TCEQ REGULATORY GUIDANCE
Air Permits Division
RG-622 • Revised September 2025

Calculating Volatile Organic Compounds (VOC) Flash Emissions from Crude Oil and Condensate Tanks at Oil and Gas Production Sites

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Background

One of the largest sources of VOC emissions from an oil and gas production site is oil or condensate storage tanks.

There are three types of emissions generated by a storage tank:

1. Breathing losses (also called standing losses) are a result of evaporative losses during storage. The standing loss mechanism for a fixed roof tank is known as breathing, which is the expulsion of vapor from a tank through vapor expansion and contraction that results from changes in temperature and barometric pressure.
2. Working losses are evaporative losses during filling operations. Emissions due to filling operations are the result of an increase in the liquid level in the tank.
3. Flashing losses occur when entrained gases bubble out of solution when a liquid stream experiences a pressure drop upon introduction into a storage tank.

Flash emissions occur when produced liquid (crude oil or condensate) is exposed to temperature increases or pressure decreases during the transfer from the production separators (or similar sources) into atmospheric storage tanks. New information and technology have led to many questions recently as to the various methodologies and their accuracy to estimate flash emissions at oil and gas sites from the oil and condensate tanks.

Sources for the information in this document, as well as further information, can be found at:

2023 Emissions Inventory Guidelines[1]

Clearinghouse for Inventories and Emissions Factors (CHIEF)[2]

Methane Emissions from the Oil and Gas Sector[3]

Note: this guidance is not applicable to produced water tanks. Also, this guidance focuses only on VOC emissions, not hydrogen sulfide emissions, which may also occur, but will be addressed in a separate guidance.

Guidance

This guidance is being provided to help evaluate flash emissions and the methodologies used to estimate those emissions. There are several methods to calculate or measure emissions from storage tanks and some are more accurate than others. Some methods only calculate working and breathing losses, while other methods only calculate flash losses. However, there are also several methods to calculate all three types of emissions simultaneously.

Note: Vapor recovery units (VRUs) and flares are very efficient control devices for VOC emissions. These devices are good at controlling high VOC emission rates, especially the VRUs, and their use is encouraged. There is an informative article from 2003 by the EPA regarding the cost savings associated with VRUs, titled Installing Vapor Recovery Units on Crude Oil Storage Tanks[4].

Vapor recovery towers (VRTs) are used in tandem with VRUs to collect flash emissions. For a VRT, the pressure drop which normally would occur in the storage tank instead occurs in the VRT. Flash emissions are then routed to either a sales line or a control device. After flashing in the VRT, liquids continue to the storage tank at ambient pressure.

The Air Permits Division of the Texas Commission on Environmental Quality (TCEQ) is aware of the following methods to estimate emissions (seen in the table below). Each method for estimating emissions has specific constraints. Regardless of which method is used, all supporting data used to calculate the emissions—including identification of the calculation method, description of sampling methods, and copies of lab sampling analysis—must be provided with the emissions estimate. The relative accuracy of the methods shown below is a preliminary opinion only.

[1] www.tceq.texas.gov/downloads/air-quality/point-source/guidance/rg-360-23.pdf
[2] www.epa.gov/chief
[3] www.epa.gov/natural-gas-star-program
[4] www.tceq.texas.gov/goto/ivrucost

Table 1: Flash Loss Estimation Methods

No.	Method	Emissions Calculated	Comments
1	Direct measurement of tank emissions	Working, Breathing, Flash	**Sampling and analysis** are expensive, but the results are relatively accurate.
2	Process simulator computer programs	Working, Breathing, Flash	There are several different process simulators (e.g., WinSim, Designer II, HYSIM, HYSIS, VMG, PROMAX, etc.). The software is expensive, but the results are accurate when based on site-specific **sample and analysis.**
3	E&P Tanks software, V 3.0, using an option that requires site-specific sampling	Working, Breathing, Flash	A pressurized liquid and/or gas **sample analysis** from a separator will be needed. This choice does not include the geographical database option.
4	Laboratory measurement of the gas-oil-ratio (GOR) from a pressurized liquid sample	Flash only	This is direct laboratory analysis of the flash gas emitted from a pressurized oil/condensate **sample.**

TCEQ always prefers that the most accurate emission estimates be submitted, based on site-specific, representative worst-case data when possible. If applicants choose to use a less accurate method, they should be aware of the risk of potentially underestimating emissions at a site. More details about each of these methods—and the appropriate way to use these methods—are given in the appendix sections to this document.

