Air Permit Reference Guide

APDG 5942

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

Air Permits Division
Texas Commission on Environmental Quality
Revised May 2012

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

Background

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

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

- Breathing losses (also called STANDING losses) which is the normal evaporation of liquid in a tank. Breathing losses will increase if the temperature increases;
- Working losses are an increase in evaporation due to agitation of liquid from activities such as filling the tank;
- Flash losses occur when the pressure of a liquid is decreased or the temperature is increased.

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 has 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 obtained at:

- www.tceq.state.tx.us/assets/public/comm_exec/pubs/rg/rg360/rg-360-05/techsupp_6.pdf
- www.epa.gov/ttn/chief/eiip/techreport/volume02/ii10.pdf
- www.epa.gov/gasstar/documents/fall2004update.pdf
- www.nmenv.state.nm.us/aqb/FAQ.html
- deq.state.wy.us/aqd/Oil%20and%20Gas/GUIDANCE2001.pdf
- www.deq.state.ok.us/factsheets/air/CalculationLosses.pdf
- www.kdheks.gov/bar/download/flashcalculationfactsheet.pdf
- www.api.org/Publications/

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; some are more accurate than others. Even though working, breathing, and flash losses are almost always mixed together and exit the tank vent at the same time, some methods only calculate working and breathing losses, while some 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 by the EPA regarding the cost savings associated with VRUs, which can be found at: www.epa.gov/gasstar/documents/ll_final_vap.pdf

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.

Table 1: Flash Loss Estimation Methods

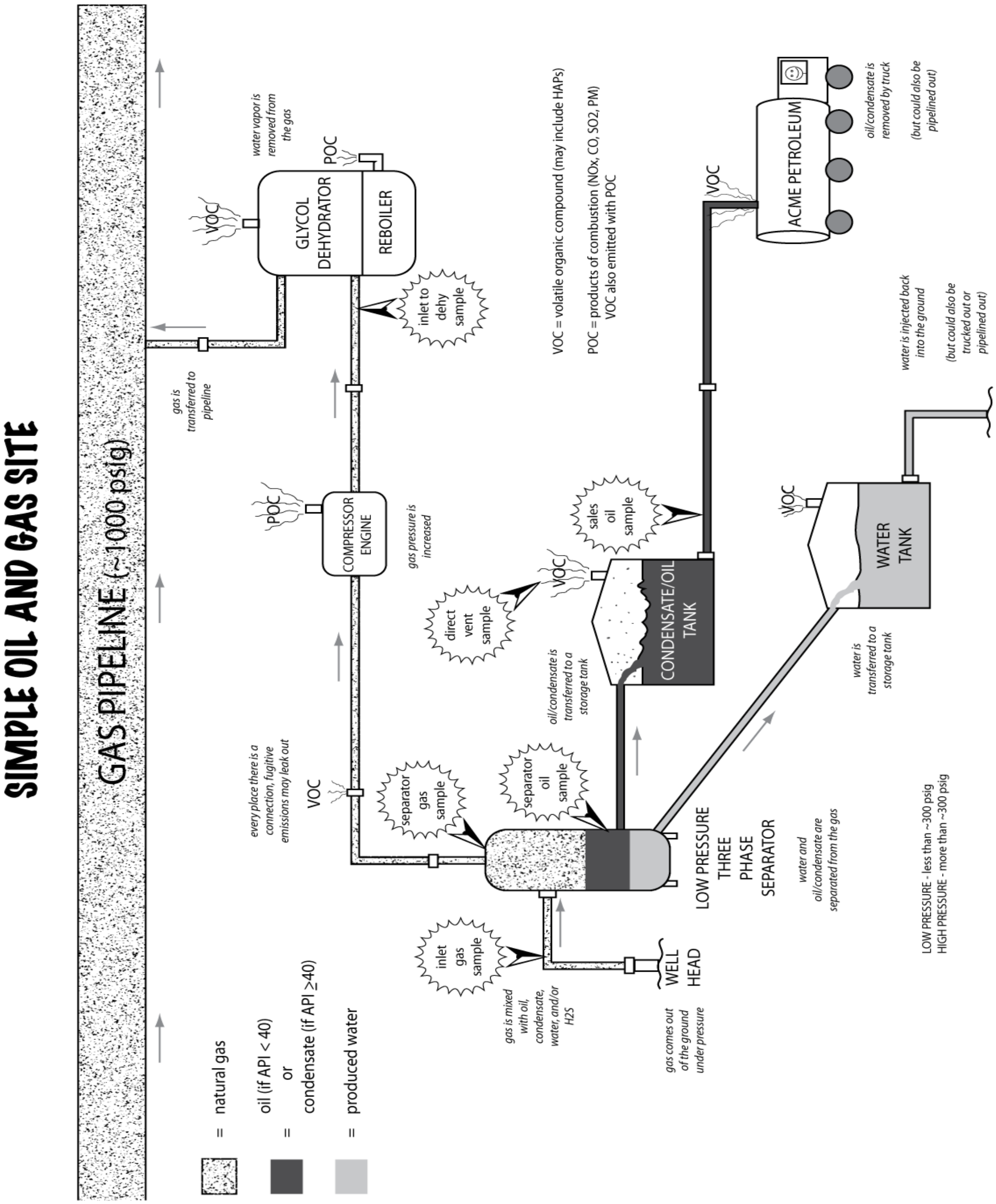
No.	Method	Emissions Calculated	Comments
1	Direct measurement of tank emissions	Working, Breathing, Flash	**Sampling and analysis** are expensive, but the results are relatively accurate.
2	Process Simulator computer programs	Flash only	There are several different process simulators (e.g. WinSim, Designer II, HYSIM, HYSIS, VMG, and 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 2.0, 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 Data base 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.**
5	Vasquez-Beggs Equation (VBE):	Flash only	A calculation method based on empirical data. The VBE variables must be **supported with a lab sampling analysis** that verifies the API gravity, separator gas gravity, stock tank gas molecular weight, and VOC fraction. If an operating variable used in the VBE calculations falls outside of the parameter limits, the applicant must use another method to calculate flash emissions.
6	E&P Tanks Software, V 2.0, Geographical Database Option	Working, Breathing, Flash	Emissions are based on choosing an example case that closely matches operating parameters at the site in question. A justification for using this method must be included if the site is existing. The geographical database is based on 103 sampled sites and is a very poor estimate of emissions from any particular storage tank.
7	Griswold and Ambler GOR Chart Method	Flash only	A graph developed by Griswold and Ambler (1978) can be used to approximate total potential vapor emissions from a barrel of oil based on pressure differentials. The curves were constructed using empirical flash data from laboratory studies and field measurements.

