

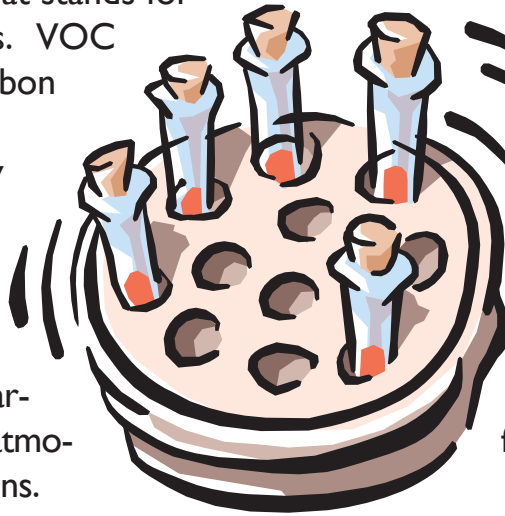
AIR

Calculation of Flashing Losses/VOC Emissions from Hydrocarbon Storage Tanks

THE BASICS . . .

Q: What is VOC?

A: VOC is an acronym that stands for Volatile Organic Compounds. VOC are components of hydrocarbon liquids such as crude oil and condensate. VOC means any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions.



However, there is a list of compounds that are excluded from being VOC because they have negligible photochemical reactivity such as methane, ethane, and fluorinated and chlorinated hydrocarbons. The list of chemicals excluded from the definition of VOC is found in 40 CFR 51.100 (s)(1).

Q: What are flashing losses/VOC emissions from hydrocarbon storage tanks?

A: There are three types of emissions from hydrocarbon storage tanks: working losses, breathing losses, and flashing losses. Flashing losses/VOC emissions occur when a liquid with entrained gases goes from a higher-pressure to a lower-pressure. As the pressure on the liquid drops some of the lighter compounds dissolved in the liquid are released or “flashed” and some of the compounds that are liquids at the initial pressure/temperature transform from a liquid into a gas/vapor and are also released or “flashed” from the liquid. As these gases are released, some of the heavier compounds in the liquids may become entrained in these gases and will

be emitted with them. Flashing losses/VOC emissions are greater as the pressure drop increases and as the amount of lighter hydrocarbons in the liquid increases. The temperature of the liquids and the storage tank will also influence the amount of flashing losses/VOC emissions. These flashing losses/VOC emissions are then either vented to the atmosphere through the tank’s pressure relief valve, hatch, or other opening, or they may be vented to a capture and/or control system. Flashing losses/VOC emissions from hydrocarbon storage tanks include emissions of VOC, hazardous air pollutants (HAP), and toxic air contaminants (TAC).

Q: Where do flashing losses/VOC emissions from hydrocarbon storage tanks occur?

A: The main areas where tank-flashing losses/VOC emissions occur are at:

- wellhead sites when produced liquids are sent to an atmospheric storage vessels from the last pressurized vessel;
- tank batteries when produced liquids are sent to an atmospheric storage vessels from the last pressurized vessel;
- compressors stations when produced liquids are sent to an atmospheric

- storage vessels from the last pressurized vessel;
- gas plants when produced liquids are sent to an atmospheric storage vessels from the last pressurized vessel; and/or
- when the liquids in the gas lines are “pigged” (physically purged of condensate) and then sent to an atmospheric storage vessel.

Q: What are working and breathing losses/VOC emissions from hydrocarbon storage tanks?

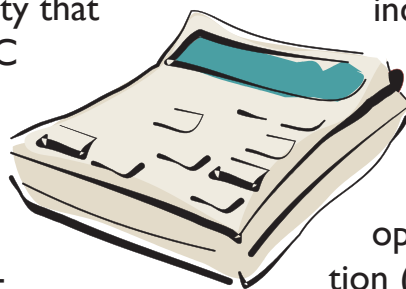
A: Working and breathing losses/VOC emissions from hydrocarbon storage tanks occur in addition to flashing losses/VOC emissions. Working losses are due to displacement of the vapors within the storage tank as a tank is filled. Breathing losses are due to displacement of vapors within the

storage tank due to changes in the tank temperature and pressure throughout the day and throughout the year. Working and breathing losses/VOC emissions can be estimated with the latest EPA TANKS program or its equivalent.

