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

APPROVED MINUTES

Advisory Council Technical Committee
10:00 a.m., Tuesday, April 1, 2003

1. **Call to Order – Roll Call.** Quorum present: 10:02 a.m. Robert Harley, Ph.D., Chairperson, Sam Altshuler, P.E., William Hanna, Stan Hayes, John Holtzclaw, Ph.D., Norman Lapera, Jr., Robert Sawyer, Ph.D.

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

3. **Approval of Minutes of February 4, 2003.** Mr. Altshuler moved approval of the minutes; seconded by Dr. Holtzclaw; carried unanimously.

4. **Refinery Flares.**

   (A) Staff Presentation on Bay Area Refinery Flares. Jim Karas, Air Quality Engineering Manager, stated that as part of the 2001 Ozone Attainment Plan staff is reviewing refinery flare data for potential emission reductions, control measure application and use in photochemical modeling. Noting that flares combust the excess fuel gases from a variety of refinery activities, he displayed a diagram of a refinery flare system with the purge and pilot gas systems, water seal and flare tip. The composition of waste gases varies with inflow components. Presently there are 28 flares at Bay Area refineries, of which 25-26 are operational and differ in height and priority of use.

   Staff has evaluated the flare system at each refinery for gas recovery capability, pilots and purges, and monitoring devices. It also tried to obtain daily data for large flaring events of one million cubic feet a day but found that threshold was too small because one refinery routinely flared six to eight million cubic feet daily. Staff reviewed initial submittals of refinery flare gas sampling data and used estimates where data gaps occurred. Staff arrived at a baseline assumption of 75% total hydrocarbon (HC) content, including methane. Some of these submittals have since been revised.

   Given the difficulty of making field samples of flare emissions, the District formed a work group to discuss flare efficiency. It arrived at an estimate of 98%. Flare efficiency is measured by the difference in the amount of carbon entering and exiting the system. The major factors that effect efficiency are exit velocity, crosswinds and gas composition. Numerous flare studies were also reviewed. The 1983 Environmental Protection Agency (EPA) study took samples from a model flare and found that better than 98% efficiency is achievable under low wind conditions. The 1999 Alberta Research Council (ARC) study sampled a model oil and gas field flare and arrived at a combustion efficiency of 62%. However, the lower efficiency was likely due to the crosswind speeds from wind tunnels used to measure downstream emission composition. Several other studies have attempted but failed to accurately predict flare efficiency. In December of last year, the District published its Technical Assessment Document (TAD) on refinery flare monitoring.

Staff initially found that flows and flaring frequency were higher than expected, but it appears that the District's flare study has led both to reduced flow to the flares and the recovery of eight million additional cubic feet of flare gas at one refinery. The flare-monitoring rule will be expedited to obtain better data earlier. Staff believes that some of the initial and revised flare-monitoring data sets are unreliable. NOx was estimated with original refinery data in the range of two tons per day (tpd) for all refineries. Estimates of SO_2 emissions were based on sample data at 10-13 tpd. Staff found that the samples taken of fuel inputs prior to the water seal stage could not be correlated with a specific refinery activity even after the samples were speciated.

Staff intends to further evaluate and assess the revised refinery data, respond to the comments from the public and the Council and post this response on the District's website. The Council is being asked to provide input on flow measurement, data characterization, molecular weight and HC content assumptions, flare combustion efficiency, correction factors for flare emissions, the applicability of studies of model flares to refinery flares, emission calculation parameters, the estimation of flare emissions on an hourly basis for the ozone episodes that will be modeled for the attainment plan update, as well as on a daily, monthly and annual basis for emission inventory purposes.

Peter Hess, Deputy Air Pollution Control Officer, noted that the impact of flare emissions on ozone formation depends on reactivity. Staff will measure total organic gas emissions and then speciate them to assess how the content of refinery flare emissions differ. The 2001 Ozone Attainment Plan contained requirements to submit a flare-monitoring rule and to evaluate potential emission reductions from flares. The TAD will lay the groundwork for flare monitoring which will in turn create the basis for viable control mechanisms.

Mr. Hess added that on high ozone days wind speeds are low or stagnant, rendering flare emission transport to adjacent air basins unlikely. However, this could be more accurately evaluated if the flare emission characterizations were made on an hourly basis, with meteorological conditions taken into account. While the flare-monitoring rule will obtain more reliable data over the long-term, the ozone plan must be updated within the more immediate future.

In response to Committee member questions, Messrs. Karas and Hess noted the following:

- The fact that the emission calculation formula as a function of flow rates is distinct from a frequency distribution of emissions from flare events *per se,* renders the characterization of flare emissions difficult. Emissions were large when a power outage occurred. Staff identified such events in the TAD and estimated flare emissions. On other days the ranges were not as high. The issue is whether to present these data on a worst day, a typical day, or as an average.
- The validation of historical episodes through modeling is more difficult than projecting future emissions, but some of the larger refinery events occurred within the episode periods modeled.
- Texas is looking into the spectral analysis of flares, and some spectral measurements have been conducted in Sweden and Belgium. Staff seeking to obtain this data.
- Lake County's exclusion from the record of attainment data of an episodic release of hydrogen sulfide at a geothermal facility, affecting the attainment of ambient air quality standards, is permitted under federal law. Staff will examine its applicability to refinery flare episodes.
- Flare emissions have rarely varied by the heat of day, although the reason for this is unknown.
- Data are not available on the formaldehyde content of flare emissions.

