

Approved Calculation Methods and Practices

Air emissions are usually calculated and shown in two formats. Please supply both these formats when possible, using the following significant figure representations:

- x.xx lb/hr (Pounds per hour format)
- x.x TPY (Tons per year format)

1. EMISSIONS FROM RECIPROCATING ENGINES

Complete a “ Reciprocating Engine Form” (AQD-OG2) for each engine.

The Division’ s accepted method to calculate reciprocating engine emissions is by using:

- a. Manufacturer' s emission factors in grams per horsepower hour (g/hp-hr) for nitrogen oxides (NOx), carbon monoxide (CO) and non-methane/non-ethane hydrocarbons (NMEHC, also considered VOC).

Note: If manufacturer’ s emission factors can not be obtained then it is acceptable to use the appropriate emission factors from EPA’ s AP-42, Section 3, latest version.

The most commonly used emission factor table from AP-42, Section 3; for uncontrolled natural gas fired internal combustion engines has been included for convenience.

Emission Factors for Uncontrolled Natural Gas Prime Movers
AP-42, Table 3.2-1

Pollutant	2-Cycle Lean Burn		4-Cycle Lean Burn		4-Cycle Rich Burn	
	lb/hp-hr (power input)	lb/MMBtu (fuel input)	lb/hp-hr (power input)	lb/MMBtu (fuel input)	lb/hp-hr (power input)	lb/MMBtu (fuel input)
NOx	0.024	2.7	0.026	3.2	0.022	2.3
CO	0.00331	0.38	0.00353	0.42	0.019	1.6
TOC ¹	0.013	1.5	0.011	1.3	.00265	0.27

1-TOC is total organic compounds (also sometimes referred to as THC). To determine VOC emissions calculate TOC emissions and multiply the answer by the VOC weight fraction calculated using a fuel gas analysis.

- b. Manufacturer' s maximum site horsepower rating (site horsepower would be the maximum horsepower derated for elevation and temperature).
- c. Calculated hazardous air pollutants using GRI-HAPCalc version 2.0 (or latest).

Reciprocating engine emission calculation example:

Manufacturer's NO_x Emission Factor (EF) is 2.0 g/hp-hr
Engine's Maximum Site Rated Horsepower was calculated to be 250 hp
Engine is expected to operate year round or 8,760 hours/year

$$\begin{aligned} \text{Emissions (lb/hr)} &= \text{EF (g/hp-hr)} * (1 \text{ lb}/454 \text{ g}) * \text{Max. Site HP (hp)} \\ \text{Emissions (lb/hr)} &= (2.0 \text{ g/hp-hr}) * (1 \text{ lb}/454 \text{ g}) * (250 \text{ hp}) = \underline{\underline{1.10 \text{ lb/hr NO}_x}} \end{aligned}$$

$$\begin{aligned} \text{Emissions (TPY)} &= \text{Emissions (lb/hr)} * \text{Operating Hours (hrs/yr)} * (1 \text{ ton}/2000 \text{ lb}) \\ \text{Emissions (TPY)} &= (1.10 \text{ lb/hr}) * (8760 \text{ hours/year}) * (1 \text{ ton}/2000 \text{ lb}) = \underline{\underline{4.8 \text{ TPY NO}_x}} \end{aligned}$$

Reciprocating engine VOC emission calculation example:

AP-42 TOC Emission Factor (EF) = 0.00265 lb/hp-hr
Engine's Maximum Site Rated Horsepower was calculated to be 250 hp
Engine is expected to operate year round or 8,760 hours/year
*** **Assumption:** Use TOC factor for VOC factor.

$$\begin{aligned} \text{VOC Emissions (lb/hr)} &= \text{TOC EF (lb/hp-hr)} * \text{Max. Site HP (hp)} \\ \text{Emissions (lb/hr)} &= (0.00265 \text{ lb/hp-hr}) * (250 \text{ hp}) = \underline{\underline{0.66 \text{ lb/hr VOC}}} \end{aligned}$$

$$\begin{aligned} \text{VOC Emissions (TPY)} &= \text{VOC Emissions (lb/hr)} * \text{Operating Hours (hrs/yr)} * (1 \text{ ton}/2000 \text{ lb}) \\ \text{Emissions (TPY)} &= (0.66 \text{ lb/hr}) * (8760 \text{ hours/year}) * (1 \text{ ton}/2000 \text{ lb}) = \underline{\underline{2.9 \text{ TPY VOC}}} \end{aligned}$$

2. EMISSIONS FROM GLYCOL DEHYDRATOR REBOILER STILL COLUMN VENTS:

Complete a " Glycol Dehydration Unit Form" (AQD-OG3) for each unit.