CALCULATION METHODS . . .

Q: Do I need to estimate flashing losses/VOC emissions from my hydrocarbon storage tanks?

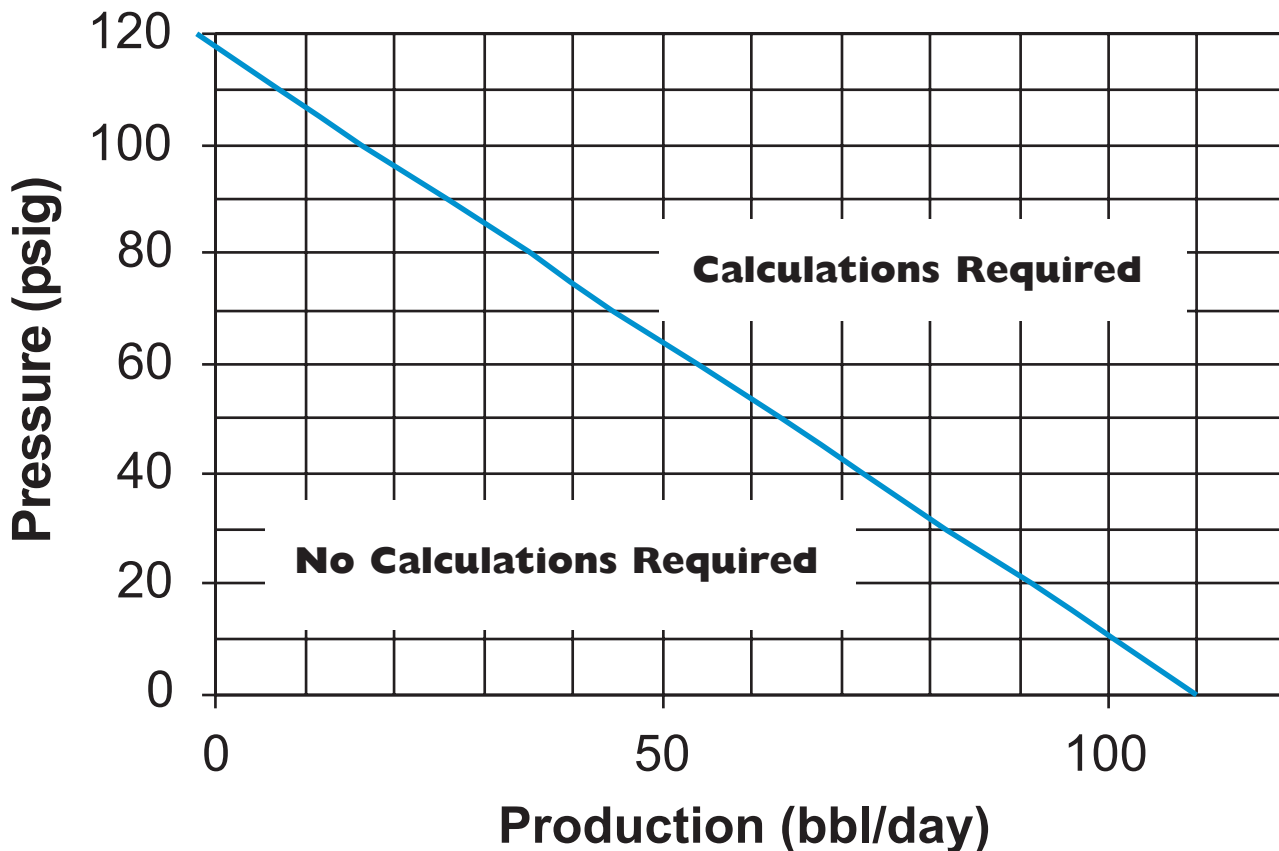
A: Yes, estimates of flashing losses/VOC emissions from hydrocarbon storage tanks will be requested for every facility that has potential flashing losses/VOC emissions from hydrocarbon storage tanks (e.g., natural gas compressor stations, natural gas processing plants, condensate tank batteries, crude petroleum liquid storage facilities, etc.) However, facilities that are determined to be de minimis or permit exempt facilities are not required to submit flashing losses/VOC emis-