Verification of the inputs and calculation methods are required with all methods. State the calculation method used and any critical parameters in the project description so they are available to program personnel. If at an existing production site, the emission calculations should be determined from site-specific sampling or analysis. If a site is not yet in operation, information from sister sites, nearby sites on the same field, or other empirical data may be used with a justification as to why that information is appropriate. The E/CR equation, Vasquez Beggs equation, E&P Tanks software, V 2.0, geographical database option, and Griswold and Ambler GOR chart method were removed from the list of acceptable methods because they are older methods that are no longer supported.

TCEQ always recommends that once site-specific information is available that the permitted emissions be reevaluated if other generic information, defaults, or a database were used in calculating the emissions initially. If you find that the emissions are greater than what was originally represented in a certified permit by rule (PBR) or standard permit, you must revise your emissions to reflect the increase.

Appendix A

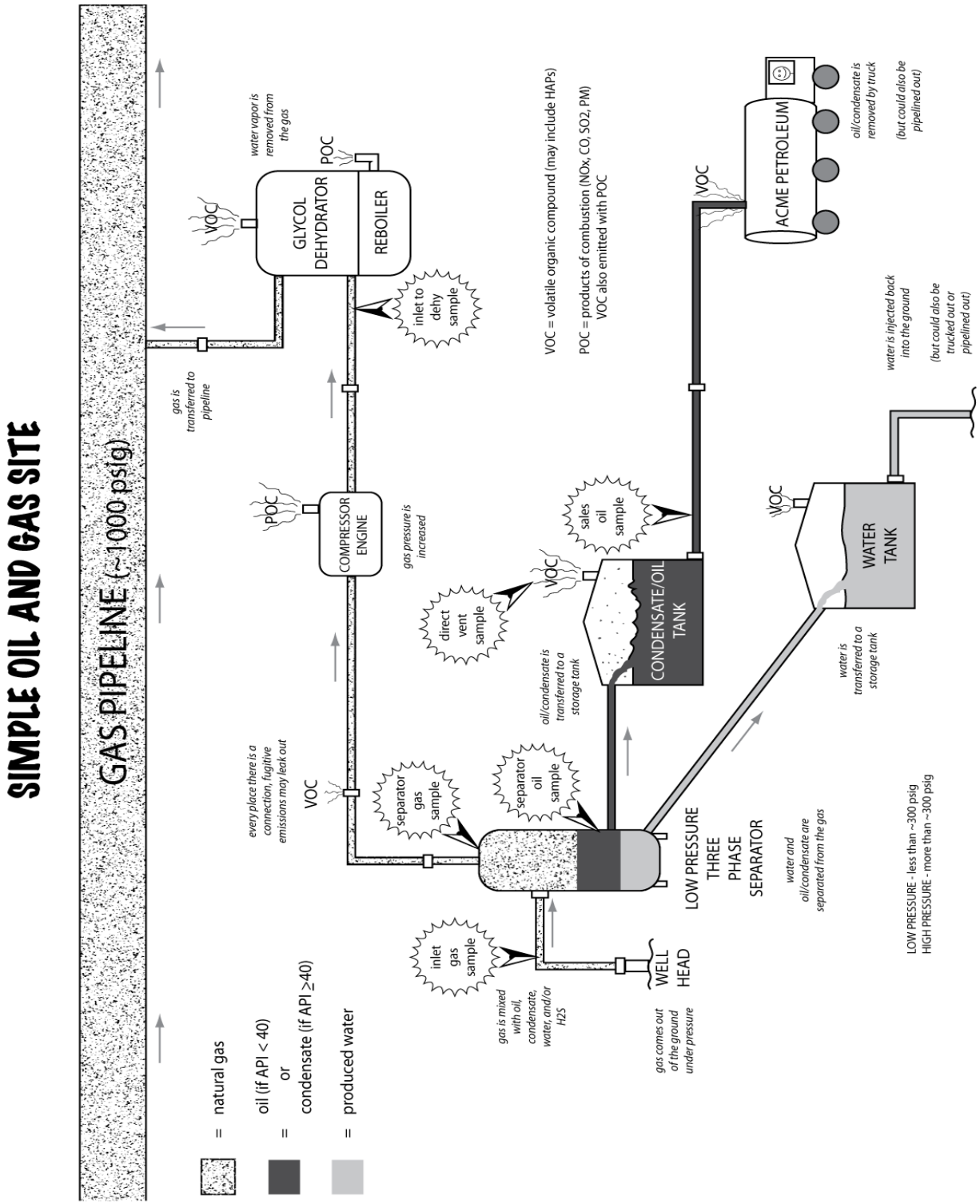

Figure 1. This is an example of a generic oil and gas production site. Not all expected emissions or sources are represented.

Note: Lab analysis may be labeled as "inlet" or "separator" gas analysis. Initial production sites where pressure is too high to safely sample will need to sample at the separator. If it is a process site where the gas is received conditioned, the sample needs to be taken at the inlet.

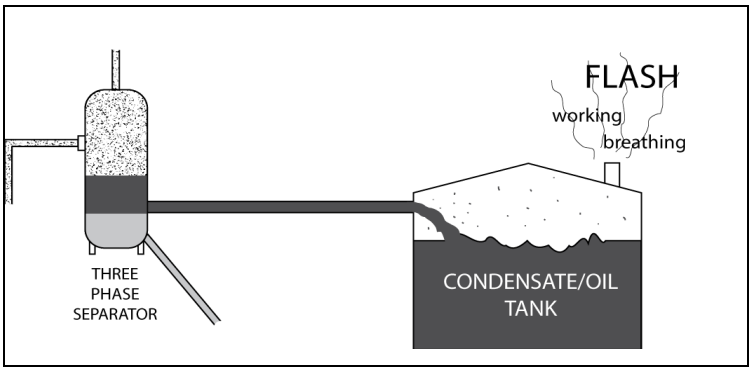

Figure 2. For a typical tank that receives condensate or oil from a separator, emissions will include working, breathing, and flash losses.