The TCEQ always prefers that the most accurate emission estimates be submitted, based on site-specific, representative worst-case data when possible. Therefore we would prefer, but do not require, that methods 1-4 be used rather than other available methods. 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 to this document. Remember, no matter which method is used to calculate flash emissions, verification of the inputs and calculation methods are required. 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 was removed from the list of acceptable methods because it is an older method that is no longer supported.

The TCEQ always recommends that once site specific information is available that the permitted emissions be re-evaluated 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.

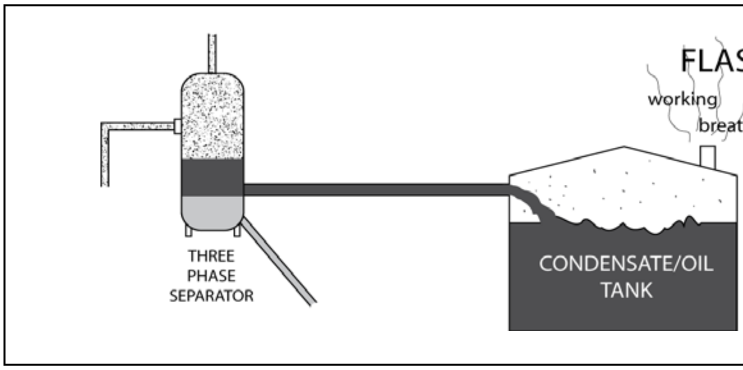
Appendix A

This is an example of a generic Oil and Gas Production Site. Not all expected emissions or sources are represented.

