Ex-ante* baseline emission calculations – Method C – Vasquez-Beggs equation

Data / Parameter table 10.

Data / Parameter:	G_{fg}
Data unit:	-
Description:	Specific gravity of the tank flash gas, where air = 1.
Source of data:	Lab analysis or default
Measurement procedures (if any):	Determined based on the default value 1.22, or lab analysis if available.
Monitoring frequency:	During *ex-ante* estimation of baseline
QA/QC procedures:	-
Any comment:	*Ex-ante* baseline emission calculations – Method C – Vasquez-Beggs equation

Data / Parameter table 11.

Data / Parameter:	G_{oil}
Data unit:	-
Description:	API gravity of stock tank oil at 60°F
Source of data:	Lab analysis
Measurement procedures (if any):	Determined based on available API gravity measurement of the liquids
Monitoring frequency:	During *ex-ante* estimation of baseline
QA/QC procedures:	-
Any comment:	*Ex-ante* baseline emission calculations – Method C – Vasquez-Beggs equation

Data / Parameter table 12.

Data / Parameter:	P_{sep}
Data unit:	Psi
Description:	Pressure in separator (or other vessels directly upstream)
Source of data:	Operator’s logs/equipment
Measurement procedures (if any):	Pressure gauge / transmitter of the separator / vessel
Monitoring frequency:	During *ex-ante* estimation of baseline
QA/QC procedures:	-
Any comment:	*Ex-ante* baseline emission calculations – Method C – Vasquez-Beggs equation

	For all projects, to compare to the operating conditions after project implementation

Data / Parameter table 13.

Data / Parameter:	T_{sep}
Data unit:	°F
Description:	Temperature in separator (or other vessel directly upstream of the tank)
Source of data:	Operator's logs/equipment
Measurement procedures (if any):	Temperature gauge / transmitter of the separator / vessel
Monitoring frequency:	During *ex-ante* estimation of baseline
QA/QC procedures:	-
Any comment:	*Ex-ante* baseline emission calculations – Method C – Vasquez-Beggs equation For all projects, to compare to the operating conditions after project implementation

Data / Parameter table 14.

Data / Parameter:	Q_i
Data unit:	bbl/y or m^3/y
Description:	Throughput – amount of hydrocarbon stored during the monitoring period in bbl/y (1 barrel = 0.159 m^3)
Source of data:	Technical operational data for the facility
Measurement procedures (if any):	The amount of oil that is stored/loaded in each tank *i* is determined by the operational data available for the facility (e.g. historical records) or forecasted value, as applicable
Monitoring frequency:	Undertaken for the purpose of calculating *ex-ante* estimation of baseline
QA/QC procedures:	-
Any comment:	*Ex-ante* baseline emission calculations – Method B/C

Data / Parameter table 15.

Data / Parameter:	CH_{4i}
Data unit:	%
Description:	Methane fraction in vapours (%)
Source of data:	Lab analysis or default value
Measurement procedures (if any):	Methane fraction in the emitted vapours shall be determined by results of laboratory analysis based on sampling the vapours emitted. If more than one tank is sampled, the minimum shall be used. In cases where no sampling and laboratory analysis has been performed, this value shall be determined by an expert opinion based on observed gas analyser readings during the site visit, or similar observations. If no reliable analysis can be provided, a default value of 27.4% can be used for the volume fraction.
Monitoring frequency:	Undertaken for the purpose of calculating ex-ante estimation of baseline
QA/QC procedures:	Methods B, C and D serve as QA for Method A.
Any comment:	This parameter is used with the quantity of the methane-rich vapour to obtain the amount of methane

Data / Parameter table 16.

Data / Parameter:	$Q_{gas,ex-ante}$
Data unit:	m^3/hr
Description:	*Ex-ante* amount of emissions (methane-rich vapours) vented from tanks in cases where vapours are routed to a vent stack and then released to the atmosphere i.e. the vented emissions, in cases that emission rates are directly measured.
Source of data:	Vane anemometer, calibrated bag, hotwire anemometer, high volume sampler or turbine meter
Measurement procedures (if any):	The measurement device should be calibrated as per the manufacturer's specs. For the vane anemometer, to ensure the most accurate measurements when using this device, the velocity should be measured at the centre of the pipe, close to the open end of the vent, and the temperature of the gas stream measured. An appropriately sized meter can be used to prevent the gas flow from exceeding the full measurement range of the meter and conversely to have sufficient momentum for the meter to register continuously in the course of measurement. For hotwire anemometer, to ensure accurate measurements, it is recommended that calibration curves be developed by following the manufacturer's instructions.
Monitoring frequency:	Undertaken to calculate *ex-ante* estimation of baseline
QA/QC procedures:	Methods B, C and D serve as QA for Method A
Any comment:	For calculating *ex-ante* estimation of baseline under Case 2.(a)(i).