sions for their hydrocarbon storage tanks. The graph on the following page has been included to aid facility operators in determining if flashing losses/VOC emissions from hydrocarbon storage tanks need to be calculated. The graph was developed using the Vasquez-Beggs Equation (VBE) and the default parameters on Page 6 of this fact sheet (with the exception of the Stock Tank API gravity). This graph cannot be used if the Stock Tank API gravity of the hydrocarbon liquids in the

storage vessel exceeds 60°. Operators may choose to calculate their facility's flashing losses/VOC emissions from hydrocarbon

storage tanks using actual site data for a more accurate evaluation.



Q: How do I estimate flashing losses/VOC emissions from my hydrocarbon storage tanks?

A: The AQD will accept any of several available methods of calculating flashing losses/VOC emissions from hydrocarbon storage tanks so long as the method selected is used only for those site-specific situations consistent with its development and underlying assumptions. There are specific constraints associated with each emission esti-

mation method. All supporting data used to calculate the emissions, including identification of the calculation method and specific constraints, description of sampling methods and conditions, and copies of lab sampling analyses must be provided to the AQD with the emissions estimates.

The following are some of the methods of calculating flashing losses/VOC emissions from hydrocarbon storage tanks:

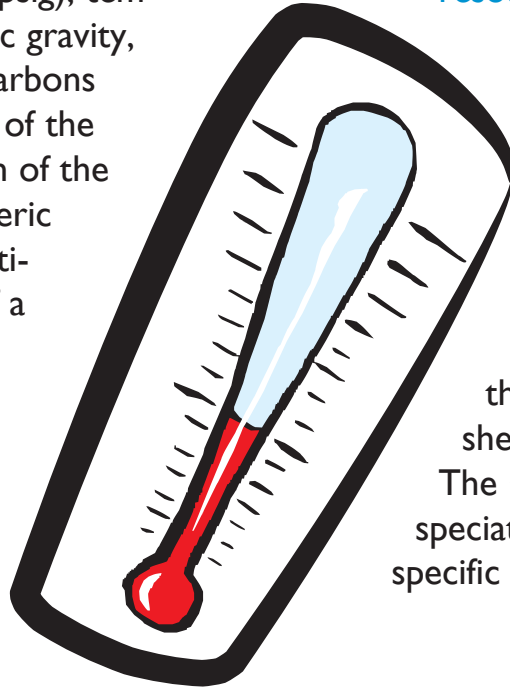
- Vasquez-Beggs Equation (VBE);
- Environmental Consultants and Research, Inc. (EC/R) Equation;
- An equation of state (EOS) calculation program such as E&P Tank®;
- Determination of the gas oil ratio (GOR) and throughput of the hydrocarbon liquids;
- Process simulators (HYSIM®, HYSYS®, WINSIM®, PROSIM®, etc.); and
- Direct measurement of emissions

VBE

The VBE was developed in 1980 as part of a research project at the University of Tulsa. More than 6,000 samples from oil fields worldwide were used in developing correlations to predict oil properties. The VBE can be utilized as a default method to estimate potential flashing losses/VOC emissions from hydrocarbon storage tanks. This equation has eight input variables: stock tank API gravity, separator pressure (psig), temperature (°F), and gas specific gravity, volume of produced hydrocarbons (bbls/day), molecular weight of the stock tank gas, VOC fraction of the tank emissions and atmospheric pressure (psia). The VBE estimates the dissolved GOR of a hydrocarbon solution as a function of the separator temperature, pressure, gas specific gravity, and liquid API gravity. Flashing losses/emissions from the

VOC storage tank are then estimated by multiplying the GOR by the tank throughput, the stock tank gas molecular weight, and the weight fraction of VOC in the gases. This method was designed for gases dissolved in crude oils. The equation is available in a spreadsheet format (EXCEL®) and can be downloaded from the ODEQ website

http://www.deq.state.ok.us/AQDnew/resources/VBE_Aug2008.xls



VBE calculations can also be done using the GRI-HAPCalc® model, which runs in a Windows® format and costs about \$75 through the Gas Research Institute (GRI). The AQD will accept this model or the VBE spreadsheet calculations discussed above. The GRI-HAPCalc® program will also speciate HAP emissions using site-specific data or default values.