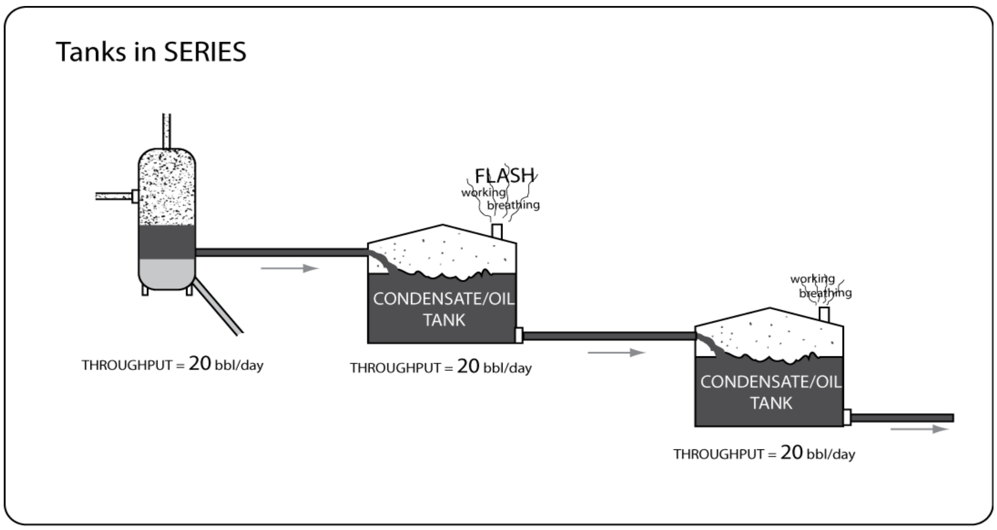


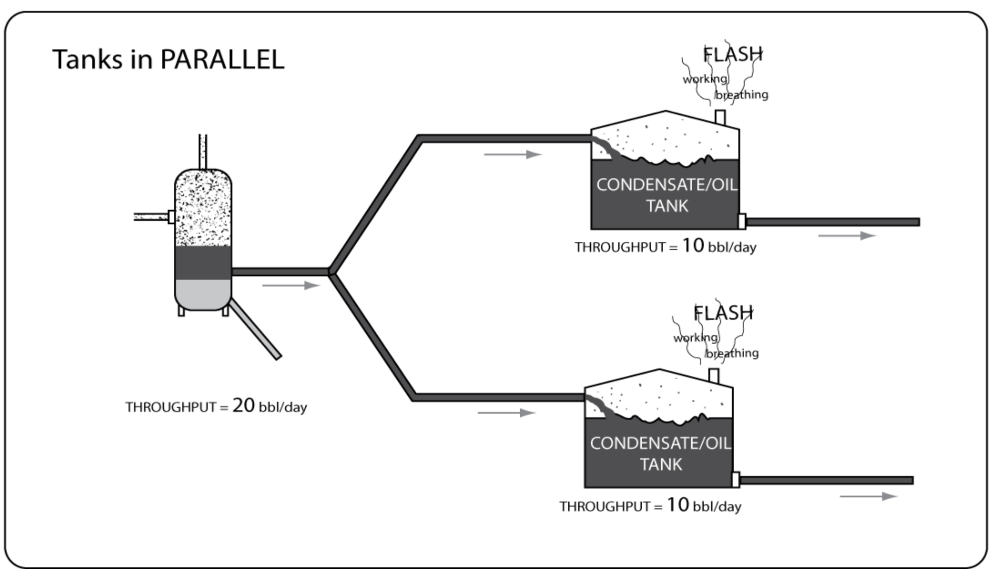
<u>Note:</u> *Lab analysis may be labeled as "inlet" or "separator" gas analysis. Initial Production sites where pressure is too high to safely sample will need to sample at the separator. If it is a process site where the gas is received conditioned, the sample needs to be taken at the inlet.*

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



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 & 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. For example, the following sample types can be used for various purposes:

Sample Type	Uses
Separator Inlet gas sample	• Vasquez-Beggs equation - for inlet gas specific gravity variable only (not MW or VOC content); • 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 TANK, 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, or can be used in Vasquez-Beggs equation for the MW and VOC content variables); • For E&P TANK, 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 TANK, Low Pressure Gas option: to get separator gas composition.
Sales oil sample	• API gravity measurement; • RVP measurement; • For E&P TANK, 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 at the site the sample was taken (i.e. from 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).

30 Texas Administrative Code (TAC) § 25.6 discusses when laboratory analysis may be accepted by the Commission and when accreditation of a laboratory is required and when no accreditation of a laboratory is required. Please check the TCEQ website to determine if accreditation is offered for the laboratory and method required. This information can be found at: www.tceq.state.tx.us/compliance/compliance_support/qa/env_lab_accreditation.html

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 memo.

Gases

Analyses: GPA 2261 – Regular gas analysis utilizing a Thermal Conductivity Detector. 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. 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 & FID). The published method is for an analysis to C15

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

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

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" October 31, 2006. Additional specific guidance on this method will be updated at the conclusion of the 2nd report on this issue, expected in 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 Designer II, HYSIM, HYSIS, VMG, and PROMAX)

- Calculates flash losses only (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[1], using option that requires sampling

- Calculates working, breathing, and flash losses;
- There are several ways to run this program, depending on the type of information available:
  - o If unable to get actual sampling data, it may be possible to use the E&P Geographical Database option. If so, follow the guidance that begins on page 17 of this document;
  - o If an actual liquid or gas sample can be taken, 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)

