<u>ATTACHMENT B</u>

to

City's Petition to EPA
Challenging Emission Factors

July 9, 2008

Reducing Emissions From Plant Flares

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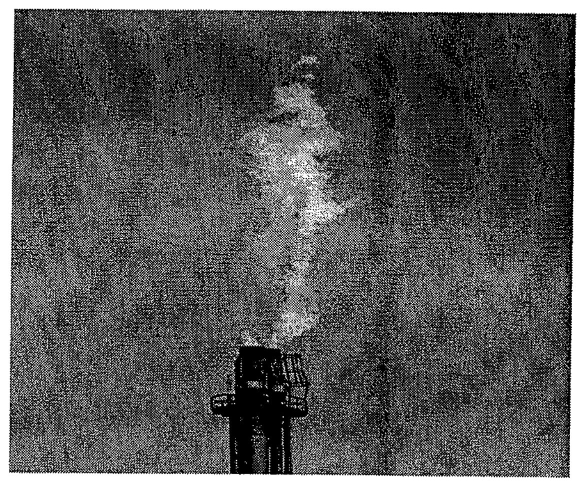
Prepared by Robert E. Levy, Lucy Randel, Meg Healy and Don Weaver

Industry Professionals for Clean Air, 3911 Arnold St., Houston, TX 77005

ABSTRACT

Regulation of emissions from plant flares in Texas is based on flare efficiency studies conducted by the US Environmental Protection Agency (EPA) in the early 1980's, which concluded that flare combustion efficiencies of 98 or 99 percent are achieved when critical operating variables are controlled appropriately. However, recent studies suggest that, even when well-controlled, flares may operate with efficiencies appreciably lower than 98 percent due to crosswinds and other factors. Lower than assumed flare combustion efficiencies, particularly during emission events, could account for a significant portion of previously unrecognized emissions from refineries and chemical plants and help to explain Houston's high ozone levels. This paper discusses the state of the art in understanding flare emissions and examines the specific shortcomings of the current Texas flare regulations, including new regulations on highly reactive volatile organic compounds (HRVOCs). In addition, it considers steps that could mitigate flare emissions, and finally provides a list of recommendations for industry and regulators. Recommendations include expanding research on factors affecting flare combustion efficiency; improving monitoring and reporting of flare operating parameters, such as steam assist and flare gas mass ratios; minimizing the volume of waste gases routed to elevated, unenclosed flares; and encouraging the use of flare gas recovery systems or wind-protected ground flares and thermal oxidizers.

INTRODUCTION



Houston is classified by the EPA as being in "severe" nonattainment of the one-hour ozone standard and in "moderate" nonattainment of the eight-hour standard. The Texas Commission on Environmental Quality (TCEQ) has recognized a link between episodic emissions of the type associated with flaring and sudden exceedances of the one-hour ozone standard by enacting a new short-term limit on highly-reactive volatile organic compound (VOC) emissions. Ozone and smog result from the reaction of VOCs with nitrous oxides in sunlight. Significant quantities of VOCs are released from elevated flares, which burn waste hydrocarbons primarily during emergencies and upset conditions.

In a 2000 annual summary of emissions, the TCEQ estimated that flares were responsible for 12 percent of total emissions of volatile hydrocarbons in the Houston-Gulf Coast area, based on an assumed 98 or 99 percent flare combustion efficiency.[1] However, flare burning efficiencies are not readily measured. Rather, VOC destruction efficiencies of 98 or 99 percent are assumed by the TCEQ[2,3] and industry, based on experimental studies completed by the EPA in the early 1980's.

In 1986, EPA used the data from these studies to codify the requirements for flares under the New Source Performance Standards (NSPS) in 40 CFR 60.18. The NSPS rule specifies limits of critical flare operating variables that must be controlled to obtain 98 percent or higher combustion efficiency. These critical operating variables include heat content of the flare fuel mixture, the ratio of fuel gas to assist gas (air or steam) and burner tip velocity. In 1994, similar control device requirements were added to the National Emissions Standards for Air Pollutants (NESHAP) in 40 CFR 63.11. Other than the addition of a provision for hydrogen fueled flares in 1998,[4] the requirements have remained essentially unchanged for 20 years.

