TECHNICAL SUPPLEMENT 4: FLARES

Technical Disclaimer

This technical supplement is intended to help you accurately determine and correctly report flare emissions. It does not supersede or replace any state or federal law, rule, or regulation.

This guidance, which reflects our current understanding of how flares work and how they generate emissions, how they are monitored or tested, and what data are available for emissions determination, may change over time as we continue our scientific studies and as new information becomes available. We welcome any data, information, or feedback that may improve our understanding of flare emissions and thereby further improve determinations within the emissions inventory.

The calculation methods represented are intended as an aid; alternate methods may be equally acceptable if they are based upon, and adequately demonstrate, sound engineering assumptions or data. If you have a question regarding the acceptability of a given emissions determination method, contact the Industrial Emissions Assessment Section at 512-239-1773.

Introduction

This technical supplement offers guidance on identifying, quantifying, and correctly reporting elevated flare emissions on the annual emissions inventory.

This document does not address flare structural representation in the inventory. For guidance on this topic, consult Chapter 3.

Definitions

In this supplement, the term “waste gas” refers to gas streams produced in the process unit and routed to the flare for destruction.

“Supplemental fuel” refers to the gas that mixes with waste gas prior to its arrival at the flare tip, ensuring the combustibility of the total gas stream.

“Flared gas” refers to the combination of waste gas and supplemental fuel.

“Pilot gas” refers to the gas routed to the flare tip to ensure flared gas ignition.

Expected Emissions

Flare emissions will include, at a minimum, nitrogen oxides (NO_x), carbon monoxide (CO), and uncombusted flared gas compounds. In addition, if the flared gas contains sulfur-bearing compounds, emissions will also include hydrogen sulfide (H_2S) and sulfur dioxide (SO_2).

Products of Combustion

Products of combustion include NO_x, CO, and SO_2. Flared and pilot gas heat outputs impact emission rates of NO_x and CO. The sulfur content of both flared and pilot gases determines SO_2 emissions.

Compounds from Uncombusted Flared Gas

The flare's destruction efficiency determines what fraction of the flared gas remains uncombusted. The uncombusted flared gas compounds are generally volatile organic compounds, but may also include H_2S, CO, ammonia, and other organic and inorganic compounds present in the flared gas.

Emissions Determination

Generally, flare emissions determinations should be consistent with *Air Permit Technical Guidance for Chemical Sources: Flares and Vapor Oxidizers* available at <http://www.tceq.state.tx.us/permitting/air/nav/air_chemdocs.html>. However, if actual flare operation deviates from the specific operating conditions assumed in permit guidance, then it may not be appropriate to use the guidance in RG-109 to determine emissions. Exceptions for actual operation are identified in the following sections.

All flare emissions determinations depend upon the flared gas flow rate and composition. Therefore, before specific emission calculations are discussed, the preferred methods for obtaining the actual flared gas flow rate and composition data will be addressed.

Flared Gas Flow Rate and Composition

To obtain the most accurate emissions determination, base your calculations on the actual flow rate and the specific composition of the gas routed to the flare. The generally preferred methods of obtaining data on flared gas flow rate and composition are, in order of preference:

1. continuous monitoring with quality assured instruments
2. continuous monitoring with instruments that may not meet all quality assurance tests
3. periodic testing with instruments and laboratory analytical methods

4a. engineering determinations based on detailed process evaluation

4b. a one-time performance test conducted during the inventory year

For flares subject to Chapter 115, Subchapter H, relating to highly reactive volatile organic compounds, flow rate and composition data required by 30 TAC §§ 115.725 and 115.726 should be used to determine emissions for any portions of 2006 during which HRVOC monitors were installed and operational.

In the absence of monitoring data, selection of the most accurate method may sometimes require exercising scientific judgment. For example, when using the results of a one-time performance test, the test conditions should be compared to the flare's actual operating conditions during the inventory year to determine whether the test accurately represents the flare's performance. If test conditions do not accurately model flare operation, then engineering determinations based on detailed process evaluation may provide the best data.

NO_x and CO Emissions

To calculate NO_x and CO emissions, you must first know the net heating value of the flared gas. Using the actual short-term flared gas composition and flow rate data for the inventory year, calculate the net heating value of the flared gas and the total heat release for each short time period. Use these total heat release data, in conjunction with the appropriate emission *Flares and Vapor Oxidizers*, to determine NO_x and CO emissions for each time segment. Since the calculated net heating value of the gas and the assist gas type will determine the appropriate NO_x and CO emission factors from *Flares and Vapor Oxidizers*, you must carefully select the correct factors for each flare.

