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### **Flare emissions: human health exposure concerns of hydrocarbons and hydrogen sulfide**

Air emissions (equipment leaks and sources) from oil & gas facilities and larger oil refineries are regulated by the Texas Commission on Environmental Quality (TCEQ). However, TCEQ allows serious loopholes at oil & gas facilities and oil refineries to release significant air emissions.

Venting of oil and gas chemicals into the open air is strictly illegal due to the harmful potential of the produced gases, including hydrocarbons and hydrogen sulfide ( $H_2S$ ). As a result, the TCEQ requires that oil & gas facilities and oil refineries either burn the hydrocarbon gases in elevated combustion devices (Flares), or collect the produced gases for processing through vapor recovery systems (including Flare Gas Recovery Systems). Flaring is frequently the preferred choice if no vapor recovery is available or is viewed as too costly a solution.

The problem is that flares are little more than Open-Tipped Incinerators, and when overloaded or under windy conditions or both, produce high volumes of unburned hydrocarbons evidence by large smoke plumes.

Flares in Texas are required by the TCEQ to meet a burn rate efficiency of 98% BACT, called Best Available Control Technology, in order to protect public health from the toxic substances produced in the wells. Hydrocarbons are also termed volatile organic compounds (VOCs).

Meeting TCEQ's rule of 98% BACT means, in theory, that at least 98% of gases, being mostly hydrocarbons or VOCs, going to the flare's burn tip are destroyed.  $H_2S$  is burned to  $SO_2$ .

Burning in the flares means, in theory, the VOCs are destroyed to carbon dioxide ( $CO_2$ ) and water vapor ( $H_2O$ ). But the reality is flares probably do not meet the TCEQ's required 98% destruction efficiency for several reasons.

Two chief reasons flares may burn less than 98% BACT are: 1) lack of real-time measurements at the flare to track efficiency and precisely calculate the destruction percent; and 2) smoking incidents that suggest efficiency levels below 98% and could be 50% but this is speculation.

Flares do not burn 100% of the dangerous chemicals entering the flare tip and flame zone where combustion is supposed to destroy the VOCs and convert them to carbon dioxide and water vapor.

Hydrogen sulfide, that is often present in the oil and gas wells, may not all be burned to sulfur dioxide, and unburned  $H_2S$  presents more than just a rotten egg odor concern.

H<sub>2</sub>S raises safety concerns since it is instantly lethal at concentrations of 800 – 1,000 parts per million (ppm).

Sour crude oil in pipelines, storage tanks and oil refineries may contain H<sub>2</sub>S at levels that are instantly lethal to a healthy adult. H<sub>2</sub>S poses a hazard to local residents if the H<sub>2</sub>S (sour gas) leaks from equipment or was vented without being burned in a flare.

The TCEQ has an H<sub>2</sub>S rule called “Control of Hydrogen Sulfide” limiting its concentration to 80 parts per billion (ppb) in a thirty-minute period under Regulation II, rule 112.31. The rule states:

*“No person may cause, suffer, allow, or permit emissions of hydrogen sulfide from a source or sources operated on a property or multiple sources operated on contiguous properties to exceed a net ground level concentration of 0.08 parts per million averaged over any 30-minute period if the downwind concentration of hydrogen sulfide affects a property used for residential, business, or commercial purposes.”*

Smoking flares are an obvious indication of incomplete burning of VOCs, and poorly burned VOC emissions raise public health issues if people live in the nearby area who might breathe the flare's smoke and unburned VOCs, including many toxic compounds.

Several factors influence burn efficiency in flares: **burner tip design, burner tip size, flare height, tip maintenance, VOC gas volume, VOC composition, wind conditions, and others.**

However, the open-tipped design makes many flares especially vulnerable to inefficient VOC destruction under windy conditions, and, in some cases, even low wind speeds as evident by constant smoke plumes visible during the day and night.

A major issue is that many flares do not burn all the VOCs and can readily produce smoke and unburned VOC gases.

#### TCEQ Air Quality Regulation 111.111 on Excessive Visible Emissions from Gas Flares

TCEQ has had a state rule **prohibiting smoke or visible emissions from flares** for 30+ years.