The TCEQ has not required reporting of operating data, except weight of total hydrocarbon burned and "engineering estimates" of stream composition. With inadequate operating data, 98 to 99 percent combustion efficiency cannot be realistically assumed. Another operating variable, crosswind velocity, was not addressed in the EPA studies, and more recent experimental work suggests crosswinds reduce flare combustion efficiency. Although some independent research has recently been initiated by the International Flare Consortium[5], neither EPA nor TCEQ has undertaken significant large-scale experimental work since the early 1980's.

In this paper, we review the literature evaluating effects of operating parameters on flare efficiency, as well as recent approaches in both industry and government to quantify and reduce hydrocarbon emissions from flares. The authors believe serious attention to these issues with enforceable goals is imperative if the Houston-Galveston area (HGA) is to reduce its "smog day count." Recycling of waste gases, rather than flaring, must be seriously considered and flares should be reserved for essential use during unavoidable emergency events.

The authors represent Industry Professionals for Clean Air (IPCA), whose members have been affiliated with the petroleum or petrochemical and are concerned about the air pollution in the Houston-Galveston region. Based on our experience and research, we believe elevated flares present the most significant problems for controlling emissions of VOCs and toxic air pollutants in our region. Our purpose is to make realistic recommendations for reducing flare emissions that will encourage industry and the regulators to take action.

EMISSIONS FROM PLANT FLARES

The Texas Commission on Environmental Quality (TCEQ) uses high destruction efficiencies, based on combustion efficiencies established in the early 1980's by the EPA to establish regulatory requirements, calculate permit limits, monitor compliance, enforce control requirements and plan for attainment of air quality standards. The TCEQ presumes that flares destroy 99% of ethylene and propylene, and 98% of other VOCs, except for certain compounds with less than 3 carbons, as long as continuous monitoring data for the flare inlet demonstrates compliance with the EPA's minimum heating value and maximum exit velocity requirements specified in 40 CFR 60.18.[6] Findings from the EPA 1983 Flare Study generally reflect use of high-efficiency flares burning simple chemicals at natural gas processing plants under optimal operating parameters and wind speeds less than five miles per hour.[7] The TCEQ's approach, therefore, makes no allowance for real world operating variables. Specifically, it is based on the unrealistic assumptions that:

- plants are consistently operated according to the parameters necessary to optimize flare destruction efficiency;
- crosswinds have minimal effect on combustion efficiency; and
- flares perpetually operate at high destruction efficiency.

In the following discussion we will examine these assumptions and develop suggestions for adoption of more realistic ones.

Because flares are designed and used for control of emission spikes, the hourly emission rate permitted[8] and experienced by a flare is likely to be the highest of any unit at a facility, even assuming a 98% to 99% VOC destruction efficiency. If realistic efficiencies were applied, then the emission rates would be dramatically higher and might account for much of the discrepancy between measured and model-predicted air pollution in the Houston region.

Determine More Realistic Flare Destruction Efficiencies

Operating Parameters

As stated earlier, EPA work in the 1980's established the basis for current federal and Texas flare regulations. 40 CFR 60.18 and corresponding state regulations require that flares operate:

- "with a flame present at all times",[9] and
- "with no visible emissions ..., except for periods not to exceed a total of 5 minutes during any 2 consecutive hours."[10]

The waste stream routed to the flare either burns on its own or, if it has low heating value (less than 300 Btu/scf), with the assistance of a high-energy (more than 1000 Btu/scf) fuel gas, like natural gas or propane, to facilitate complete combustion.[11] Typically, operators use fuel gas, or some other purge gas, to keep slow flowing emissions moving toward the flare.[12] With or without additional fuel, the combustion of many waste streams produces smoke – i.e., visible emissions.[13] For smokeless combustion, operators typically inject steam or air to "achieve more complete combustion."[14] The injection of steam or air (assist gas) "at the flare tip [also] increases the mixing of waste gas with air, as well as the residence time of the waste gas constituents into the flame zone, thereby increasing combustion efficiency."[15]