6. Monitoring methodology

57. All data collected as part of monitoring should be archived electronically and be kept for at least for two years after the end of the last crediting period. One hundred per cent of the data should be monitored if not indicated otherwise in the tables below. All measurements should be conducted with calibrated measurement equipment according to relevant industry standards.

6.1. Data and parameters to be monitored

Data / Parameter table 17.

Data / Parameter:	$F_{CH4,y}$
Data unit:	m^3CH_4
Description:	Quantity of recovered methane in Point *F* in year *y*
Source of data:	Measurements at point *F*
Measurement procedures (if any):	Measurements of the recovered gas volume are taken at point *F*. Measurements are done in M3 using a calibrated flow meter. The methane flow rate is calculated by applying the methane mole or volume fraction as a result of sampling and lab analysis. The flash analysis testing as referred to in Method D, or an equivalent international, national or industrial standard may be followed to determine the quantity of methane.
Monitoring frequency:	Gas flow: continuous monitoring as per industry practice. Data should be recorded on a daily basis and reported on a periodic basis for the purpose of calculating emission reductions Methane fraction: at least monthly sampling
QA/QC procedures:	The volume of gas shall be metered with regularly calibrated metering equipment. Meter calibration shall be undertaken according to manufacturers' specifications, or at a minimum frequency of once every three years. The methane mole or volume fraction shall be determined by monthly sampling and analysis through gas chromatography as per industrial, national or international industry standards. The average value from the measured samples during any given monitoring period shall apply.
Any comment:	If, during part of the monitoring period, the project participant cannot monitor the flow rate of the recovered gas, then no emission reductions may be claimed for that part of the monitoring period.

Data / Parameter table 18.

Data / Parameter:	EC_y
Data unit:	kWh
Description:	Quantity of electricity consumed by the project activity in year *y*
Source of data:	Measurements at point E
Measurement procedures (if any):	As per the provisions of the latest version of TOOL05. When applying the tool, requirements for $EC_{PJ,j,y}$ specified in the tool shall apply.
Monitoring frequency:	As per the provisions of the latest version of TOOL05. When applying the tool, requirements for $EC_{PJ,j,y}$ specified in the tool shall apply.
QA/QC procedures:	As per the provisions of the latest version of TOOL05. When applying the tool, requirements for $EC_{PJ,j,y}$ specified in the tool shall apply.
Any comment:	-

Data / Parameter table 19.

Data / Parameter:	$EF_{EL,y}$
Data unit:	tCO_2/kWh
Description:	Emission factor for electricity generation in year *y*
Source of data:	Applicable options as provided by TOOL05 may be used to calculate the emission factor. The tool also refers to TOOL07.
Measurement procedures (if any):	This parameter is determined according to one of the following three options: *Option A – Compressor(s) and/or pump(s) and/or other equipment used at the VRU use grid electricity:* • The grid emission factor shall be used (Option A from TOOL05) *Option B – Compressor(s) and/or pump(s) and/or other equipment used at the VRU use electricity generated on-site:* • Emission factor of the generator shall be used (Option B from TOOL06) *Option C – Compressor(s) and/or pump(s) and/or other equipment used at the VRU use electricity generated on-site but emission factor is not available:* • Conservatively, emission factor of 0.0013 tCO_2/kWh shall be used.
Monitoring frequency:	Annual assessment and determination
QA/QC procedures:	-
Any comment:	-

Data / Parameter table 20.