EC/R Equation

The EC/R equation estimates the ratio of each component in the liquid phase versus the vapor phase based on the tank pressure and the mole fraction of the vapor flashed. The flash emissions from the tank are then calculated using that information, the tank throughput, the density of the

hydrocarbon liquids, and the mass fraction of each component in the liquid. At pressures below 1.6 atm (~8.8 psig), emissions are assumed to approach zero and at pressures greater than 5.1 atm (~60.3 psig), another emission estimation method is required.

EOS calculation programs (E&P TANK®)

E&P TANK® is a software program designed for use on personal computers. E&P TANK® was developed in an effort to estimate the working, breathing and flashing components of hydrocarbon production tanks. The E&P TANK program is based on the Peng-Robinson (PR) EOS. An EOS is a mathematical equation relating to the relation-

ships between thermodynamic variables such as pressure, temperature, and volume of a specific material in thermodynamic equilibrium. The minimum inputs needed for the model are separator oil composition, separator temperature and pressure, sales oil API gravity and Reid Vapor Pressure (RVP), and sales oil production rate and ambient tem-

perature and pressure. The separator oil composition can be determined using an analysis of the low-pressure separator oil, high-pressure separator oil, or low-pressure separator gas, or using an analysis from the geographical database provided with the program. The database is sorted by geographic region, sales oil physical properties, and separator pressure and separator tem-

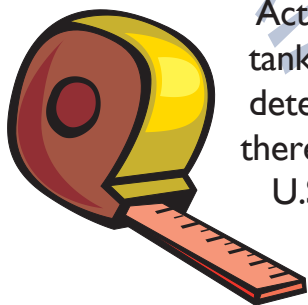
Determination of the GOR

Determination of the hydrocarbon liquid GOR can be obtained by collecting a pressurized sample upstream of the storage tank (i.e. separator dump line). The flashing losses/emissions can then be determined by multiplying the GOR by the throughput of the

Process simulators (HYSIM®, HYSIS®, WINSIM®, PROSIM®, etc.)

Process simulators are computer models that use EOS and mass and energy balances to simulate petroleum processes for a variety of engineering purposes. There are several different manufactures of process simulators (HYSIM®, HYSIS®, WINSIM®, PROSIM®, etc.) each utilizing similar basic principles. Process simulators are mainly used in process design and have been demonstrated to accurately predict natural gas and petroleum processes. Process simulators can be used to estimate flash emissions and speciate these emissions. Required inputs may include an extended pressurized condensate analysis as well as

Direct measurement of emissions



Actual testing of emissions from tanks can also be performed to determine flash emissions. Since there are no currently approved U.S. EPA reference methods that are developed specifically for measuring emissions from storage tanks,

perature. The selected case should be selected such that the parameters are similar to your particular facility. Using these inputs, the program estimates flashing losses/emissions as well as working and breathing losses. The program costs about \$450 (for non-members in 2004) from the American Petroleum Institute (API).

tank. An extended hydrocarbon analysis of the flash gas from the sample should also be conducted to identify the concentrations of the individual components of the tank's flash emissions.



other parameters (e.g. temperature, pressure, and flow) for the process being simulated. Process simulators are not constrained by API gravity. This method of estimating potential flash emissions can be very expensive and complicated and is expected to be more accurate when estimating flashing losses/VOC emissions from hydrocarbon storage tanks than other emissions estimation methods.

approved reference methods and modified reference methods or other approved methods may be used to characterize and determine these emissions, with prior approval of the AQD. However, it should be noted that such testing is just a snapshot of the emissions and should be used in conjunction with a safety factor to establish emission limits.