The Division's accepted method to calculate VOC/HAP emissions from a natural gas dehydration unit reboiler still column vent is by using a process simulation software known as GRI-GLYCalc, version 3.0 (or latest version).

Information provided to the Division should include:

- a. A copy of a recent " wet gas" extended lab analysis (a " wet" gas sample would be one taken upstream of the contactor/absorber tower, of the dehydration unit).
- b. A copy of the model input parameters printout.

Note: The glycol circulation rate **must** be based on the actual, maximum or anticipated glycol pump rate NOT a glycol recirculation ratio. Be sure to include the glycol pump manufacturer and model number information on the AQD-OG4 form.

- c. A copy of the model output printout.

3. EMISSIONS FROM HYDROCARBON STORAGE TANKS:

Complete a “ Storage Tanks and Other VOC Emission Source Form” (AQD-OG4) for each tank.

There are three causes of emissions from hydrocarbon liquid storage tanks; flashing losses, working losses and breathing losses. All three must be accounted for when determining the total emissions from storage tanks.

Note: Some simulation models may have the capabilities to simulate flashing, working and breathing emissions. This capability should be noted and adequately documented in the simulation output data.

The Division will accept several different methods for the calculation of VOC/HAP emissions from storage tanks. Regardless of the method used, information provided to the Division should include:

- a. A copy of any input parameters used in the simulation model or calculations, also include any assumptions used, copies of any lab sample analysis, etc.
- b. A copy of the complete simulation model output or calculation steps.

Flashing Losses

Flashing losses are emissions which occur due to a hydrocarbon liquid going from a higher pressure to a lower pressure (i.e., from separator pressure to storage tank pressure). Flashing loss emission estimation methods are listed below:

1. Simulation Software (HYSIM, K-FLASH) - Which uses either Peng-Robinson or SR-K methods to model the VOC/HAP flash emissions. (An extended hydrocarbon liquid analysis of a pressurized hydrocarbon liquid sample, from the separator upstream of the flash being modeled, is required).
2. Vasquez-Beggs Correlation - This calculation method requires only basic facility process information. **(An Excel 5.0 spreadsheet can be obtained from the Division to perform this calculation.)**
3. TANKCalc (API Process Simulation Model) - Available in July, 1997 and will be reviewed by the Division for acceptability once it is released.
4. Other Methods - Alternate methods must receive prior approval by the Division.

Working and Breathing Emissions

Working losses are those vapors which are vented from the tank due to liquids entering the tank. The liquid level in the tank rises which displaces gas from the vapor space, causing the tank to vent.

Breathing losses (also known as standing or storage losses) are those vapors which are vented from the tank due to the expansion and contraction of the vapor space caused by changes in temperature and barometric pressure.

The Division will accept VOC/HAP emission calculations for hydrocarbon storage tank working and breathing losses as estimated by:

1. EPA's Tanks 3.0 software
2. AP-42, Section 7 calculation methods

4. FLASHING EMISSIONS FROM A PRESSURE VESSEL

Complete the appropriate section of the “ Storage Tanks and Other VOC Emission Source Form” (AQD-OG4) for flashing vessel.

The Division accepts the same methods to calculate these flashing emissions as those for atmospheric hydrocarbon storage tanks.

These flashing vessel emissions result when hydrocarbon liquids go from a high pressure separator to a lower pressure separator. The flash gas is generated in the lower pressure vessel. Typically this low pressure vessel is designed to operate within a specific pressure range. As more flash gas is generated the pressure rises in the low pressure separator until some of the gas must be vented. If the vent is to atmosphere then this emission source must be accounted for.

Flashing vessel emission calculation example:

Approximately 15 barrels per day of a 50° API Hydrocarbon liquid is sent from a high pressure separator (operating at 500 psig) to a heater treater (operating at 20 psig). The flash gas generated in the heater treater is used as fuel for the 0.5 MMBtu/hr heater treater burner. (Fuel gas analysis of the treater flash gas provides a lower heating value, LHV, of 1,300 Btu/scf.) The heater treater burner is thermostatically controlled and is in use an average of 15 minutes/hour, year round.