Data / parameter:	***FC_y***
Data unit:	Mass or volume unit per year (ton/y or m^3/y)
Description:	Quantity of fossil fuel consumed during the year *y*
Source of data:	On-site measurements
Measurement procedures (if any):	As per the provisions of the latest version of TOOL03. When applying the tool, requirements for $FC_{i,j,y}$ specified in the tool shall apply.
Monitoring frequency:	As per the provisions of the latest version of TOOL03. When applying the tool, requirements for $FC_{i,j,y}$ specified in the tool shall apply.
QA/QC procedures:	As per the provisions of the latest version of TOOL03. When applying the tool, requirements for $FC_{i,j,y}$ specified in the tool shall apply.
Any comment:	As per the provisions of the latest version of TOOL03. When applying the tool, requirements for $FC_{i,j,y}$ specified in the tool shall apply. Monitoring is required only when fossil fuel is consumed by the project activity. If more than one type of fossil fuel is consumed, then the quantity for each type should be monitored.
Any comment:	Monitoring is required only when fossil fuel is consumed by the project activity. If more than one type of fossil fuel is consumed, then the quantity for each type should be monitored.

Data / Parameter table 21.

Data / Parameter:	***P_{sep}***
Data unit:	Pa, Bar
Description:	Pressure in separator (or other vessels directly upstream)
Source of data:	Operator’s logs/equipment
Measurement procedures (if any):	Pressure gauge / transmitter of the separator / vessel
Monitoring frequency:	Continuously
QA/QC procedures:	-
Any comment:	Measured during the project monitoring period. To compare with the pressure recorded at validation. If there are multiple separators, the pressure shall be measured for each of them.

	During validation, the DOE shall establish a cap of Psep through one of the following methods: a) Average value of monthly average pressure plus 10% for the 3-year historical period prior to submission of PDD for validation; or b) Using a design value for the pressure specified by the manufacturer; or c) Measuring the pressure during a 6-month period prior to submission of PDD for validation and adopting the average of mean daily values during the measurement period plus 10%. The DOE should validate *ex-ante* measurements aligned with historical values, if available. If, during any part of the monitoring period, the pressure P_{sep} exceeds the cap of P_{sep}, no emission reductions can be claimed during such period of time. If the parameter is measured in Psi, then the conversion factor is 1 lbf/in^2 (Psi) = 6,894.757 Pascals (Pa).

Data / Parameter table 22.

Data / Parameter:	T_{sep}
Data unit:	°C
Description:	Temperature in separator (or other vessels directly upstream of the tank)
Source of data:	Operator’s logs/equipment
Measurement procedures (if any):	Temperature gauge / transmitter of the separator / vessel
Monitoring frequency:	Continuously
QA/QC procedures:	-
Any comment:	Measured during the project monitoring period. To compare with the temperature recorded at validation. If there are multiple separators, the temperature shall be measured for each of them. Measured during the project monitoring period. To compare with the temperature recorded at validation. If there are multiple separators, the temperature shall be measured for each of them. During validation, the DOE shall establish a threshold of T_{sep} through one of the following methods: a) Average value of monthly average temperature minus 10% for the 3-year historical period prior to submission of PDD for validation; or b) Using a design value for the temperature specified by the manufacturer; or c) Measuring the temperature during a 6-month period prior to submission of PDD for validation and adopting the average of mean daily values during the measurement period minus 10%. The DOE should validate *ex-ante* measurements aligned with historical values, if available

	If, during part of any monitoring period the, temperature T_{sep} falls below the threshold of T_{sep}, no emission reductions can be claimed during such period of time.

Data / Parameter table 23.

Data / Parameter:	***Flare efficiency***
Data unit:	%
Description:	As per the provisions of the latest version of TOOL06. When applying the tool, requirements to determine the parameter $\eta_{flare,m}$ specified in the tool shall apply.
Source of data:	As per the provisions of the latest version of TOOL06. When applying the tool, requirements to determine the parameter $\eta_{flare,m}$ specified in the tool shall apply.
Measurement procedures (if any):	As per the provisions of the latest version of TOOL06. When applying the tool, requirements to determine the parameter $\eta_{flare,m}$ specified in the tool shall apply.
Monitoring frequency:	As per the provisions of the latest version of TOOL06. When applying the tool, requirements to determine the parameter $\eta_{flare,m}$ specified in the tool shall apply.
QA/QC procedures:	As per the provisions of the latest version of TOOL06. When applying the tool, requirements to determine the parameter $\eta_{flare,m}$ specified in the tool shall apply.
Any comment:	As per the provisions of the latest version of TOOL06. When applying the tool, requirements to determine the parameter $\eta_{flare,m}$ specified in the tool shall apply.

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