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

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

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	AP-42	Flash Working Breathing	• Laboratory analysis of liquid sample from low pressure separator; • Tank specifications and location	These options will give the most accurate results. (Preferred Method.)
Tank with Separator	Low Pressure Oil	RVP Distillation	Flash Working Breathing	• Laboratory analysis of liquid sample from low pressure separator	
Tank with Separator	High Pressure Oil	AP-42	Flash Working Breathing	• Laboratory analysis of liquid sample from high pressure separator; • Tank specifications and location	Similar to above options, but only used if separator that sample was taken from is not the last separator before storage tank, unless only separators at the site.
Tank with Separator	High Pressure Oil	RVP Distillation	Flash Working Breathing	• Laboratory analysis of liquid sample from high pressure separator	
Tank with Separator	Low Pressure Gas	AP-42	Flash Working Breathing	• Laboratory analysis of gas sample from low pressure separator; • Laboratory analysis of gas oil ratio (GOR); • Laboratory analysis of hydrocarbon liquid produced (to obtain API gravity, RVP, and C7 - C10+ characteristics)\; • Tank specifications and location	Make sure all three required laboratory analyses are submitted: separator 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.
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) • Laboratory analysis of hydrocarbon liquid produced (to obtain API gravity, RVP, and C7 - C10+ characteristics)	
Stable Oil Tank	n/a	AP-42	Working Breathing (not flash)	• Laboratory analysis of composition of liquid in tank, up to C10+; • Tank specifications and location	Do not use default composition from E&P Tank

- If the AP-42 option is chosen, a separate run of E&P Tanks needs to be performed for each tank. Combining the throughput of several tanks into one run may underestimate standing/breathing emissions.
- 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. The example E&P report notes where this information can be found.
- Make sure to double check <u>all</u> inputs used in E&P Tanks; it has been discovered sometimes slight errors can make a big difference. See tables below for information on inputs:

If low pressure oil or high pressure oil option chosen:

Input Variable	Located on Lab Analysis?	Comments
Separator pressure	probably yes	Make sure value on E&P report equals value on lab analysis.
Separator temperature	probably yes	Make sure value on E&P report equals value on lab analysis.
Chemical composition of liquid or gas sample	yes	Make sure values on E&P report equals values on lab analysis.
C10+ MW (molecular weight of components with at least 10 carbon atoms)	probably yes	Make sure value on E&P report equals value on lab analysis.
C10+ SG (specific gravity of components with at least 10 carbon atoms)	probably yes	Make sure value on E&P report equals value on lab analysis.
API gravity of sales oil sample	probably yes	Make sure value on E&P report equals value on lab analysis.
Ambient Temperature (estimate total annual emissions)	probably no	Small changes can make a huge difference, be sure to use a reasonable value. You can check on the web at a site such as: www.weatherbase.com/weather/city.php3?c=US&s=TX&refer=
Average Ambient pressure	probably no	Normal pressure is ~14.7 psia, but can vary by ~ 1-2 psia.
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
All the tank specifications and nearest city (if AP-42 option chosen)	no	Make sure tank specifications are reasonable, and make sure correct nearest city is chosen

If low pressure gas option chosen, some information above will be the same, but there will be some differences:

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 (g/cm^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.

Example of E&P Tank Report

****
*   Project Setup Information   *
****
Project File   : Untitled.Ept
Flowsheet Selection   : Oil Tank with Separator
Calculation Method   : AP42
Control Efficiency   : 100.0%
Known Separator Stream   : Low Pressure Oil
Entering Air Composition: No

Date   : 2008.01.18

e are the options that
e chosen on Project
p page of E&P software.

****
*   Data Input   *
****

Separator Pressure   : 23.00[psig]
Separator Temperature   : 85.00[F]
Ambient Pressure   : 14.70[psia]
Ambient Temperature   : 70.00[F]
C10+ SG   : 0.8990
C10+ MW   : 166.00

be

-- Low Pressure Oil --

No.	Component	mol %
1	H2S	0.0508
2	O2	0.0000
3	CO2	0.2437
4	N2	0.0102
5	C1	0.9543
6	C2	0.6701
7	C3	2.1827
8	i-C4	1.1269
9	n-C4	4.6091
10	i-C5	3.1066
11	n-C5	5.0558
12	C6	4.1726
13	C7	10.3655
14	C8	10.8426
15	C9	5.5127
16	C10+	45.9695
17	Benzene	0.5685
18	Toluene	0.2132
19	E-Benzene	0.0711
20	Xylenes	0.6802
21	n-C6	3.5939
22	224Trimethylp	0.0000

info should be on
nalysis (but may
to do a little math
et some of these
numbers).