Calculate emissions using the most accurate data on gas flow rate and composition available. (See “Flared Gas Flow Rate and Composition” earlier in this supplement for more information on preferred data.) Regardless of the data's source, code NO_x and CO emissions with a determination methodology of “A” for ‘TCEQ-approved factor.’

For flares subject to the HRVOC regulations in Chapter 115, Subchapter H, use the net heating value data required by 30 TAC §§ 115.725–26 to determine NO_x and CO emissions for any portions of 2006 during which HRVOC monitors were installed and operational.

Uncombusted Flared Gas Emissions

Uncombusted flared gas emissions usually include VOCs, H_2S, or both. Emissions calculations for these contaminants are based on the flared gas flow rate and composition and the appropriate destruction efficiency, which depends upon the actual flare operation. Flare destruction efficiency varies with flame stability, operating conditions, flare tip size and design, the specific compounds being combusted, and gas composition. The EPA has determined operating limits (see 40 CFR 60.18), that result in stable operation of flare flames. Therefore, emission determinations may vary depending on whether the criteria of 40 CFR 60.18 are satisfied.

Chapter 115 HRVOC regulations address flare operational requirements in regard to 40 CFR 60.18. For flares subject to HRVOC regulations, use the appropriate destruction efficiencies specified in 30 TAC § 115.725. Additionally, for flares subject to Chapter 115 HRVOC regulations, use the required HRVOC monitoring data to determine emissions of uncombusted flared gases for any portions of 2006 during which HRVOC monitors were installed and operational.

Otherwise, if the flare's operation is consistent with 40 CFR 60.18, then use the appropriate destruction efficiencies provided in *Flares and Vapor Oxidizers*. Note that, for flare operation to be considered consistent with 40 CFR 60.18, it should:

- meet the flared gas heating value and flare exit tip velocity limitations;
- be equipped with proper liquid knockout and ignition systems; and
- operate smokelessly.

If the flare's operation is not consistent with 40 CFR 60.18, then the flare is likely to be operating at or near unstable flame mode. If specific data on destruction efficiency are available for the flare tip and design, compounds being combusted, gas composition, and operating conditions of the flare in question, these may be used to determine emissions in such cases. Otherwise, it will be necessary to use the destruction efficiency described in the following paragraph.

Although only limited test data are available for flares operating with an unstable flame, EPA test data indicate that destruction efficiencies generally range from 85 to 97 percent in such cases. The median destruction efficiency for the EPA data set appears to be approximately 93 percent. Although other data suggest that efficiencies may be even lower during unstable flame operations, you may assume a 93 percent destruction efficiency for flare operating conditions that do not satisfy 40 CFR 60.18.

On steam assisted flares, there is the potential for over-steaming of the gas stream and the destruction efficiency may be lower than the appropriate destruction efficiencies given in *Flares and Vapor Oxidizers*. You may assume a 93 percent destruction efficiency for flare operating conditions that do not satisfy 40 CFR 60.18.

Of course, if the flare flame is ever extinguished, one should assume no destruction for the period during which the flame was out.

Code uncombusted flared gas emissions with a determination methodology of “B” for ‘material balance.’

SO_2 Emissions

Calculations of SO_2 emissions are based on the amount of sulfur-bearing compounds in the flared gas and on the appropriate destruction efficiency, as discussed previously.

For example, assume that 100 pounds per hour of flared gas, composed of 80 percent butane and 20 percent H_2S, is burned in a flare that satisfies 40 CFR 60.18. The hourly uncombusted flared gas emissions would be 1.6 pounds of butane and 0.4 pounds of H_2S. In addition, the flare creates SO_2 from the H_2S. Determine the SO_2 emissions as follows:

$$\frac{20 \text{ lbH}_2\text{S}}{\text{hour}} \times 0.98 \times \frac{\text{lb-mole}}{34 \text{ lb H}_2\text{S}} \times \frac{64 \text{ lb SO}_2}{\text{lb-mole}} = 36.9 \text{ lb/hr SO}_2$$

Note that, as the criteria of 40 CFR 60.18 were met, a 98 percent destruction efficiency was assumed.

Code SO_2 emissions with a determination methodology of “B” for ‘material balance.’

