Bay Area Air Quality Management District
939 Ellis Street
San Francisco, CA 94109

APPROVED MINUTES

Advisory Council Technical Committee
9:30 a.m., Thursday, May 29, 2003

1. **Call to Order – Roll Call**. 9:33 a.m. Quorum Present: Robert Harley, Ph.D., Sam Altshuler, P.E., Louise Bedsworth, Ph.D., William Hanna, Stan Hayes, John Holtzclaw, Ph.D. Absent: Norman Lapera.

2. **Public Comment Period.** There were no public comments.

3. **Approval of Minutes of April 1, 2003.** Chairperson Harley requested that "NMHC" replace "methane" on line three, paragraph two of page three. Mr. Altshuler moved adoption of the minutes as corrected; seconded by Mr. Hayes; carried unanimously.

4. **Overview of Refinery Flares.** Barry Friedman, Senior Consulting Engineer, The Washington Group, International, Denver, Colorado, reviewed a diagram of a flaring system. He noted that in certain systems a vapor recovery compressor can be placed in front of the seal drum to recover fuel vapors and reduce the amount of gas vented to the flares. However, fuel gas recovery is limited by the need to balance fuel produced with fuel consumed in the refinery, maintain the quality of recycled gas and retain sufficient capacity for emergency relief. To more fully utilize the recovered fuel gas, some refineries have installed power recovery gas turbines. However, enough waste gas must be recovered to justify their purchase and installation.

   Flare tip types vary from pipe flares to steam assisted, air assisted, steam and air assisted, staged, and fuel assisted. Pipe flares are the simplest. Steam assisted flares have a ring with jets that generate turbulence at the flare tip to reduce smoke. Steam and air assisted flares have exterior and interior steam rings. Staged flares utilize individual burner nozzles on a ring at the flare tip.

   Flaring provides for controlled equipment shutdown in emergencies arising out of the failure of instrumentation, process units and power supply, as well as operator error, fire exposure or loss of cooling water. Non-emergency flaring provides for the safe shutdown and start-up of equipment prior to maintenance and inspections, and prevents the direct venting to the atmosphere of small quantities of emissions from various miscellaneous systems that may contain hydrogen sulfide.

   In the early 1980's, the Energy and Environmental Research Corporation and the Environmental Protection Agency (EPA) studied flare efficiency by placing a hood above a small flare tip and sampling the gases coming off the hood. With a stable flame, flare efficiencies of 98% or greater were achieved. Flame stability is affected by heating value, wind velocity and flare tip design. Flare efficiency is highest when the flame is connected to the tip, but it drops when too much steam separates it from the tip. The Chemical Manufacturer's Association (CMA) also conducted studies at this time and found high combustion efficiencies over a wide range of flow rates.

More recently flare emissions have been analyzed with Fourier Transform Infrared Spectroscopy (FTIR). EPA compared FTIR with the hood samples and found it accurate, although it requires use of EPA's engineering assumptions. These assumptions are that soot constitutes less than 0.05%, and unburned heavier hydrocarbons (HC) less than 0.05%, of the total HCs entering the flare. BP Oil has developed a Light Detecting and Ranging (LIDAR) technology. It is similar to radar and measures gases, HCs and methane.

In 1997, Shell Oil studied the combustion efficiency of three large operating natural gas plant flares and found that at high flows efficiency ranged from 99.5-99.7% and at low flows from 98.8-99.2%. In October of 2001, Shell studied two flares at a European olefin plant and found that combustion efficiency in an elevated flare registered at 98%, and at 92% in a poorly maintained ground flare. In June of 2002, Shell studied eight solution gas flares and measured efficiency at 98%.

In 1996, BP Oil studied three steam-assisted refinery flares in England with 42"-48" tips. Flare efficiency registered at 98%. Some data showed even higher efficiencies but these did not discount for soot and unburned HCs. This study used LIDAR and considered the effect of crosswind speed on flare emissions as well.

In 1996, the Alberta Research Council (ARC) studied two small oil production flares and measured sweet solution flare efficiency at 62-71% and sour gas flare efficiency at 84%. Sampling devices were suspended from cranes near the flare plume. Some experts have criticized this sampling method. Also, the advisory group to the ARC study opined that the results of that study deviated in a major way from all previous studies and applied exclusively to flares 6" or less in diameter.

The University of Alberta subsequently studied oil production flares in a wind tunnel and found that crosswind velocity considerably reduced efficiency of flares with 2"-6" tips. The study also opined that these results could not be extrapolated to flare tips larger than 6". In 2000, Blackwell used FTIR to study CO in a flare with a high heating value and subjected to crosswinds. He measured flare efficiency at 98% and found that he could not replicate the ARC study.

EPA flaring regulations (40 CFR 60.18) are based on tests in the 1980's when flares were used for emissions control. The standards are used in setting flare emission inventories and set minimum heating values and velocity requirements, as well as applied Ringelmann opacity standards to smoke levels. They contain broad limits for continuous emissions but do not mandate record keeping.

In reply to questions, Mr. Friedman noted the following:

- Variability in fuel type may prohibit the consistent use of a steam-to-gas ratio in flaring. Automated gas recovery compressors may occasionally require operator adjustment.
- Flare operators can observe flare opacity to a certain extent at night.
- If a flaring event occurs, the operator usually has advanced warning and can react to situations where high-pressure set points are exceeded by high inflows. However, if the events that lead to a flaring event occur in rapid succession, the flare is the only indicator of an upset.
- Operator judgment must not be affected by imposing flare limits that adversely affect safe refinery operations. An error in operator judgment arising out of an effort to conform to flaring limits could result in an accident that emits a far greater than normal quantities of emissions.