-- Sales Oil --
Production Rate   : 2000[bbl/day]
Days of Annual Operation: 365 [days/year]
API Gravity   : 46.0
Reid Vapor Pressure   : 7.70[psia]
Bulk Temperature   : 80.00[F]

nd RVP should be on
lab analysis.
oughput is consistent
esentations in the file

-- Tank and Shell Data --
Diameter   : 21.00[ft]
Shell Height   : 16.00[ft]
Cone Roof Slope   : 0.06
Average Liquid Height   : 8.00[ft]
Vent Pressure Range   : 0.06[psi]
Solar Absorbance   : 0.54

-- Meteorological Data --
City   : Homer, AK
Page 1-- E&P TANK
Ambient Pressure   : 14.70[psia]
Ambient Temperature   : 70.00[F]
Min Ambient Temperature   : 29.50[F]
Max Ambient Temperature   : 43.60[F]
Total Solar Insulation   : 831.00[Btu/ft^2*day]

f using AP42 option, make
ure a separate run of E&P is
performed for each tank.

Example of E&P Tank Report (continued)

****
* Calculation Results *
****

-- Emission Summary --

Item	Uncontrolled [ton/yr]	Uncontrolled [lb/hr]
Total HAPs	12.090	2.760
Total HC	686.156	156.657
VOCs, C2+	577.798	131.917
VOCs, C3+	**498.049**	**113.710**

VOC emissions from tank

Uncontrolled Recovery Info.

Vapor	**40.9200**	**[MSCFD]**
HC Vapor	37.8200	[MSCFD]
GOR	20.46	[SCF/bbl]

ca
S
n
10

-- Emission Composition --

No	Component	Uncontrolled [ton/yr]	Uncontrolled [lb/hr]
1	H2S	**4.573**	**1.044**
2	O2	0.000	0.000
3	CO2	56.266	12.846
4	N2	2.271	0.518
5	C1	108.358	24.739
6	C2	79.749	18.208
7	C3	161.162	36.795
8	i-C4	48.744	11.129
9	n-C4	138.471	31.614
10	i-C5	45.852	10.468
11	n-C5	54.040	12.338
12	C6	15.650	3.573
13	C7	14.964	3.416
14	C8	5.679	1.297
15	C9	1.106	0.253
16	C10+	0.289	0.066
17	Benzene	1.123	0.256
18	Toluene	0.138	0.032
19	E-Benzene	0.017	0.004
20	Xylenes	0.144	0.033
21	n-C6	10.672	2.437
22	224Trimethylp	0.000	0.000
	Total	749.268	171.066

H_2S emissions from tank

-- Stream Data --

No.	Component	MW	LP Oil mol %	Flash Oil mol %	Sale Oil mol %	Flash Gas mol %	W&S Gas mol %	Total Emissions
1	H2S	34.80	0.0508	0.0358	0.0353	0.6793	0.7369	0.6812
2	O2	32.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	CO2	44.01	0.2437	0.0950	0.0901	6.4933	6.3414	6.4884
4	N2	28.01	0.0102	0.0005	0.0003	0.4189	0.1814	0.4114
5	C1	16.04	0.9543	0.1553	0.1346	34.5319	26.5975	34.2787
6	C2	30.07	0.6701	0.3661	0.3555	13.4456	13.8885	13.4597
7	C3	44.10	2.1827	1.7950	1.7801	18.4760	20.7381	18.5482
8	i-C4	58.12	1.1269	1.0530	1.0499	4.2332	4.9494	4.2561
9	n-C4	58.12	4.6091	4.4328	4.4251	12.0182	14.2885	12.0906
10	i-C5	72.15	3.1066	3.1043	3.1037	3.2018	3.9344	3.2252
11	n-C5	72.15	5.0558	5.0864	5.0867	3.7713	4.7063	3.8012
12	C6	86.16	4.1726	4.2496	4.2520	0.9366	1.2162	0.9455
13	C7	100.20	10.3655	10.5937	10.6012	0.7742	1.0458	0.7829
14	C8	114.23	10.8426	11.0945	11.1029	0.2563	0.3607	0.2596
15	C9	128.28	5.5127	5.6428	5.6472	0.0450	0.0658	0.0456
16	C10+	166.00	45.9695	47.0631	47.1001	0.0087	0.0143	0.0088
17	Benzene	78.11	0.5685	0.5803	0.5807	0.0723	0.0953	0.0730
18	Toluene	92.13	0.2132	0.2181	0.2183	0.0075	0.0103	0.0076
19	E-Benzene	106.17	0.0711	0.0728	0.0728	0.0008	0.0012	0.0008
20	Xylenes	106.17	0.6802	0.6962	0.6968	0.0068	0.0098	0.0069
21	n-C6	86.18	3.5939	3.6646	3.6668	0.6222	0.8182	0.6285
22	224Trimethylp	114.24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

		LP Oil	Flash Oil	Sale Oil	Flash Gas	W&S Gas	Total Emissions
MW		123.89	125.93	125.93	37.91	**41.44**	38.03
Stream Mole Ratio		1.0000	0.9768	0.9760	0.0232	0.0008	0.0240
Heating Value	[BTU/SCF]				2001.39	2196.12	**2007.60**
Gas Gravity	[Gas/Air]				1.31	1.43	1.31
Bubble Pt. @ 100F	[psia]	56.28	20.19	19.23			
RVP @ 100F	[psia]	126.75	80.50	78.33			
Spec. Gravity @ 100F		0.800	0.803	0.803			

Can be used for MW of truck loading vapors

Can be used for Flare calculations (Heat Value of Source, Btu/SCF)

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 in order 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.