Operators must maintain a delicate, but essential, balance between smokeless and oversteamed emissions. Studies in the 1980s "demonstrated that assist gas to waste gas mass ratios between 0.4 and 4 were effective in reducing soot while ratios between 0.2 and 0.6 achieved the highest hydrocarbon destruction efficiency."[16] Too much assist gas (over steaming or over aerating) "may ... reduce the overall combustion efficiency by cooling the flame to below optimum temperatures for destruction of some waste gas constituents, and in severe cases may even snuff the flame, thus significantly reducing combustion efficiency and significantly increasing flare exhaust gas emissions."[17] The EPA 1983 Flare Study noted: "Combustion efficiencies were observed to decline under conditions of excessive steam (steam quenching) and high exit velocities of low Btu gases."[18] Thus, EPA regulations establish parameters for heat content and exit velocity.[19]

The EPA 1983 Flare Study also demonstrated that separation of the flame from the burner tip results in a serious drop in burning efficiency.[20] This flame separation has been observed during emergency flaring events under high winds and during addition of excess steam. The reported loss of efficiency occurs because, under these conditions, some of the gases do not remain in the combustion zone long enough for complete conversion to carbon oxides. Some of the gases have the opportunity to partially or totally bypass the combustion zone, with the result that unburned VOCs are emitted to the atmosphere.

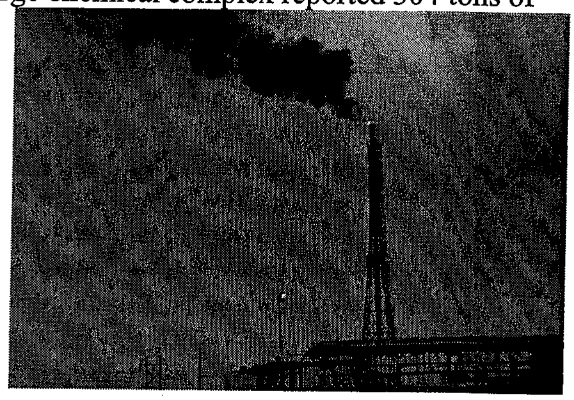
In addition, the TCEQ learned from a contractor's evaluation of flare gas flow rate and composition measurement methodologies that although "data on destruction efficiency versus assist gas ratio obtained under controlled conditions would suggest that poor assist gas control might negatively impact destruction efficiencies, there are little or no data available on the impact of assist gas ratio control on destruction efficiency of operating flares."[21] Thus, "the effect of assist gas to waste gas ratio on flare combustion efficiency, as well as destruction efficiency, requires further investigation."[22] Based on a review of some 50 refinery and petrochemical plant flares, and discussions with petrochemical plant operators, the TCEQ learned that the assist gas injection rate for 90% of the flares is controlled manually "by the operator based on [visual] flare observations (either directly or on a video monitor)."[23] Nevertheless, neither the EPA's nor the TCEQ's regulations adequately address the critical role that steam content plays in flare combustion, and apparently neither agency is actively investigating steam content control for flares in the Gulf Coast region.

Furthermore, because the EPA 1983 Flare Study focused on simple hydrocarbons, subsequent analyses may not take into account the possibility that while the original compound may be destroyed, large hydrocarbons could simply be broken down into smaller hydrocarbons and other compounds, some of which may be toxic as well.

An independent group, the International Flare Consortium, has initiated research focused on exactly these issues in their project: "The effect of flare gas flow & composition; steam assist & flare gas mass ratio; wind & flare gas momentum flux ratio; and wind turbulence structure on the combustion efficiency of flare flames focusing on speciated emissions of the highly reactive volatile organic compounds (ethylene, propylene, butadiene) and the class archetypal hazardous air pollutant carcinogens (formaldehyde, benzene, benzo(a)pyrene)."[24]

Upsets present even more of an operations problem. An evaluation of emission events in the Houston-Galveston area between January 31 and December 31, 2003 "shows that HRVOC events and possibly VOC emissions events have the potential to contribute significantly to ozone formation in HGA."[25] A 2002 TCEQ toxicological evaluation of VOC monitoring data collected downwind of three Harris County plants noted that "exposure to recurrent elevated short-term levels of 1,3-butadiene may increase the risk of reproductive and developmental effects."[26]