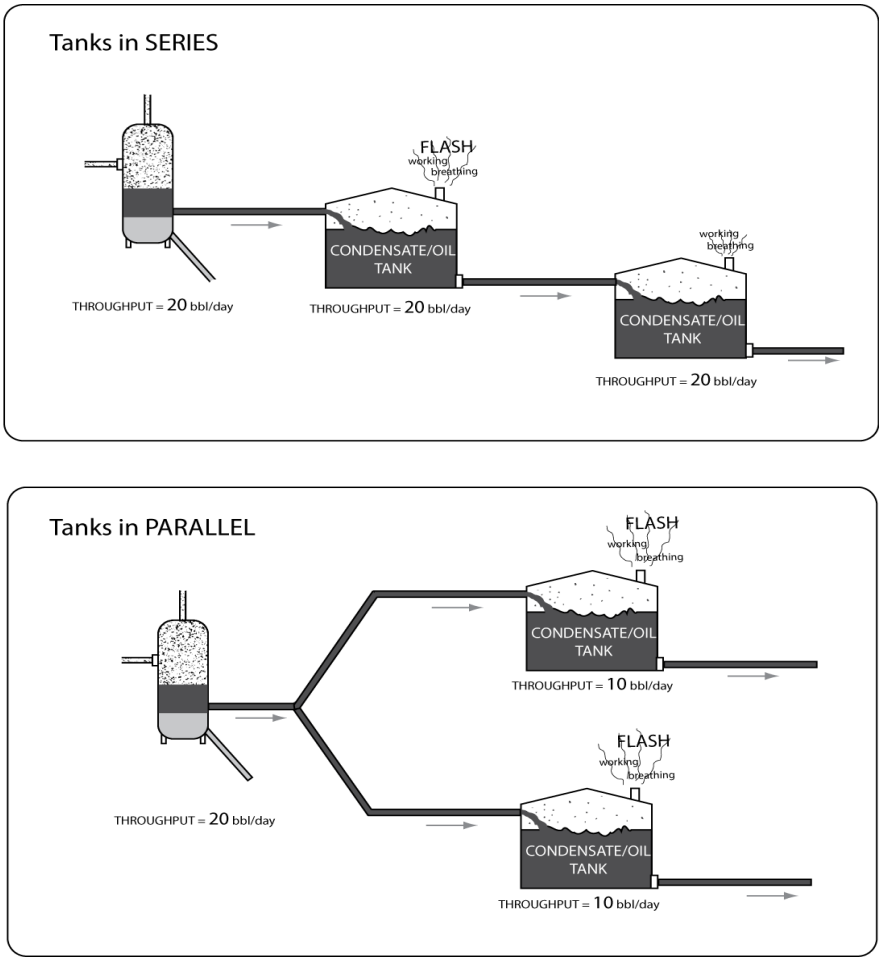

Figure 3. If a site has multiple tanks, the types of emissions from each tank will depend on whether the tanks are in series or parallel.

Appendix B

Laboratory Analysis

There are many types of samples that can be taken at an oil and gas site, and there are many different analytical methods that can be used on these samples. It is very important that the type of sample and the type of analysis used are appropriate to the calculation method used.

Table 2: Sample Types and Various Uses

Sample Type	Uses
Separator inlet gas sample	• Fugitive emission VOC content. • H_2S content of gas to determine if site is sweet or sour (but only if H_2S is specifically measured in the analysis).
Pressurized separator oil sample	• For E&P Tanks, low pressure oil or high-pressure oil option: to get separator oil composition. • GOR measurement (a flash gas analysis can also be made at the same time, which can be used to calculate flash losses directly). • For E&P Tanks, low pressure gas option: to get API gravity, RVP, C7:C8:C9:C10+ molar ratio, C10+ MW, and C10+ SG of condensate/oil.
Outlet separator gas sample	• For E&P Tanks, low pressure gas option: to get separator gas composition.
Sales oil sample	• API gravity measurement. • RVP measurement. • For E&P Tanks, low pressure gas option: to get API gravity, RVP, C7:C8:C9:C10+ molar ratio, C10+ MW, and C10+ SG of condensate/oil.
Direct vent sample	• Direct measurement of emissions coming from a tank.

Whenever an analysis from a laboratory is used as a basis for a calculation, you must submit a copy of the original laboratory analysis. Please also make sure that the following information about the lab analysis is submitted along with the original analysis itself:

- Where the sample was taken at the site (i.e., from the wellhead, separator, tank, etc.).
- Whether the sample was taken from the actual site or from a representative site. (If the sample is taken from a representative site, a justification must be given as to why it is representative. Whether or not another site would be considered representative will depend on factors such as distance from actual site, if it draws from the same gas field, formation and depth).
- The date the sample was taken (if not on lab report).

Title 30 Texas Administrative Code (30 TAC) Section 25.6 discusses when laboratory analyses may be accepted by TCEQ when accreditation of a laboratory is required—and when laboratory accreditation is not required at all. Please check TCEQ's website for a list of accredited laboratories[5].

The following is a list of typical lab analyses that would be needed at an oil and gas site. As TCEQ becomes more aware of different analyses, they will be added to the list.

Gases
Analyses: GPA 2261—regular gas analysis utilizing a thermal conductivity detector (TCD).

Breakout of components through pentanes and the heavy ends reported as hexanes plus (C6+). Properties of plus fraction are weighted and assigned according to published methods.