First, calculate the percent run time of the heater treater burner -

$$\begin{aligned} \text{Percent run time (\%)} &= \text{run time (min/hr)} * 1 \text{ hr}/60 \text{ min} * 100 \\ \text{Run time (hrs/day)} &= 15 \text{ min/hr} * 1 \text{ hr}/60 \text{ min} * 100 = \underline{\underline{25\%}} \end{aligned}$$

Second, calculate the total fuel consumption for heater treater burner -

$$\text{Fuel required (scf/hr)} = \text{Burner rating (MMBTU/hr)} * 1/\text{LHV (Btu/scf)} * \% \text{Run time}/100 * 1,000,000 \text{ Btu/MM Btu}$$
$$\text{Fuel required (scf/hr)} = (0.5 \text{ MMBtu/hr}) * 1/1,300 \text{ Btu/scf} * 25\%/100 * 1,000,000 \text{ Btu/MM Btu} = \underline{\underline{96.15 \text{ scf/hr}}}$$

Third, calculate the amount of flash gas generated -

From the Vasquez-Beggs method, the total flash gas generated is approximately 3000 SCFD or 125 scf/hr

Fourth, calculate how much of the flash gas is not consumed as fuel -

$$\text{Vented gas (scf/hr)} = \text{Total gas (scf/hr)} - \text{Fuel required (scf/hr)}$$
$$\text{Vented gas (scf/hr)} = (125 \text{ scf/hr}) - (96.15 \text{ scf/hr}) = \underline{\underline{28.85 \text{ scf/hr}}}$$

Finally, calculate how much of the vented gas is VOC -

**** Assumption:** The flash gas molecular weight (Gas MW) = 50 lb/lb-mole
The VOC weight fraction of the flash gas = 0.9

$$\text{Emissions (lb/hr)} = \text{Vented gas (scf/hr)} * 1/379 \text{ scf/lb-mole} * \text{Gas MW (lb/lb-mole)} * \text{VOC wt. fraction}$$
$$\text{Emissions (lb/hr)} = (28.85 \text{ scf/hr}) * (1/379 \text{ scf/lb-mole}) * (50 \text{ lb/lb-mole}) * 0.9 = \underline{\underline{3.43 \text{ lb/hr}}}$$

$$\text{Emissions (TPY)} = \text{Emissions (lb/hr)} * 8,760 \text{ hrs/yr} * 1 \text{ ton}/2,000 \text{ lb}$$
$$\text{Emissions (TPY)} = (3.43 \text{ lb/hr}) * (8,760 \text{ hrs/yr}) * (1 \text{ ton}/2,000 \text{ lb}) = \underline{\underline{15.0 \text{ TPY}}}$$

5. EMISSIONS FROM TRUCK LOADOUT

Complete the appropriate section of the “ Storage Tanks and Other VOC Emission Source Form” (AQD-OG4) for truck loadout.

VOC emissions should be calculated from the following formula, using data from the tables taken from AP-42, Section 5.2

$$L_L = 12.46 * S * P * M/T$$

Where:

L_L = loading loss, pounds per 1,000 gallons (lb/1,000 gal) of liquid loaded.

S = a saturation factor (See Table 5.2-1 below)

P = true vapor pressure of liquid loaded, pounds per square inch absolute, psia.

M = molecular weight of tank vapors, pounds per pound-mole (lb/lb-mole)

T = temperature of bulk liquid loaded, °R, (°F + 460)

Table 5.2-1 below, is required to supply the “ S ” variable in the above equation and Table 7.1-2 may provide the “ P ” and “ M ” values.