Consider this specific example in which a large chemical complex reported 304 tons of VOC emissions due to upsets and 622 tons of VOC emissions total for the year 2000. The applicable permit allowed only 124 tons of VOC emissions. Among other emission events in 2000, this company reported an upset, shutdown and startup from July 17, 2000 through August 18, 2000. As part of the response to this upset, the plant operator "maximized steam flow to the flares to optimize combustion and minimize smoke."[27]



As noted above, too much steam can reduce combustion efficiency by cooling the flame. A TCEQ study determined that an "assist gas to waste gas mass ratio between 0.2 and 0.6 achieved the highest hydrocarbon destruction efficiency."[28] The company cited above reported that "[t]he hydrocarbon stream being flared during the July upset most likely required a steam to hydrocarbon ratio of 0.7." We do not have enough information to accurately calculate the destruction efficiency of this company's flare during the July 2000 upset, but experience suggests it is likely that the heat content was too low and the exit velocity too high for the efficiency to be 98+%, as assumed in most of the Upset/Maintenance Notification Forms filed regarding the incident.

The TCEQ's new regulations regarding flares that burn HRVOCs assign 93% destruction efficiency to flares not meeting the EPA's standards for minimum heat content and maximum exit velocity based on continuous monitoring.[29] During the above-cited July 2000 upset, if a flare destruction efficiency of 93% is assumed, rather than 98%, the 304 tons of VOC emissions would become 1064 tons of VOC emissions. This represents 1.7 times the 622 tons of total VOC emissions reported at this plant during the entire year 2000. Moreover, reductions in residence time during startup and shutdown operations, when flares operate at high rates for extended periods, may reduce combustion efficiency substantially below the 93% provided for in the new regulations.

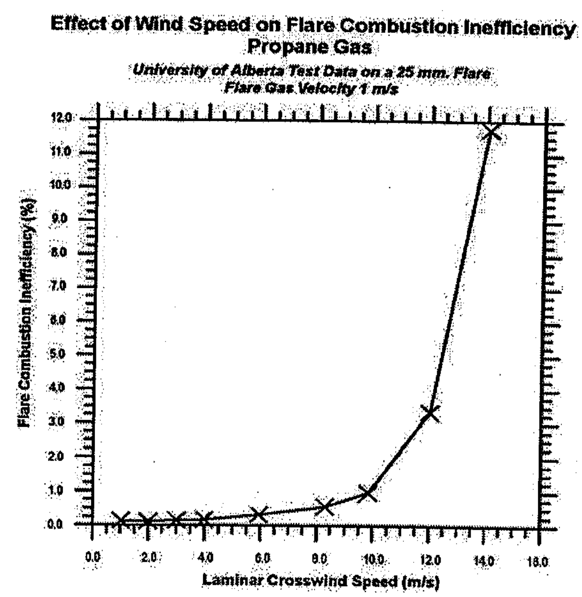
Crosswinds

The TCEQ's assumed flare destruction efficiencies of 98+% also do not take into account routine, yet less than ideal, weather conditions, such as crosswinds. An open flame, in the absence of a crosswind, assumes a symmetrical shape of maximum volume having an equilibrium flame temperature dependent upon operating conditions. Crosswinds distort the flame, reducing flame volume and flame temperature. High combustion efficiency requires that the combustible material be present in the high temperature region of the flame for a significant period. Crosswinds in excess of 5 miles per hour, however, may significantly degrade combustion efficiency because they shorten the residence time of the combustible material in the flame.

The EPA 1983 Flare Study only conducted tests on flares at wind speeds up to 5 miles per hour because flame instability made it impossible to obtain proper samples at higher wind speeds.[30] Consequently, there is a significant gap in the EPA field data, but lab-scale data suggests potentially significant reduction in combustion efficiency at high wind speeds.[31,32]

Ongoing studies by the Engineering Department of the University of Alberta and the Alberta Resource Council also demonstrate the need to consider the effects of crosswinds on flares. The University of Alberta studies not only confirm findings in the EPA 1983 Flare Study regarding flame separation, they also conclusively demonstrate that crosswinds can have a serious deleterious effect on the combustion efficiency of an open flame.