GPA 2286—extended gas analysis utilizing a flame ionization detector (FID). The FID cannot detect N_2 or CO_2.

Oils
Analysis: GPA 2186 modified—extended oil analysis. As with the extended gas, it requires two analyses (TCD and FID). The published method is for an analysis to C15.

Follow GPA and API methodology to obtain the liquid samples, such as GPA 2174.

Please note that there may be equivalent methods published by ASTM or others.

[5] www.tceq.texas.gov/downloads/compliance/labs/tx-nelap-lab-list.docx/view

Appendix C

Discussion of the different types of calculation methods.

1. Direct Measurement

- Measures working, breathing, and flash losses, consistent with the sampling and analysis methods as published in the "VOC Emissions from Oil and Condensate Storage Tanks Final Report" Oct. 31, 2006, revised April 2, 2009.
- If this method is used, please coordinate any measurements and sampling with the appropriate regional office to give them the opportunity to observe and coordinate any specific guidance on site-specific issues.
- This method involves:
  - Routing all emissions from a tank (or tanks) to a single emission point (sealing all other vents or sources of leaks).
  - Taking a direct sample of vapors from this point.
  - Measuring the gas flow rate through this point.
  - Measuring the temperature of the gas at this point.
  - Analyzing the composition of the sampled vapor using extended gas chromatography (equivalent to test method GPA 2286-95).
- Ideally, the sample is taken when conditions at the site would be either representative of normal conditions or slightly more conservative. Sampling should not occur in the winter or early spring. Sampling should occur only while the tank is receiving liquid from the separator at or above the average production rate. In addition, consider that separator pressure fluctuates at different times during the day or different times during the year, and the sample should be taken when the separator pressure is either at an average or higher-than-average value.
- If this method is used to estimate tank emissions, the following information must be submitted to Air Permits and the appropriate regional office:
  - Description of where and how the sample was taken, and how measurements were made.
  - Copy of original laboratory analysis of tank vapors.
  - Flow rate of tank vapors, with documentation to verify the values.
  - Temperature of tank vapors, with documentation to verify the values.
  - Supporting calculations for all emission estimates.

2. Process Simulator Software (e.g., WinSim Design II, HYSIM, HYSYS, VMG, and PROMAX)

- Calculates working, breathing, and flash losses (some programs can also calculate emissions from certain process units, such as amine units).
- The inputs to these programs are often from an inlet gas analysis, along with the operating parameters and arrangement of the various processing equipment at the site. The programs use complex equations of state to estimate emissions.
- If this method is used, the following information must be submitted:
  - Copy of the report (if not a complete report, then at least the portions of the report listing all the inputs and outputs).
  - Copy of original laboratory analysis used as inputs to the program.

3. E&P Tanks Software[6], Using Option That Requires Sampling

- Calculates working, breathing, and flash losses.
- To run this program, an actual liquid or gas sample is needed. Follow the guidance in this section.
- If this method is used, the following information must be submitted:
  - Complete printout of the report (not just the results page)
  - Original copies of all required laboratory analyses (see table below)

There are several ways to use this program, depending on the type of samples available. The options are chosen on the project setup page of the program. These options are summarized, along with the information that is required for each option, in the table below:

Table 3: Option Summaries and Information Required

Flowsheet Selection	Known Separator Stream Information	Model Selection for W&S losses	Types of emissions calculated	Required Information	Comments
Tank With Separator	Low Pressure Oil	RVP Distillation	Flash, Working, Breathing	• Laboratory analysis of liquid sample from low pressure separator	This option will give the most accurate results. (Preferred method.)
Tank With Separator	High Pressure Oil	RVP Distillation	Flash, Working, Breathing	• Laboratory analysis of liquid sample from high pressure separator	Similar to above option but only used if the separator that the sample was taken from is not the last separator before the storage tank, unless only separators are at the site.
Tank With Separator	Low Pressure Gas	RVP Distillation	Flash, Working, Breathing	• Laboratory analysis of gas sample from low pressure separator • Laboratory measurement of gas oil ratio (GOR)	Make sure all three required laboratory analyses are submitted: separator