Table 5.2-1 Saturation (S) Factors for Calculating Petroleum Liquid Loading Losses

Cargo Carrier	Mode of Operation	S Factor
Tank Trucks and Rail Tank Cars	Submerged loading of a clean cargo tank	0.50
	Submerged loading: dedicated normal service	0.60
	Submerged loading: dedicated vapor balance service	1.00
	Splash loading of a clean cargo tank	1.45
	Splash loading: dedicated normal service	1.45
	Splash loading: dedicated vapor balance service	1.00

Table 7.1-2 Properties of Selected Petroleum Liquids

(Only crude oil properties are supplied here for the oil and gas industries. The full table can be found in AP-42, Table 7.1-2)

Petroleum Liquid	Vapor Molecular Weight at 60°F, Mv (lb/lb-mole)	Condensed Vapor Density at 60 °F, Wvc (lb/gal)	Liquid Density At 60 °F, Wl (lb/gal)	True Vapor Pressure, Pva (psi) at various temperatures in °F.						
				40	50	60	70	80	90	100
Crude Oil RVP 5	50	4.5	7.1	1.8	2.3	2.8	3.4	4.0	4.8	5.7

Example of a Truck Loadout Emission Calculation:

An average of 360 bbls of crude oil per month, stored at an average annual temperature of 50°F, is loaded into a tank truck when sold from the lease. The tank truck is primarily used to haul hydrocarbon liquids from lease storage tanks to the crude oil buyer. The truck is designed to so the liquids do not splash into the tank but instead enter the tank truck from the bottom, so the liquids do not splash.

- From Table 5.2-1, for submerged loading, dedicated normal service: “ S” = 0.6
- From Table 7.1-2, for crude oil, RVP= 5 at 50°F: “ P” = 2.3
- From Table 7.1-2, for crude oil, RVP= 5 at 50°F: “ M” = 50

Therefore:

$$L_L = \frac{12.46(0.60)(2.3 \text{ psi})(50 \text{ lb/lb-mole})}{(50^\circ\text{F} + 460)} = \underline{1.69 \text{ lb/1,000 gal loaded}}$$

**** Assumption:** The truck capacity is 180 bbl and requires 2 hours to load.

$$\begin{aligned} \text{Emissions (lb/hr)} &= L_L \text{ (lb/1,000gal)} * \text{truck load rate (bbl/hr)} * 42 \text{ gal/bbl} \\ \text{Emissions (lb/hr)} &= 1.69 \text{ lb/1,000 gal} * 180 \text{ bbl/2 hr} * 42 \text{ gal/bbl} = \underline{6.39 \text{ lb/hr}} \end{aligned}$$

$$\begin{aligned} \text{Emissions (TPY)} &= L_L \text{ (lb/1,000gal)} * \text{Annual Sales Vol. (bbl/yr)} * 42 \text{ gal/bbl} * 1 \text{ ton/2,000 lb} \\ \text{Emissions (TPY)} &= 1.69 \text{ lb/1,000 gal} * (360 \text{ bbl/mo} * 12 \text{ mo/yr}) * 42 \text{ gal/bbl} * 1 \text{ ton/2,000 lb} = \underline{0.2 \text{ TPY}} \end{aligned}$$

6. FUGITIVE VOC/HAP EMISSIONS

Complete the appropriate section of the Storage Tanks and Other VOC Emission Source Form (AQD-OG4) for fugitives.

The Division will accept fugitive VOC/HAP emission estimates calculated by:

- a. Methods contained in EPA publication EPA-453/R-95-017, titled Protocol for Equipment Leak Emission Estimates, November 1995.
- b. Emission estimation software known as GRI-HAPCalc, version 2.0 (or latest version).

Information provided to the Division should include:

- a. A listing of the component counts (i.e., number of valves, flanges, threaded connections, relief valves)

Note: Component counts may be obtained by any of the following methods:

1. An actual component count of the facility.
2. An estimate of the facility component count based on other like facilities, facility drawings, etc.
3. The default component count for the applicable facility type in GRI-HAPCalc.

- b. A determination of the VOC/HAP weight fraction of the various service categories used.

The component emission factors, provided in the following table, may be used to calculate average fugitive emissions for oil and gas production operations. The emission factors are based on the emission factor table called "Oil and Gas Production Operations Average Emission Factors" from EPA-453/R-95-017.

Note: The emission factors shown are for total hydrocarbons emissions and must be multiplied by the appropriate VOC/HAP weight fraction of the fluids being used.