Since significant crosswinds are usually present along the Texas Gulf Coast,[33] these wind effects must be accounted for. Yet, the TCEQ inappropriately dismissed the findings from the University of Alberta research when they reviewed the data in 2001 and 2002. We requested internal documents from the TCEQ relating to this review and found that the TCEQ dismissed the entire body of research from the University of Alberta based primarily on the TCEQ Staff's review of only one 2001 study.[34] In analyzing this study, the TCEQ Staff concluded:



- questionable simplifying assumptions were made in the development of a mathematical model from the experimental work on a pilot-scale facility; and

- poor flare destruction efficiency results obtained with field studies of a simple oil field flare could not be extrapolated to more sophisticated plant flares "with engineered burners and good liquid knockout systems." [35]

The University of Alberta researchers did not directly investigate commercial plant flares with engineered flare tips, but the basic findings of this study indicate that crosswinds affect combustion efficiency under a variety of circumstances. Thus, while we agree with TCEQ's specific critiques, it is inappropriate for them to exclude the basic research by the University of Alberta on the basis that results of a field study of an oil field flare could not be directly applied to Gulf Coast flares because of design differences.

Baylor University collected some samples in canisters during flyovers it conducted in 2001 for TCEQ, but apparently there has been no follow-up to this work. We have found no documentation indicating that the EPA or the TCEQ subsequently considered the effects of crosswinds on flares in policies or guidelines related to flares.

In the TCEQ Emissions Inventory Guidelines, in the technical supplement on flares revised in 2004, TCEQ does acknowledge the potential for unstable flames in developing the 93% destruction efficiency to be used when 40 CFR 60.18 requirements are not met[36]. Nonetheless, neither the EPA nor the TCEQ routinely consider the critical variable of wind speed in permit reviews, compliance investigations or emission reduction planning. The entire question of crosswind impact on flare combustion efficiency appears to have disappeared from their deliberations, without explanation, for more than two decades.

Research being undertaken by the International Flare Consortium[37] is intended to directly address the issue of crosswind effects on industrial flares and needs to be followed closely by the EPA and TCEQ.

Performance Testing

The absence of further study or testing by the regulatory authorities is particularly perplexing, since the TCEQ and the EPA acknowledge problems with accurately estimating air emissions generally, and from flares in particular. The TCEQ "has determined that [VOC] emissions may be underestimated in air shed emission inventories."[38] These deficiencies are important because emission inventories are the foundation for effectively controlling air pollution.[39] And, since flare emissions represent a significant portion of an industrial plant's ozone-forming emissions,[40] undercounting of flare emissions could represent a significant portion of underestimated emission inventories.

Flare emissions, however, are much more difficult to measure than those of other pollution control devices. According to the EPA 1983 Flare Study, "Flare emission measurement problems include: the effects of high temperatures and radiant heat on test equipment, the meandering and irregular nature of flare flames due to external winds and intrinsic turbulence, the undefined dilution of flare emission plume with ambient air, and the lack of suitable sampling locations due to flare and/or flare heights, especially during process upsets when safety problems would predominate."[41] In addition, the EPA 1983

Flare Study specifically "excluded abnormal flaring conditions which might represent large hydrocarbon releases during process upsets, start-ups and shutdowns."[41]

This, however, does not justify excusing the monitoring of flare emissions. Without proper monitoring it is impossible to know whether flares are performing as expected. The TCEQ expects "that emissions from flares would be better estimated if they were based on waste gas flow rate and composition measurements. ... The overall objective of the [TCEQ] studies on flare emissions is to obtain performance specifications that ensure quality assured sampling, testing, monitoring, measurement and monitoring systems for waste gas flow rate, waste gas composition, and assist gas flow rate."[42] Modern insertion meters can measure mass flow within $\pm$1%, and continuous composition analyzers are readily available. However, measuring flows within an uncertainty of $\pm$ 5% to 10% "in flare systems with highly variable compositions or where the meter cannot be located in a section of pipe with a representative flow profile will be a challenge."[43]