5. Vasquez-Beggs Equation (VBE)[2]:

- Calculates flash losses only;
- If this method is used, the following information must be submitted:
  - ➢ All inputs used in the VBE calculation;
  - ➢ If a VOC fraction of less than 1.0 (100%), or a stock tank gas molecular weight that does not match the vapor molecular weight from the corresponding working and breathing loss calculation method (such as Tanks 4.0), then a laboratory flash gas analysis must also be submitted.
- If submitting emissions where the VBE is used, please:

  1. **Verify that all inputs are in valid ranges** (see "Valid Range" section of table on page 16). Some variables may be adjusted so that the VBE can be used; other variables cannot be adjusted. See "Explanation" section of the table to determine which variables are critical. If a variable is outside of the acceptable range, and no adjustments can be made, the VBE cannot be used.
  2. **Verify origin of all inputs** (see "How to Verify" section of table on page 16). If asked, you must provide any available documentation that will verify the values used in the VBE. If unable to verify the inputs, another method to calculate flash (whose inputs will also have to be verified) must be used.

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[2] A spreadsheet that will calculate flash emissions using this method is available at the following site: www.deq.state.ok.us/AQDnew/resources/Calculations11.xls

- If a site specific analysis is not available, APD will accept:

    1. A recent analysis for a representative site, as long as an explanation is provided as to why the analysis used is representative of the site in question.

    2. Whether or not a site would be considered representative will depend on factors such as distance from site under review, whether it draws from the same production field, formation and depth.

APD will not accept any generic stream speciation, regardless of the source.

Appropriate Inputs for the Vasquez-Beggs Equations

Variable	Valid Range	Explanation	If you have questions about a variable, how to verify:
API Gravity	16 - 40°	If API below range, they can increase to minimum (16°API) **If API over 40°, CANNOT USE VBE**	If asked, you must submit documentation to verify the API gravity, such as: • an actual lab analysis; • a copy of an oil sales receipt; • a copy of Form W-2 (if oil well) or G-1 (if gas well) submitted to the Texas Railroad Commission
Separator Pressure	50 - 5250 psia or ~35.3 - 5235.3 psig * The VBE spreadsheet uses **psig** (psig = psia - P_{atm})	If below range, you may increase to minimum (50 psia / 35.3 psig).	This value will depend upon the well characteristic and the facility design. Please be aware that you must be able to demonstrate to TCEQ personnel, if a site inspection were to occur, that the value used here is an accurate representation of the actual value.
Separator Temperature	70 - 295°F	If outside of range, **cannot use VBE!**	This is the temperature inside the separator itself, not the temperature of the storage tank. This value will depend upon the well characteristic and the facility design. Please be aware that you must be able to demonstrate to TCEQ personnel, if a site inspection were to occur, that the value used here is an accurate representation of the actual value.
Separator Gas Gravity at Initial Conditions (a.k.a. specific gravity, SG)	0.56 - 1.18	If below range, you may increase to minimum (0.56). **If SG over 1.18, cannot use VBE.**	This is the SG of the inlet gas. An inlet gas analysis should be submitted to verify this information.
Barrels oil per day	(no limits)	N/A	Should be consistent with all other calculations (working, breathing, and truck loading).
Stock tank gas Molecular Weight (MW)	18 - 125 lb/lb-mole	a MW outside of this range should not be seen	If a flash gas analysis (not inlet gas) is not available, use the default "Vapor Mol. Weight" value from Tanks 4.0 report, pg 2. For example: For RVP 5, MW = 50. This is the only default from another program that can be used.
VOC fraction	0.5 - 1.0 (50% - 100%)	Should almost always use 1.0 (100%)	This is the percent of the flash gas that is VOC. If a value other than 100% is used, you must submit a **flash** gas analysis (not inlet gas) to verify the fraction used.
Atmospheric Pressure	(no limits)	Average P_{atm} = 14.7 psia.	Should be close to 14.7, unless at an elevated location. The actual P_{atm} will be on pg. 1 of a Tanks 4.0 report.