**Fugitive Equipment Leak Emission Factors
(lb/hr/component)**

Equipment Type	Equipment Service Category			
	Gas	Heavy Oil (< 20 API Gravity)	Light Oil (> 20 API Gravity)	Water/Light Oil ¹
Connectors ²	.00044	.0000165	.000463	.000243
Flanges	.00086	.00000086	.000243	.00000639
Open-ended Lines	.00441	.000309	.00309	.00055
Pumps	.00529	N/A	.02866	.0000529
Valves	.00992	.0000185	.0055	.000216
Other ³	.01940	.0000705	.0165	.0309

1-The Water/Light Oil emission factors apply to water streams in light oil service with a water content between 50% and 99%. For streams with a water content greater than 99% the emission rate is considered negligible.

2-Connectors are considered thread and coupling type connections.

3-The "Other" equipment type includes compressor seals, relief valves, diaphragms, drains, dump arms, hatches, instruments, meters, polished rods and vents.

Fugitive emission calculation example:

For 25 valves in light oil service containing condensate.

**** Assumption:** 20% (by weight) of the vapor emitted from the components is VOC and 10% (by weight) of the vapor is hazardous air pollutants (HAP).

VOC Emissions (lb/hr) = E. F. From Table (lb/hr/component)* Quantity* VOC wt. Fraction

$$\text{VOC Emissions (lb/hr)} = .0055(\text{lb/hr/component}) * 25 \text{ valves} * 0.20 = \underline{\underline{0.03 \text{ lb/hr}}}$$

VOC Emissions (TPY) = Emissions (lb/hr)* 8760 hrs/yr* 1 ton/2000 lb

$$\text{VOC Emissions (TPY)} = .03(\text{lb/hr}) * 8760 \text{ hrs/yr} * 1 \text{ ton/2000 lb} = \underline{\underline{0.1 \text{ TPY}}}$$

HAP Emissions (lb/hr) = E.F. From Table (lb/hr/component)* Quantity* HAP Wt. Fraction

$$\text{HAP Emissions (lb/hr)} = .0055(\text{lb/hr/component}) * 25 \text{ valves} * 0.10 = \underline{\underline{0.01 \text{ lb/hr}}}$$

HAP Emissions (TPY) = Emissions (lb/hr)* 8760 hrs/yr* 1 ton/2000 lb

$$\text{HAP Emissions (TPY)} = .01\text{lb/hr} * 8760 \text{ hrs/yr} * 1 \text{ ton/2000 lb} = \underline{\underline{0.04 \text{ TPY}}}$$

7. EMISSIONS FROM PNEUMATIC SOURCES

Complete the appropriate section of the “ Storage Tanks and Other VOC Emission Source Form” (AQD-OG4) for pneumatic sources.

The Division accepted method to calculate emissions from pneumatic sources is by the following formula:

$$\text{Emissions (lb/hr)} = \text{PSCR (scf/min)} * (60 \text{ min/1 hr}) * (1/379 \text{ scf/lb-mole}) * \text{gas MW (lb/lb-mole)} * \text{VOC wt. fraction}$$

Where -

PSCR = Pneumatic source consumption rate (scf/min), as per manufacturer’s literature.

Gas MW = Supply gas molecular weight (lb/lb-mole)

Pneumatic source emission calculation example:

The facility uses a pneumatic chemical pump and uses field gas rather than instrument air for supply gas for the pump. The field gas has a molecular weight of 22 lb/lb-mole and a VOC weight fraction of 0.24. The pump uses 1 scf/min of supply gas to pump the required chemical, as per manufacturer’s literature.

$$\text{Emissions (lb/hr)} = \text{PSCR (scf/min)} * (60 \text{ min/1 hr}) * (1/379 \text{ scf/lb-mole}) * \text{gas MW (lb/lb-mole)} * \text{VOC wt. fraction}$$

$$\text{Emissions (lb/hr)} = (1 \text{ scf/min}) * (60 \text{ min/hr}) * (1/379 \text{ scf/lb-mole}) * (22 \text{ lb/lb-mole}) * (0.24) = \underline{\underline{0.84 \text{ lb/hr VOC}}}$$

$$\text{Emissions (TPY)} = (0.84 \text{ lb/hr VOC}) * (8,760 \text{ hr/yr}) * (1 \text{ ton}/2,000 \text{ lb}) = \underline{\underline{3.7 \text{ TPY VOC}}}$$

8. EMISSIONS FROM EXTERNAL COMBUSTION EQUIPMENT

Complete the appropriate section of the “ Heaters, Boilers, Flares and Other External Combustion Equipment Form” (AQD-OG5) for Heaters, Boilers, Etc.