Accordingly, the TCEQ now requires that operators of flares that burn HRVOCs – 1,3-butadiene, butenes, ethylene and propylene – continuously monitor compliance with "maximum tip velocity and minimum heat content requirements to ensure proper combustion by the flare."[44] These new regulations do not adequately reduce flare emissions, however, because:

- In setting the appropriate assist gas flow rates and aggregate flow velocity, it is important to know the composition of the flow. The TCEQ, however, does not require continuous composition monitoring.
- Most operators control assist gas injections manually, based on the visual evaluation of the flame's smokiness by the operator. Thus, depending on the skill and attention of the operator, significant fluctuations in heating value and exit velocities can occur over the course of an hour, such that substantial short-term fluctuations in heating value could offset each other. One study notes that the ratio of assist gas to waste gas with manual control varied from about 2 to more than 50.[45] In this way, oversteaming can significantly reduce combustion efficiency without violating the minimum heat value requirement for the one-hour average.
- Although most flares are designed to be most efficient at the high volumes experienced during non-routine operations, many are routinely used for disposal of low-flow emissions.
- The TCEQ presumes that "because many of these flares are also used for non-HRVOC streams, the regulations will result in better combustion of other VOC streams as well. This improved combustion will reduce emissions of less-reactive VOCs."[46] The TCEQ, however, did not make the continuous monitoring requirement applicable to waste gas streams of other VOCs. So there is no quality control on flares that burn only other VOCs and air toxics, which could represent a significant volume of VOC emissions in the Houston-Galveston area.
- The results of industry monitoring are not readily accessible to the public. Although the San Francisco Bay Area has far fewer industrial flares emitting much lower volumes of pollutants, the Bay Area Air Quality Management District (BAAQMD) in California requires all refinery operators with elevated flares to submit monthly reports of daily quantities (and species) of releases during the

period reported.[47] The BAAQMD posts these reports, complete with graphs illustrating daily spikes in emissions, on its website.[48]

- Historically, TCEQ enforcement of monitoring requirements, if any, generally comprised only minor recordkeeping violations.
- The monitoring requirements on many flares with the potential for substantial emissions are significantly weaker. Generally, these relaxed regulations require only a combination of calorimeter, engineering calculations and process knowledge for monitoring flares used for abatement of emissions from loading operations, maintenance, startup and shutdown activities, emergencies, temporary service, liquid or dual phase streams, and metal alkyl production processes.[49]

In addition, the type of continuous monitoring required by the TCEQ may not be adequate. Flow measurement devices typically "calculate volumetric flow by sensing a velocity in the pipe and multiplying that velocity by the cross sectional area of the pipe in which the velocity is being sensed."[50] The accuracy of these measurements, however, is based on assumptions that:

- velocity is uniform across the cross section; and
- the gas is of a known composition.

Thus, frequent changes in the waste gas composition could significantly marginalize the quality of flare performance assessments.

Although safety concerns may preclude direct monitoring of emissions, parametric monitoring and remote sensing techniques do exist which would provide data more indicative of actual flare performance and emissions. For example, Open Path Fourier Transformation Infrared (FTIR) technology "can identify, measure, and speciate over 100 compounds" from a distance of more than 100 meters.[51] FTIR is particularly suited for VOC identification and quantification because VOCs present strong absorption spectra in the infrared region.[52]

In the near term, the TCEQ could follow the lead of California regulators in requiring more extensive reporting of flare operations and emissions as a means to identify priorities in reducing flare emissions and motivating operators to undertake emission reduction projects sooner rather than later. Even before the BAAQMD issued its Flare Monitoring Rule, its staff reported that flaring dropped dramatically because of increased industry attention to flaring and flare monitoring.[53]

Similar observations were made in Southern California. Their monitoring rule, Rule 1118 – Emissions from Refinery Flares, was promulgated by South Coast Air Quality Management District (SCAQMD) in 1998 and amended in November 2005. During the period from 2000 to 2003, SO_x emissions were reduced from 2633 tons to 735 tons with only a fraction attributed to new equipment and the rest to expanded use of " best management practices."[54]

These same data showed 79% of emissions were from unknown causes or nonrecordable events. In response SCAQMD amended Rule 1118 to require a "Specific Cause

Analysis" of significant flaring events as defined by 1118 (c)(D), or an analysis of the relative cause of "any other flare events where more than 5,000 standard cubic feet of vent gas are combusted. (Rule 1118 (c)(E)). The revised rule also incorporates other provisions to further reduce flaring emissions, such as mitigation fees and flare management plans (1118 (d)).