Regulation I basically states that flares can not smoke more than 5-minutes in a two-hour period and flares too often are seen smoking for many hours almost continuously.

The TCEQ flare rule states in Texas Administrative Code Title 30 Part 1 TCEQ Chapter 111 Control of Air Pollution from Visible Emissions and Particulate Matter, Subchapter A, Visible Emissions and Particulate Matter, Division 1 Visible Emissions, Rule **§111.111** Requirements for Specified Sources: (a) (4) *“Visible emissions from a process gas flare shall not be permitted for more than five minutes in any two-hour period, except as provided in §101.11(a) of this title (relating to Exemptions from Rules and Regulations). Process gas flares are those used in routine or scheduled facility operations. Beginning September 1, 1993, compliance with this subparagraph for process gas flares shall be determined: ...”* See rule sections (i) and (ii) for compliance.

### Carcinogenic chemicals released by poorly operated and poorly maintained flares

Benzene is a known human carcinogen and VOC emitted in several ways from flares.

First, benzene that is not destroyed in the flare combustion zone can escape into the ambient air.

Second, new benzene (*de novo*) can be formed from the partially burned VOCs. For instance, three unburned C2's or VOC molecules can instantly form one C6 benzene ring, or two C3's can form benzene, and other combinations can instantly form benzene in a fraction of a second.

Additional toxic VOCs formed in flares include 1,3-butadiene (C4) that is a known human carcinogen like benzene.

Many other benzene or aromatic-containing compounds are emitted in flares such as ethylbenzene, dimethylbenzene (xylenes), toluene, styrene and others. Flares can release dozens of other toxic VOCs like carcinogenic formaldehyde into the ambient air and many new VOCs can be formed if the flare is burning poorly such as during smoking incidents.

### Carcinogenic chemicals created by flares

Polycyclic aromatic hydrocarbons (PAHs) are found in the smoke or soot emissions from flares.

Aromatic means benzene-containing and refers to the benzene rings present in PAHs; polycyclic means they have multiple benzene rings linked together as one complex hydrocarbon.

One highly toxic PAH is benzo-a-pyrene (BAP) that is known to be more carcinogenic than benzene.

Chemical studies have identified many PAHs that can quickly form in smoke or soot. Smoke from flares is an indication that many PAHs are likely being formed and released into the ambient air.

The formation of smoke and PAHs is not in the best interest of public health.

### Soot emissions of PM2.5 Fine Particulate Matter - 1997 EPA national standards

The U.S. Environmental Protection Agency (EPA) adopted a new soot or fine particle standard in 1997 due to the medical evidence that combustion particulate matter from burning fossil fuels is harmful to human health at relatively low levels.

See: <https://www.epa.gov/criteria-air-pollutants/naaqs-table>

Soot particles are harmful for two reasons:

- 1) microscopic size allows them to go deeply into sensitive lung tissues called *alveolar sacs*; and
- 2) they carry highly toxic substances that can penetrate deeply, almost like an injection, into the bloodstream from the lung's alveolar sacs.

For this reason, EPA adopted a 24-hour standard of 65 micrograms per cubic meter that was revised a few years ago to a more protective level of 35 micrograms per cubic meter.

The EPA's annual standard of 15 micrograms per cubic meter has not been changed since 1997 but was reviewed in 2012 and tightened to 12 micrograms per cubic meter.

In a nutshell, small puffs of smoke from a flare have the potential to instantly exceed the EPA's 24-hour fine particle standard due to the high concentrations of PM<sub>2.5</sub> particles in the smoke.

Realize that 35 micrograms per cubic meter is an extremely small, invisible concentration of soot.

### **CARB's 1996 classification of PAHs as Known Human Carcinogens**

The California Air Resources Board (CARB) adopted new toxicology rules on PAHs in 1996 at the recommendation of its medical advisory board of physicians, epidemiologists and toxicologists.

CARB basically recognized that about forty of the PAHs are human cancer-causing agents including Benzo-a-pyrene.

These PAHs are the same as those detected in flare smoke, soot and PM<sub>2.5</sub> fine particles.

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