6. E&P Tanks software, Geographical Database Option

- Calculates working, breathing, and flash losses;
- This optional way to use E&P Tanks is very different from the E&P options discussed above. Unlike the other options, the Geographical Database does not rely on site-specific data. Therefore, this option is considered a completely different flash calculation method;
- To use the Geographical database, 1 of 103 cases is chosen. These cases represent actual runs of E&P Tanks based on the composition of oil/condensate samples taken from 103 actual oil and gas sites throughout the United States. However, the composition of the oil/condensate can make a huge impact on emissions. If a case is chosen whose composition is very different from the actual composition at the site in question, then the emissions may be very different. Therefore, this option could potentially give very inaccurate emissions;
- A particular case is chosen based on information from the site in question:
    - Geographical region of the United States (NW, NE, SW, SE);
    - API Gravity of the oil/condensate;
    - RVP of the oil/condensate;
    - Separator Pressure;
    - Separator Temperature;
- If this option is used, the following information must be submitted:
    - ➢ A complete copy of the E&P Tanks report (not just the results) including case # chosen and an explanation as to why this case should be considered the most equivalent to the project;
    - ➢ The actual expected API Gravity, RVP, separator pressure, and separator temperature.

E&P Geographical Databases Default Cases (RVP Distillation Model):

E&P National Case #	E&P Regional Case #	API Gravity (°API)	RVP (psia)	Separator Pressure (psig)	Separator Temperature (°F)	**VOC emissions if throughput = 10 bbl/day (tpy)**
1	NW case 1	15	0.8	45	106	**0.124**
2	NW case 2	17	2.0	22	155	**1.239**
3	NW case 3	18	0.6	20	160	**0.569**
4	NW case 4	19	2.3	53	101	**1.229**
5	NW case 5	19	4.8	15	120	**1.029**
6	NW case 6	20	1.2	23	79	**0.062**
7	NW case 7	20	3.3	17	106	**0.353**
8	NW case 8	20	3.8	18	75	**0.226**
9	NW case 9	21	1.1	54	125	**1.494**
10	SE case 1	23	1.8	35	76	**0.165**
11	NW case 10	23	0.2	8	154	**0.023**
12	NW case 11	23	4.0	30	66	**1.275**
13	NW case 12	24	0.6	20	122	**0.104**
14	NW case 13	24	3.9	20	88	**2.192**
15	NW case 14	24	4.6	22	86	**1.383**
16	NW case 15	24	4.8	20	68	**2.117**
17	NW case 16	25	4.1	19	133	**0.512**
18	NW case 17	25	4.9	30	60	**1.789**
19	NW case 18	27	3.3	25	136	**0.926**
20	NW case 19	27	5.2	31	64	**2.202**
21	SE case 2	29	3.1	23	79	**0.257**
22	SW case 1	29	4.8	17	86	**3.299**
23	SW case 2	29	4.9	20	120	**2.776**
24	SW case 3	29	6.2	22	98	**3.026**
25	SE case 3	30	4.8	280	106	**6.605**
26	SW case 4	30	2.6	4	80	**0.085**
27	NW case 20	30	2.7	25	180	**2.500**
28	NW case 21	30	2.8	64	70	**0.967**
29	SE case 4	33	2.2	80	77	**3.371**
30	SE case 5	33	3.1	20	115	**0.980**
31	SE case 6	34	2.0	60	78	**0.424**
32	SE case 7	34	2.2	18	70	**0.193**
33	SW case 5	34	3.2	40	110	**0.831**
34	SW case 6	35	4.7	18	80	**3.732**
35	NW case 22	35	4.5	15	108	**2.734**
36	NW case 23	35	4.9	17	100	**2.430**
37	SE case 8	36	2.5	30	125	**0.332**
38	SE case 9	36	3.8	50	68	**0.654**
39	SE case 10	36	3.9	57	80	**1.133**
40	SE case 11	36	4.1	75	81	**2.158**
41	SW case 7	36	3.8	28	60	**2.013**
42	SW case 8	36	7.2	18	95	**3.953**