Require Alternatives to Elevated Flares

For more consistent reductions in flare emissions over the long term, the TCEQ could require alternatives to elevated flares. It is common practice for industry to use elevated flares for routine destruction of vent gases or off-spec hydrocarbons, not just for emergency or short-term releases. Most flares are built for non-routine events, such as upsets, startup and shutdown, so they are not designed for optimal efficiency at low temperatures and low flow rates.[55] Consequently, routine flaring may result in unnecessary emissions of HRVOCs, VOCs and toxic materials.

The TCEQ appropriately requires that many vent and relief valve emissions be controlled, rather than vented to the atmosphere. Ideally, these routine emissions should be recovered in a flare gas recovery system,[56] which recycles the valuable components of the waste stream, using an elevated flare only as a backup system.

Where gas recovery is impractical, we believe TCEQ should require operators to install high efficiency combustion devices to handle all predictable demand. Enclosed ground flares, incinerators and thermal oxidizers are acceptable alternatives because they can consistently achieve high combustion efficiencies as a result of the enclosed firebox, longer residence times at high temperature and negligible wind effects.

But high-efficiency combustion devices themselves need further attention from the TCEQ as well. Like owners of motorized vehicles, operators should be required to demonstrate the emission control performance of each device on an annual basis. After the TCEQ gains experience with the results of such testing, the frequency for specific classes of equipment, or particular companies, could be adjusted to ensure that testing occurs at appropriate intervals.

While avoiding flaring of routine vent gases is important, minimizing episodic emissions may be even more critical in reducing emissions of combustion byproducts, carbon monoxide (CO), carbon dioxide (CO_2) and nitrogen oxides (NO_x). As demonstrated by the example cited earlier, emissions from a single episodic event can exceed annual average emissions. In reviewing emission events occurring during 2003, the University of Texas' Center for Energy and Environmental Resources found that the Houston Galveston Area averaged more than one emission event per week: "Over an 11-month period there are 58 times (affecting 395 hours) when ethylene event emissions exceed the 2000 annual average of 586 lbs/hr and 7 times (affecting 44 hours) when event emissions exceed 5 times the annual average."[57] Unlike in the rest of Texas, and the rest of the United States, emissions in Houston "change all the time," and "[p]oor air quality [is] due mostly to days with both ozone conducive meteorology and high emissions."[58] Hence preventing unnecessary releases may provide the greatest decrease in overall VOC emissions while also reducing emission of combustion byproducts, CO, CO_2, and NO_x.

In an effort to reduce such variable emissions, EPA Region 6, the Texas Natural Resources Conservation Commission (TNRCC, predecessor to the TCEQ), the Louisiana Department of Environmental Quality, and 13 petrochemical facilities in Louisiana and Texas, participated in the Episodic Release Reduction Initiative. In 1999 and 2000, the Initiative participants evaluated "the causes of releases to the air associated with startups/shutdowns, equipment failures, and process upsets."[59]

In the Technical Exchange on Startup/Shutdown practices, petrochemical facilities shared case studies and examples of methods used to reduce flaring. Participants noted that changes to procedures and training as well as design improvements could be used to reduce emissions.[60] Key findings on ways to reduce emissions include:

- using flare gas recovery systems for routine venting and planned shutdowns;
- improving training of operators, better documentation of procedures highlighting environmental impacts, and allowing additional time for startup and shutdown; and
- reducing flaring among ethylene producers by recycling off-spec streams to furnace feed, augmenting the plant's steam capacity, and using a ground flare to handle off-spec and startup loads.