Q: Are there some default values that may be used when calculating flashing losses/VOC emissions from hydrocarbon storage tanks at my facility?

A: Yes, while some of the variables of the VBE equation are facility-dependent, such as separator pressure (psig) and throughput (BOPD), other variables are not as easily

obtainable or may require default values that may be used. The values shown below have been accepted as default values for VBE calculations:

Inputs	Units	Default Value
Stock Tank API Gravity	API	78.0
Separator Temperature	°F	60.0
Separator Gas Specific Gravity	---	0.9
Stock Tank Gas Molecular Weight	lb/lb-mole	49.0
VOC Fraction of the Stock Tank Gas	Fraction	0.8
Atmospheric Pressure	psia	14.7

Other values may be used as long as they have been obtained from site-specific data collection or are based on a “representative sample.”

Q: Are there restrictions or limits to take into consideration when using any of the calculation methods?

A: Yes, the VBE and the EC/R equation are relatively simple calculations and can be used for a general estimate of flashing losses/VOC emissions from hydrocarbon storage tanks. However, if these simpler estimation methods result in flashing losses/VOC emissions that are greater than 50 TPY, another more accurate method shall be used. If using the more accurate emission estimation methods shows that the simpler emission estimation methods are conservative (calculate more emissions), then the simpler emission estimation methods can be used for permitting and reporting annual emissions.

Also, when using a process simulator, care should be exercised to ensure that the amount of lighter hydrocarbons (propane, ethane, and methane) remaining in the flash

oil (hydrocarbon liquids remaining in the tank after flashing occurs) is not significant (>4%). If a process simulator and the EPA TANKS program are used together to calculate flashing and working and standing losses/emissions from a tank, respectively, it should be noted that the EPA TANKS program does not calculate emissions of lighter hydrocarbons that evolve from the liquids due to their low boiling points. The EPA TANKS program does not even allow entering compounds lighter than pentane. As stated in AP-42 (7/97), Section 7.1, “the equations are not intended to be used in estimating losses from unstable or boiling stocks or from mixtures of hydrocarbons or petrochemicals for which the vapor pressure is not known or cannot be readily predicted.” If the

amount of the lighter hydrocarbons predicted to remain in the flash oil by the process simulator or other program is significant, another method should be used to calculate the working and standing losses/emissions. In these cases, the working and standing losses/

VOC emissions can be calculated using a simple distillation calculation in the process simulator or the temperature of the tank can be increased to reduce the amount of lighter hydrocarbons in the flash oil.

Q: Do I need to perform individual gas or liquid sampling to estimate flashing losses/VOC emissions for each hydrocarbon storage tank or pigging operation?

A: No, the AQD is aware there may be some cost and potential problems associated with taking samples from each crude oil or condensate-gas system or during each pigging operation and that there is some variability in the composition of the hydrocarbon liquids collected. In order to avoid taking samples in each case, facilities can use default values provided in some models (e.g. E&P TANK®, GRI-HAPCalc®, etc.) or “representative analysis” for commonly located oil/gas facilities. If a database or “representative sample” of condensate/oil is used



to represent the actual composition of the facility’s condensate/oil, the company should select one that has similar properties and composition to the facility’s condensate/oil. Sampling is typically justified when there is a potential to violate an applicable requirement (e.g., high throughput facilities, facilities where the pressure drop is very high, when the variability of the hydrocarbon liquid constituents changes frequently, or when the amount of emissions are calculated to exceed major source permitting thresholds).

PERMITTING . . .

Q: If a facility is required to estimate flashing losses/VOC emissions from hydrocarbon storage tanks, does it need an Air Quality permit?

A: If a facility is a de minimis facility as defined under OAC 252:100-7 or satisfies the following permit exempt requirements, a permit is not required:

- The facility has actual emissions every calendar year that are 40 TPY or less of each regulated air pollutant;
- The facility is not subject to an emission standard, equipment standard, or work practice standard in 40 CFR Part 60 (NSPS) or 40 CFR Parts 61 and 63 (NESHAP);
- The facility is not a potential “major source” as defined in OAC 252:100-8; and
- The facility is not located in a non-attainment area;

Q: Is a facility required to include flashing losses/VOC emissions from hydrocarbon storage tanks located at their facility that are owned by another company?