Annual and Ozone Season Rates

Typically, flared gas flow rate and composition are highly variable; therefore, calculations of flare emissions need to take this variability into consideration. In general, emission determinations should not be based on annual average conditions. Instead, calculate emissions for short time segments during which flare flow rate and composition are relatively constant, and then sum those short-term emissions to obtain the actual annual total. For example, if hourly flow rates and composition data are available, then calculate hourly emissions (lb/hr) and sum all hourly rates to obtain the annual total. If only weekly data are available, then calculate weekly average emissions and sum those to obtain the annual total.

These principles are especially important for ozone season emission calculations. The actual short-term emissions calculated for the months of

June, July, and August should be used to develop the daily average ozone season emissions.

If no flow rate or composition data are available, then engineering estimates should account for annual process variations that might affect flared gas.

Speciation of Uncombusted Flared Gas Compounds

Depending on the flare service, emissions of uncombusted flared gas could include carbon, nitrogen, and sulfur compounds.

At this time, the composition of the uncombusted flared gas is assumed to remain unchanged. Although complex oxidation reactions in the flare flame may alter the emissions composition, no definitive method exists to identify those new compounds. Thus, emission determinations should assume no change in the composition of the uncombusted gas.

For example, consider a flared gas flow rate of 100 pounds per hour of VOC with a composition by weight of:

- 20 percent toluene,
- 60 percent xylene,
- and 20 percent butane.

If the flare satisfies 40 CFR 60.18 performance criteria with this flow rate and composition, then a 98 percent destruction efficiency may be used. Based on the flow rate, composition, and destruction efficiency, **total** VOC emissions would be 2 pounds per hour.

Since these emissions are assumed to be 20 percent toluene, 60 percent xylene and 20 percent butane by weight, speciated VOCs would be reported as:

- 0.4 pound per hour toluene,
- 1.2 pounds per hour xylene, and
- 0.4 pound per hour butane.

For flares subject to HRVOC regulations, determine speciated uncombusted flare gas emissions according to the requirements (including destruction efficiencies) outlined in 30 TAC § 115.725.

Supporting Documentation

Flare emissions depend heavily on a flare’s destruction efficiency. Provide the following supporting documentation with your inventory:

- sample calculations showing the basis of flare emission determination; and
- a completed Flare Data form (see end of supplement)

For each flare in HRVOC service, indicate “Yes” on the “HRVOC Service?” characteristic.

In addition, IEAS staff may request data for those times during which the flare did not satisfy did not satisfy 40 CFR 60.18 criteria. These data include, but are not limited to:

- the date and time of the period;
- the flare emission point;
- waste gas and supplemental fuel flow rate in scfm;
- waste gas and supplemental fuel composition in volumetric percentages
- the Btu/scf value for each component of the waste gas and supplemental fuel
- the flare tip diameter; and
- the steam/air assist gas rate.

References

Engineering Science, preparer. 1983. *A Report on Flare Efficiency Study.* Vol. 1. Chemical Manufacturers’ Association.

Energy and Environmental Research Corporation, preparer. 1984. *Evaluation of the Efficiency of Industrial Flares: Test Results*. EPA report 600/2-84-095. Industrial and Environmental Research Lab.

Texas Commission on Environmental Quality. 2000. *Air Permit Technical Guidance for Chemical Sources: Flares and Vapor Oxidizers.* TCEQ Air Permits Division draft document. Available online at: <http://www.tceq.state.tx.us/permitting/air/nav/air_chemdocs.html>. Accessed December 27, 2006.

U.S. Environmental Protection Agency. 1985. *Evaluation of the Efficiency of Industrial Flares: Flare Head Design and Gas Composition*. EPA report 600/2-85-106. Washington, DC: Environmental Protection Agency.

Flare Data Form

TCEQ Emissions Inventory Year______

TCEQ Air Account Number:

Flare FIN:	**Flare EPN:**

For the path(s) that the flare abates, flare CIN:

Minimal Flow Data *For the period during which flow rate to the flare was lowest*	
Minimal Flow Rate: __________ Mscf/minute	**Gross Heating Value:** __________ Btu/scf
Tip Velocity: _________ feet/second	**Net Heating Value:** _________ Btu/scf

Maximal Flow Data *For the period during which flow rate to the flare was highest*	
Maximal Flow Rate: __________ Mscf/minute	**Gross Heating Value:** __________ Btu/scf
Tip Velocity: _________ feet/second	**Net Heating Value:** _________ Btu/scf

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