Since that time, individual facilities in Texas have implemented site-specific programs to reduce flaring. In 2001, the Dow Chemical Plant in Freeport, TX initiated a flare minimization project at the Light Hydrocarbons plant. Before project implementation, nearly all off-spec hydrocarbons at the unit, which includes an ethane/propane cracking process, were flared. By optimizing equipment and procedures related to plant start-up, shutdown, upsets and plant trips, including improving overall plant reliability, the plant had an "89% reduction in overall upset flaring – using a two year running average." Further, from 2001 to the end of 2003, the plant achieved documented savings of $2.5 million.[61]

Also in Texas, Shell Chemicals developed a "parking mode" to reduce feed rates during upset conditions in order to minimize flaring at its two ethylene units in Deer Park. Implementation resulted in a 50% reduction in flaring between 2002 and 2003.[62]

In the San Francisco Bay Area, flare minimization projects and studies such as these are now required of refineries regulated by BAAQMD under Regulation 12, Rule 12: "Flares at Petroleum Refineries", adopted July 20, 2005. This rule builds on their 2003 rule, Regulation 12, Rule 11: "Flare Monitoring at Petroleum Refineries". Flare minimization plans submitted under Rule 12 must be approved by the Air District and "must include:

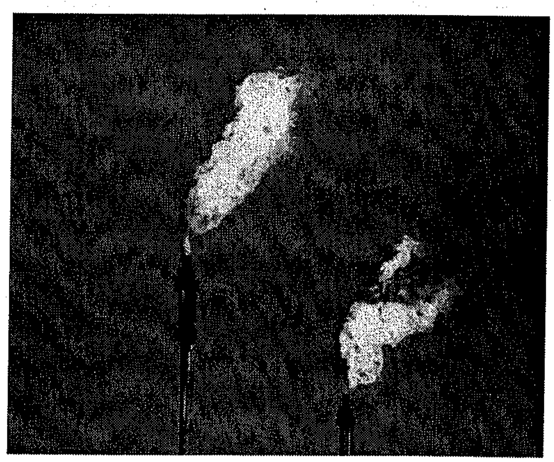
- Detailed information about equipment and operating practices related to flares,
- Steps the refinery has taken and will take to minimize the frequency and duration of flaring, and

- A schedule of implementation of all feasible flare prevention measures."[63]

TCEQ should consider implementing regulations similar to BAAQMD Rule 12 that would encourage other facilities in Texas to follow the examples of Dow and Shell cited above.

More extensive testing and reporting by plant operators on the operating parameters and performance of flares and other waste gas combustion devices also would help the TCEQ enforce existing regulations and identify priorities for reducing the use of elevated flare stacks as emission control devices.

CONCLUSION AND RECOMMENDATIONS



We conclude that the TCEQ must take action to determine more realistic flare destruction efficiencies, minimize the volume of emissions routed to elevated, unenclosed flares, and encourage the use of flare gas recovery systems, or wind-protected ground flares and thermal oxidizers. Specific recommendations are as follows:

1. Enforce existing requirements for flare operations rigorously and consistently.

2. Expand and accelerate TCEQ, EPA and others' research on the factors affecting combustion efficiency of flares, alternatives to flares and flare monitoring technologies.

3. Revise TCEQ policies and guidelines for estimating flare emissions. At a minimum, the effects of steam and crosswinds should be factored into emission estimates for rulemaking, permitting, enforcement, reporting and planning activities. These effects must be based on best available data rather than assumed values.

4. Conduct a rulemaking proceeding for regulations requiring more extensive monitoring and reporting of flare emissions. At a minimum, operators should be required to report daily emissions each month, and the TCEQ should post these reports on its website.

5. Develop a strategy to increase the use of flare gas recovery systems or, where impractical, use of more effective destruction technologies, such as enclosed ground flares or thermal oxidizers, rather than elevated flare stacks, as emission control devices.

6. Use elevated flare stacks only for release of combustibles in emergencies, for safety reasons, or as necessary during planned startups or shutdowns of equipment.

7. Divert uncontrolled emissions from vents and relief valves to vapor recovery systems and other alternatives to flares, with flares serving only as a backup system. The TCEQ should set a goal for eliminating uncontrolled, authorized VOC emissions by a specified date, and systematically review its regulations and permitting policies to identify steps towards that goal.

8. Test high efficiency combustion devices, such as enclosed ground flares and thermal oxidizers, regularly to demonstrate emission control performance.

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KEY WORDS

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