[6] Designed by the American Petroleum Institute (API). Available from the IHS Standards Store at global.ihs.com/

Flowsheet Selection	Known Separator Stream Information	Model Selection for W&S losses	Types of emissions calculated	Required Information	Comments
				• Laboratory analysis of hydrocarbon liquid produced (to obtain API gravity, RVP, and C7 - C10+ characteristics)	gas, GOR, and liquid in tank. This method is preferred for sour sites because H_2S can more easily be measured in a gas sample.

- If tank emissions are routed to a flare, the E&P Tanks report gives several outputs that make calculating flare emissions relatively straightforward: flow rate of tank vapors, heat value of vapors, VOC emission rate, and H_2S emission rate.
- Make sure to double-check all inputs used in E&P Tanks; sometimes slight errors can make a big difference. See tables below for information on inputs:

Table 4: Information on Input Variables

Input Variable	Located on Lab Analysis?	Comments
Separator pressure	Probably yes	Make sure values on E&P report equal values on lab analysis.
Separator temperature	Probably yes	
Chemical composition of liquid or gas sample	Yes	
C10+ MW (molecular weight of components with at least 10 carbon atoms)	Probably yes	
C10+ SG (specific gravity of components with at least 10 carbon atoms)	Probably yes	
API gravity of sales oil sample	Probably yes	
Ambient temperature (estimate total annual emissions)	Probably no	Small changes can make a huge difference, be sure to use a reasonable value. You can refer to AP-42 Chapter 7: www.epa.gov/air-emissions-factors-and-quantification/ap-42-fifth-edition-volume-i-chapter-7-liquid-storage-0
Average ambient pressure	Probably no	Normal pressure is ~14.7 psia but can vary by ~ 1-2 psia.

Input Variable	Located on Lab Analysis?	Comments
Estimated annual production rate	No	Make sure value used is consistent with other representations in the file.
Reid vapor pressure (RVP)	Probably no	Not normally measured, but if requested, a laboratory can test this value.
Bulk temperature	No	
Days of annual operation	No	Should be 365. If not, please explain.

Table 5: Information on Low Pressure Gas Option

Input Variable	Located on Lab Analysis?	Comments
Molar GOR or Volumetric GOR	Yes (will be on GOR laboratory analysis)	Volumetric GOR (SCF/bbl) can be converted to Molar GOR as long as you also have oil density (lb/ft^3) and oil molecular weight (lb/lb-mole).
C7, C8, C9, C10+ molar ratios in separator oil	Yes (will be on laboratory analysis of hydrocarbon liquid)	These values will be the ratios of the mol% values, for each of these components, to each other.
C10+ MW and C10+ SG of separator oil		Make sure value on E&P report equals value on lab analysis.
API gravity		Make sure value on E&P report equals value on lab analysis.
Reid vapor pressure (RVP)		Not normally measured, but if requested, a laboratory can test this value.

4. Laboratory Measurement of Gas-Oil-Ratio (GOR) from Pressurized Liquid Sample:

- Calculates flash losses only.
- This method involves:
  - Collecting a pressurized liquid sample (condensate or oil) from a gas/oil separator.
  - Taking the sample to a lab.
  - In the lab, the conditions at the site (temperature and pressure) are simulated.
  - The liquid is allowed to flash.
  - The flash gas is captured.
  - The volume of flash gas is measured to determine the GOR. The GOR is the volume of flash gas produced (in standard cubic feet) per barrel of liquid.
  - The composition of the flash gas is analyzed.
  - Flash emissions are calculated based on the GOR (SCF/bbl) and the VOC content of the flash gas.
- If this method is used, the following information must be submitted:
  - Laboratory analysis that contains the following information:

- Gas-oil-ratio (in SCF/bbl).
- Composition of flash gas.

- Supporting calculations for all emission estimates.