NOx, CO and VOC emissions from production unit heaters should be calculated using the emission factors (EF) provided in AP-42, Tables 1.4-2 and 1.5-2. A table showing these factors is shown below:

Emission Factors for Fuel Boilers & Heaters

Pollutant	Fuel to be Combusted (Combuster Size, MMBtu/hr heat input)				
	LP Gas ¹ (0.3 to 10)	LP Gas (10 to 100)	Natural Gas ² (< 0.3)	Natural Gas (0.3 to 10)	Natural Gas (10 to 100)
NOx	14 lb/1000 gal	19 lb/1000 gal	94 lb/mmcf	100 lb/mmcf	140 lb/mmcf
CO	1.9 lb/1000 gal	3.2 lb/1000 gal	40 lb/mmcf	21 lb/mmcf	35 lb/mmcf
TOC ³	0.5 lb/1000 gal	0.5 lb/1000 gal	11.0 lb/mmcf	8.0 lb/mmcf	5.8 lb/mmcf

1-LP gas emission factors are based on an average liquid propane heating value of 91,500 Btu/gal. Ratio the emission factor according to the Btu content of the LP actually used.

2-Natural gas emission factors are based on an average natural gas heating value of 1000 Btu/scf. Ratio the emission factor according to the Btu content of the natural gas actually used.

3-VOC emissions may be determined by multiplying the calculated TO (total organic compounds) emission rate by the weight percent of VOC compounds in the fuel gas stream.

Natural gas fuel fired burner example calculation:

- A heater treater, using natural gas for fuel, has a burner rating of 0.5 MMBtu/hr.
- Fuel gas analysis shows the gas to have a lower heating value (LHV) of 1,200 Btu/SCF.
- A VOC weight fraction of 0.2 was calculated using the mole percent of VOCs (from the fuel gas analysis) and the corresponding molecular weights of the VOC components.
- The burner is assumed to operate all the time, 8,760 hours per year (however, actual conditions may be that the burner is thermostatically controlled and comes on only a fraction of this time.)

- **From Table 1.4-2**, for a natural gas fired burner rated at 0.5 MMBtu/hr, the NO_x EF = 100 lb/mmcf

Emissions (lb/hr)= Burner Rating (MMBtu/hr)* EF (lb/mmcf)* 1 mmcf/1,000 MMBtu* 1,200 LHV/1,000 LHV
 NO_x Emissions (lb/hr)= 0.5 MMBtu/hr* 100 lb/mmcf* 1 mmcf/1,000 MMBtu* 1,200/1,000 = **0.06 lb/hr NO_x**

Emissions (TPY)= Emissions (lb/hr)* annual operating hours (hr/yr)* 1 ton/2,000 lb
 NO_x Emissions (TPY)= 0.06 lb/hr NO_x* 8760 hr/yr* 1 ton/2,000 lb = **0.3 TPY NO_x**

9. EMISSIONS FROM FLARES

Complete the appropriate section of the “ Heaters, Boilers, Flares and Other External Combustion Equipment Form” (AQD-OG5) for Flares.

NO_x and CO emissions from flares should be calculated using the emission factors provided in AP-42, Tables 13.5-1. This table is provided below:

Emission Factors for Flare Operations¹

Component	Emission Factor (lb/MMBtu)
Carbon Monoxide	0.37
Nitrogen Oxides	0.068

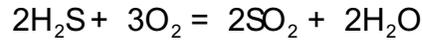
¹Based on tests using crude propylene containing 80% propylene and 20% propane.

Emissions (lb/hr)= Flare gas vol (scf/hr)* LHV (Btu/scf)* (1 MMBtu/1,000,000 Btu)* EF (lb/MMBtu)

VOC emissions should be calculated based on a 98% destruction efficiency of the VOC gas stream going to the flare.

$$\text{Emissions (lb/hr)} = \text{Flare gas vol (scf/hr)} * 1/379 \text{ scf/lb-mole} * \text{Flare gas MW (lb/lb-mole)} * \text{VOC wt. fraction} * 0.02$$

For sour gases (i.e., gas containing H₂S) the SO₂ emissions should be calculated based on the mass balance conversion of H₂S to SO₂, when the gas is flared.