Chairperson Harley called for public comment and the following individuals came forward:

Julia May
Communities for a Better Environment
Oakland, California

- A recently published EPA fact-sheet stated that flaring that could be predicted (i.e., start-up/shut-down) may not comply with the Clean Air Act. The District should address this.
- Today's presentation does not necessarily apply to Bay Area refineries. For example, the Tesoro refinery knock-out system vents directly to the atmosphere rather than to the flares.
- Residents near refineries experience eye irritation and adverse respiratory impacts during flaring. The District estimates that flaring emits 15 tons per day of sulfur oxides (SOx). Combustion efficiency does not affect the levels of SOx emitted. Some combusted HCs are converted into toxic PM. Flares also emit such greenhouse gases as CO_2 and methane.
- Combustion efficiency estimates are controversial. Industry sponsored studies lack objectivity. A recent Swedish study evaluated high and low flaring loads and found high combustion efficiency at high loads but low efficiency at low loads, with emissions remaining fairly constant. Steam-to-fuel ratios for high loading levels worked well but could not be applied to lower loading levels. This may explain the lower combustion efficiency at lower load levels.
- The Blackwell study also found combustion efficiencies of 85%. The State of Texas has adopted a low loading contingency and selected the mid-range efficiency rate of 93%.
- A recent Dow Chemical study urged that dispersion analyses of flare emissions be conducted. A study of optical sensing techniques to evaluate flares is underway in Texas. Optical monitors measure ground level emissions at the ConocoPhillips refinery fenceline. The Council might opine on how optical sensing might be applied to flare plume analysis in the Bay Area.

Kevin Buchan
Western States Petroleum Association (WSPA)

- Reviewed a slide entitled "Refinery Flare Emissions: January 2001 - March 2003."
- WSPA believes that voluntary measures to reduce flaring should be fully implemented before formal emission control measures are considered for refinery flaring.

5. **Continued Discussion of Refinery Flares.** Mr. Hayes made the following points:

- The ARC study greatly diverges from the predominance of evidence that shows 98% flare efficiency. A 6" pipe in an oil and gas production flare is not analogous to a 48" refinery flare.
- On high ozone days, winds are usually stagnant and therefore flare destabilization is unlikely. Hence, a 98% combustion efficiency estimate can be used for ozone attainment planning.
- PM emissions from flares are likely to be low since operators try to minimize smoke as much as possible and maintain a smokeless flame. Chairperson Harley replied that flares can be kept in a smokeless condition up to, but not beyond, specified flare tip design flow rates.
- A 1997 South Coast AQMD staff report on Rule 1118 indicated that, based on standard estimation techniques, one refinery emitted 1,000 tons of SOx over a six-month period. It is important to evaluate stack emissions and ground level concentrations of SOx.

- Refineries are required to conform to federal and state ambient air quality standards for SO_2. The AB 2588 Hots Spots rule addresses toxic impacts from industrial facilities and refineries. The District is considering a toxics New Source Review rule for new and modified sources.

In further discussion, the Committee members offered the following comments:

- Raised stack elevation would increase SO_2 dispersion. Refineries should use smart systems and algorithms to map steam and energy flow characteristics. Former Council member Robert Sawyer, Ph.D., would encourage consideration of flaring boundary conditions. (Altshuler)
- Methane in flare emissions affects global warming and should be inventoried. The time that a stable flame is absent is the key to quantifying ozone precursors from flares. (Bedsworth)
- Flare PM content should be studied and flow monitor calibration clearly described. (Holtzclaw)
- Routine maintenance, waste gas recycling, and refinery operational safety must be balanced. Differently sized stacks could accommodate different non-emergency, routine flows. (Hanna)
- The use of the optical remote sensing technology that measures vehicle emissions might be used to evaluate flare emissions. If successfully applied, it would obtain actual data and thereby avoiding having to extrapolate the results of other studies to the Bay Area. (Harley)

Mr. Hanna moved that the Committee recommend that the Advisory Council concur with the flare combustion efficiency estimate of 98%; seconded by Dr. Holtzclaw; carried unanimously.

In reply to Committee questions, Jim Karas, BAAQMD Air Quality Engineering Manager, stated:

- The Committee has responded to staff's request to opine on the combustion efficiency issue by reaching consensus on the estimate of 98% efficiency, based on the weight of evidence.
- Optical measurement of flares poses resource issues. Technically sophisticated spectroanalysis of flares is underway in Europe and staff will meet with the experts on this in the near future.
- The difference between District and industry calculations of flare HC content is due to different assumptions, the inclusion or exclusion of methane, and flow data variability. Much of the original flow data is unreliable. The flow-monitoring rule will generate better monitoring data.
- Boundary conditions are problematic, which is why the refineries are being encouraged to reduce flaring. One refinery has eliminated half of its flare emissions through gas recovery.

6. **Committee Member Comments/Other Business**. At its next meeting the Committee agreed to (1) receive presentations on flare emissions and the use of optical sensing technology to evaluate flares, and (2) discuss South Coast Rule 1118 with District staff, industry and the community.

7. **Time and Place of Next Meeting.** 9:30 a.m., Thursday, August 7, 2003, 939 Ellis Street, San Francisco, CA 94109.

8. **Adjournment.** 12:30 a.m.

James N. Corazza
Deputy Clerk of the Boards