E&P National Case #	E&P Regional Case #	API Gravity (°API)	RVP (psia)	Separator Pressure (psig)	Separator Temperature (°F)	**VOC emissions if throughput = 10 bbl/day (tpy)**
43	SE case 12	37	3.9	18	98	**0.916**
44	SW case 9	37	3.0	190	70	**2.526**
45	SW case 10	37	4.9	22	50	**11.976**
46	SE case 13	38	3.6	24	68	**1.421**
47	SE case 14	38	4.5	60	72	**1.073**
48	SW case 11	38	3.0	32	149	**0.752**
49	SW case 12	38	5.2	62	80	**3.625**
50	SW case 13	38	5.7	13	113	**2.984**
51	SW case 14	38	7.4	28	45	**2.072**
52	NW case 24	38	3.1	22	114	**11.432**
53	SE case 15	39	3.7	66	89	**3.239**
54	SE case 16	39	5.6	60	80	**1.953**
55	SE case 17	39	6.8	60	58	**4.760**
56	SW case 15	39	6.4	33	60	**3.831**
57	NE case 1	39	5.4	42	110	**4.096**
58	SE case 18	40	3.0	66	83	**0.875**
59	SE case 19	40	4.1	66	90	**2.228**
60	SW case 16	40	4.8	13	110	**2.037**
61	NW case 25	40	3.9	64	74	**1.267**
62	NW case 26	42	4.2	28	78	**3.086**
63	NE case 2	42	8.1	95	118	**11.568**
64	SW case 17	44	5.7	29	60	**4.116**
65	SW case 18	44	7.0	44	71	**1.795**
66	NW case 27	44	10.1	60	60	**4.867**
67	SE case 20	45	5.2	41	72	**1.582**
68	NW case 28	45	8.1	20	68	**4.483**
69	SW case 19	46	4.7	23	85	**8.751**
70	SW case 20	46	5.0	24	114	**5.060**
71	SE case 21	47	5.3	52	108	**4.091**
72	SE case 22	47	6.0	45	140	**19.753**
73	NW case 29	47	10.6	40	76	**7.667**
74	SW case 21	49	5.0	31	76	**2.710**
75	NE case 3	49	8.9	50	125	**22.932**
76	NW case 30	50	7.4	700	100	**46.622**
77	NW case 31	50	9.4	20	48	**7.991**
78	SW case 22	51	11.2	98	40	**18.802**
79	SW case 23	54	5.3	115	73	**3.506**
80	SW case 24	54	9.4	30	100	**13.307**
81	SW case 25	54	10.3	15	86	**9.672**
82	NW case 32	55	7.8	770	100	**67.726**
83	SE case 23	57	5.7	39	66	**1.552**
84	SE case 24	57	9.6	38	95	**12.798**
85	SW case 26	57	4.8	65	80	**15.144**

E&P National Case #	E&P Regional Case #	API Gravity (°API)	RVP (psia)	Separator Pressure (psig)	Separator Temperature (°F)	**VOC emissions if throughput = 10 bbl/day (tpy)**
86	SW case 27	57	13.1	54	60	**15.006**
87	SW case 28	57	13.1	870	78	**48.132**
88	NW case 33	57	7.5	600	70	**37.853**
89	SW case 29	58	8.0	780	70	**28.792**
90	NW case 34	58	8.0	60	56	**6.643**
91	NW case 35	58	9.1	500	84	**29.895**
92	NE case 4	58	10.6	300	80	**41.859**
93	SW case 30	59	10.0	110	72	**7.896**
94	NW case 36	60	9.4	750	90	**57.537**
95	SW case 31	61	7.0	85	85	**4.475**
96	NW case 37	61	9.8	730	84	**73.168**
97	SW case 32	62	10.4	57	82	**14.693**
98	SW case 33	63	7.0	72	80	**3.167**
99	NW case 38	63	11.9	730	80	**54.645**
100	NW case 39	64	6.4	580	77	**21.334**
101	NW case 40	64	11.0	730	80	**113.571**
102	NW case 41	66	11.8	807	96	**85.523**
103	NE case 5	68	12.5	170	75	**12.461**

* The gray cases are in the northwestern and northeastern United States. These sites are unlikely to be representative of a site in Texas.

7. Griswold and Ambler Gas-Oil-Ratio (GOR) Chart Method (SPE Paper 7175):

- Calculates flash losses only;
- Emissions are estimated using a graph developed by Griswold and Ambler (1978), which was based on empirical data from lab studies and field measurements;
- Requires three inputs:
  - o API Gravity;
  - o Separator Pressure;
  - o Oil/Condensate Throughput;
- To calculate flash using this method:
  1. Determine the range that the actual API gravity falls into (under 30, 30-39, or 40+);
  2. Consult the graph; find the line that corresponds to the correct API gravity range;
  3. Find the point on the line that corresponds to the separator pressure (on X axis);
  4. Determine where on the Y axis this point is, this is the GOR (SCF/bbl).
- Knowing the oil throughput, the total volume of flash gas emitted can be determined;
- To calculate VOC emissions, more information about the composition of the flash gas would need to be known (the molecular weight and VOC content). This method will not give this data.

Example:
If API Gravity = 38 °API
Separator pressure = 40 psig
Throughput = 1000 bbl/day

Then from graph, GOR = 43 SCF/bbl
Therefore, emission volume = (43 SCF/bbl) * (1000 bbl/day) = 43,000 SCF/day of flash gas