$$\text{SO}_2 \text{ Emissions (lb/hr)} = \text{Flare gas vol. (scf/hr)} * 1/379 \text{ scf/lb-mole} * 64 \text{ lb/lb-mole} * \% \text{H}_2\text{S}/100$$

Flare emission calculation example:

- Approximately 10 MSCFD of gas is being flared, it has a lower heating value (LHV) of 1,400 Btu/scf and a molecular weight (MW) of 26.4 lb/lb-mole.
- The VOC weight fraction of the flared gas is 0.28
- The flared gas also contains 4.4% H₂S

First, calculate the VOC emission before it is flared (i.e., uncontrolled):

$$\text{Emissions (lb/hr)} = \text{vented gas vol (scf/hr)} * 1/379 \text{ scf/lb-mole} * \text{Vent gas MW (lb/lb-mole)} * \text{VOC wt. fraction}$$

$$\text{Emissions (lb/hr)} = (10,000 \text{ scf/day} * 1 \text{ day}/24 \text{ hr}) * (1/379 \text{ scf/lb-mole}) * (26.4 \text{ lb/lb-mole}) * (0.28) = \underline{\underline{8.13 \text{ lb/hr}}}$$

$$\text{Emissions (TPY)} = (8.13 \text{ lb/hr}) * (8,760 \text{ hr/yr}) * (1 \text{ ton}/2,000 \text{ lb}) = \underline{\underline{35.6 \text{ TPY VOC}}}$$

Second, calculate VOC emissions after the gas is flared (controlled):

$$\text{Emissions (lb/hr)} = \text{Flare gas vol (scf/hr)} * 1/379 \text{ scf/lb-mole} * \text{Flare gas MW (lb/lb-mole)} * \text{VOC wt. fraction} * 0.02$$

$$\text{Emissions (lb/hr)} = (10,000 \text{ scf/d} * 1 \text{ d}/24 \text{ hr}) * (1/379 \text{ scf/lb-mole}) * (26.4 \text{ lb/lb-mole}) * (0.28) * (0.02) = \underline{\underline{0.16 \text{ lb/hr}}}$$

$$\text{Emissions (TPY)} = (0.16 \text{ lb/hr}) * (8,760 \text{ hr/yr}) * (1 \text{ ton}/2,000 \text{ lb}) = \underline{\underline{0.7 \text{ TPY VOC}}}$$

Third, Calculate the sulfur dioxide emissions created when the hydrogen sulfide is flared:

$$\text{SO}_2 \text{ Emissions (lb/hr)} = \text{Flare gas vol. (scf/hr)} * 1/379 \text{ scf/lb-mole} * 64 \text{ lb/lb-mole} * \% \text{H}_2\text{S}/100$$

$$\text{Emissions (lb/hr)} = (10,000 \text{ scf/d} * 1 \text{ d}/24 \text{ hr}) * (1/379 \text{ scf/lb-mole}) * (64 \text{ lb/lb-mole}) * (4.4/100) = \underline{\underline{3.10 \text{ lb/hr SO}_2}}$$

$$\text{Emissions (TPY)} = (3.10 \text{ lb/hr SO}_2) * (8,760 \text{ hr/yr}) * (1 \text{ ton}/2,000 \text{ lb}) = \underline{\underline{13.6 \text{ TPY SO}_2}}$$

Finally, Calculate the NOx or CO emissions from flaring:

$$\text{Emissions (lb/hr)} = \text{Flare gas vol (scf/hr)} * \text{LHV (Btu/scf)} * (1 \text{ MMBtu}/1,000,000 \text{ Btu}) * \text{EF (lb/MM Btu)}$$

$$(10,000 \text{ scf/d} * 1 \text{ d}/24 \text{ hr}) * (1,400 \text{ Btu/scf}) * (1 \text{ MMBtu}/1,000,000 \text{ Btu}) * (.37 \text{ lb/MM Btu}) = \underline{\underline{0.22 \text{ lb/hr CO}}}$$

$$\text{Emissions (TPY)} = (0.22 \text{ lb/hr CO}) * (8,760 \text{ hr/yr}) * (1 \text{ ton}/2,000 \text{ lb}) = \underline{\underline{1.0 \text{ TPY CO}}}$$