A: For sources with tanks adjacent to or co-located at their facility, whether the flashing losses/VOC emissions from those hydrocarbon storage tanks should be included in the facility's potential to emit should be based on current guidance for the definition of a stationary source. For example, to make

this determination, consideration should be given to the 2 digit SIC code of the tank and the source, the location of the tanks in relation to the source, the ownership or control of those tanks and the rest of the source, and whether or not the tanks are required as a support facility.

Q: What is the schedule for reporting hydrocarbon storage tank flashing losses/VOC emission on my annual emission inventories?

A: For those facilities required to submit emission inventories as specified in OAC 252:100-5, flashing losses/VOC emissions from hydrocarbon storage tanks are required to be reported on their 2003 and



2004 calendar year emission inventories and every year thereafter. Revision of emission inventories for calendar years prior to 2003 will not generally be required.

EMISSION REDUCTION OPTIONS . . .

Q: What are some options to reduce flashing losses/VOC emissions from hydrocarbon storage tanks?

A: There are several options available to reduce the amount of flashing losses/VOC emissions from hydrocarbon storage tanks and they include:

- **Implementing pollution prevention techniques** that reduce the amount of emissions such as installation of an intermediate or low-pressure separator to reduce the pressure drop from the line separators to the hydrocarbon storage tank and allow intermediate vapor recovery.
- **Installing vapor recovery systems** to reduce the amount of emissions from the hydrocarbon storage tanks. For example, the COMM Engineering, Environmental Vapor Recovery Unit™ has been verified by the EPA as a viable cost-effective method for control of emissions from hydrocarbon storage tanks.
- **Installing pollution control devices** such as flares to convert the VOC emissions to combustion products that consist primarily of CO₂ and water.
- **Establishing federally enforceable permit conditions** on operational parameters such as throughput and the maximum pressure drop allowed before venting to the atmosphere.

ASSISTANCE . . .

Q: Are there any programs or ways that a facility can get assistance when trying to calculate flashing losses/VOC emissions from hydrocarbon storage tanks and when applying for a permit?

A: Yes, the DEQ provides three methods of assistance for facilities:

- **Pre-Application Conference** - Prior to filing an application, you may request a conference with staff to answer questions and identify important issues. This meeting is typically handled by AQD staff who will be reviewing your application and drafting your permit.
- **Small Business Assistance Program (SBAP)** - This program provides guidance and assistance to small businesses (100 or fewer employees) regarding state and federal air regulations. This program is administered through the DEQ's Customer Services Division (CSD).
- **Permit Assistance Teams** - A more formalized method of educating your facility about regulatory requirements is the Permit Assistance Team. Staff from the AQD and CSD work as a team to answer permitting questions about your facility. The goal is to provide up-front information to facilitate the permitting process for our customers. This program is also administered through DEQ's CSD.

Also, please work closely with your permit drafter to ensure that the draft permit prepared for your facility represents actual conditions at your facility and is appro-

priate for issuance. This will ensure that your permit is issued in a timely manner without unnecessary delays.

For general assistance contact our Customer Service Division, toll free at 1-800-869-1400, or for specific assistance contact the AQD at (405) 702-4100.



Forms and other information are available on our web site (www.deq.state.ok.us) or upon request.

The information provided here represents our best understanding of how flashing losses/VOC emissions from hydrocarbon storage tanks will be addressed by the AQD. However, it is subject to change at a later time, and is not

final until established by rule or as a final determination in issuance of a permit. Any reference to software or equipment within this fact sheet is not an endorsement by the state of Oklahoma.

References

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GRI-HAPCalc™ 3.0 Software. Copyright (C) 1996-1999 by the Gas Research Institute. <http://www.gastechnology.org/webroot/app/xn/xd.aspx?xd=10AbstractPage\11984.xml>

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