(B) Industry Perspectives on Refinery Flares. Kevin Buchan, Bay Area Coordinator, Western States Petroleum Association (WSPA), presented his report entitled "Historic Flaring for Bay Area Refineries," dated January 2001-May 2002, containing the voluntary monitoring data provided by the refineries to the District. He stated that this data should form the basis of a flaring emission inventory, because it encapsulates flare activity at all five refineries prior to and during their voluntarily collection of monthly flare monitoring data. Where data gaps were found, the refineries made professional estimates based on source tests, process knowledge and engineering principles.

Flare gas composition data reveals a significant amount of hydrogen and nitrogen, and that the non-methane HCs (NMHCs) are relatively low. The District's assumption of 75% HC content is arbitrary and should have excluded methane. Purge and pilot lights are fueled by natural gas, which is primarily methane. Methane is not an ozone precursor and should therefore be excluded from flow estimates or emission calculations. Because purge and pilot occur upstream of the water seal, purge and pilot gases are not included in WSPA's data flow charts. Mr. Hanna noted that oxygen added after the water seal would impact the combustion efficiency that is based on flow measurement at or before the seal. Mr. Buchan replied that flare efficiency is estimated to be the destruction of HCs going into the flame. Dr. Sawyer opined that the pilot and purge gas would be negligible in a major upset at a refinery.

Mr. Buchan stated that with revised refinery data WSPA could not duplicate the District's estimate of 22 tons of HC from flares. The TAD does describe the District's calculation methodology. It is unlikely that flares contribute 22 of the 26 tons of HC that the District estimates are emitted in total by the refineries. The data baseline provided by the refineries is more reliable than calculations that backcast data and retroactively estimate emissions. Mr. Hanna suggested that the explanation for the order of magnitude difference between the 22 versus two tons lies in the difference in calculating with and without a baseline that includes NMHCs. Mr. Karas clarified that WSPA's estimates are based on revised flow data, which is significantly less than the original refinery flow data on which the District based its estimates.

Dr. Sawyer opined that uncertainties in flow rates and gas composition can be resolved but the accurate assessment of flare efficiency at 60%, 98% or 99% is much more complex. Mr. Buchan replied that two decades of flare combustion studies show efficiency at 98% or greater. This was confirmed by recent tests conducted by WSPA's consultant, The Washington Group International. The ARC studied solution gas flares with a 4-inch pipe lacking a flare tip, in a wind tunnel. These are very different from refinery flares. The University of Alberta could not reproduce the ARC's 62% efficiency estimate and concluded the results could not be applied to refinery flares. If the Council concludes similarly, the ARC study should be removed from the District's website.

Mr. Buchan added that the installation of the two flare vapor recovery compressors at one of the refineries predates by two years the monitoring issue now under discussion. These compressors have only recently come on line. Chairperson Harley suggested that as flare emission reductions have already occurred due to recent changes in refinery practices, it might be helpful to develop a base case prior to these emission reductions to document any large emission reductions to date. Dr. Holtzclaw inquired if a statistical analysis of the daily variations in the WSPA estimate of two tons per day could be conducted. Mr. Buchan stated he would prepare this analysis for review by the Committee. Dr. Sawyer urged the Committee to review flare studies and the associated laws of scaling in evaluating if oil production flares can be applied to refinery flaring systems. Mr. Buchan offered to arrange for WSPA's consultant to make a presentation on flares at the Committee's next meeting. The Committee accepted this offer.

Chairperson Harley stated that for the evaluation of inter-basin transport, it is important to evaluate if refinery flares influence ozone formation at Livermore. Mr. Hayes added that in assessing the impact of flare emissions on ozone formation, professional judgments will have to be made not only about the composition of input gases but also of the combustion products. Mr. Buchan replied that some attempts have been made in Texas to obtain data on combustion output, but these were not successful. A large flare tip with an effluent of 60 feet per second (fps) at full capacity creates significant radiation zones, thus rendering field sampling difficult.

Mr. Altshuler suggested that SO_2 be used as a tracer for flare emissions and formaldehyde as a means of evaluating flare efficiency because as a combustion product it reacts with methane feedstock. Gary Kendall, Technical Division Director, replied that sulfur was detected at several downwind stations after the July 10, 2002 incident at what is now the ConocoPhillips refinery. However, it is unclear how the sulfur from vehicle fuel would be distinguished from the sulfur that is contained in flare emissions.

Mr. Altshuler suggested that optical infrared sensing could be used to measure the energy release during a flare and also as a monitoring tool. Mr. Kendall replied that literature from the American Petroleum Institute provides a method for estimating the heat release rate from a flare based on flame size and length. Mr. Altshuler suggested this method could be combined with fuel composition data to retroactively calculate efficiency or measure emissions in real-time. Mr. Kendall replied that this could help to validate the quantity of material entering the flare. Mr. Buchan offered to obtain additional data from each refinery on purge gas for the Committee.

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

Dave Souten
Principal
ENVIRON International Corporation

stated that source data for the ozone model must be well documented and derived either from monitoring data or sound estimates. In the future, the model will include PM data, and NOx emission estimates will be important for evaluating aerosol nitrate formation. Methane has a low reactivity and is consequential. Default speciation profiles for refinery flare emissions include formaldehyde, and its measurement will help assess the accuracy of the speciation profiles.

Bob Chamberlain
Environmental and Safety Manager
Chevron Richmond Refinery

presented a detailed diagram on a refinery flare tip, and described its components and operations. He stated that smoke is an indicator of hydrocarbon destruction rather than of poor combustion. A system operator observes the flame via video camera and adjusts steam input to maximize combustion. Efforts have been made to measure the radiant energy off of the flare by automatically controlling the steam input, but these proved unsuccessful.

In response to questions from the Committee members, Mr. Chamberlain replied as follows:

- Some interest has been expressed by community groups in posting the flare operator's video recording on a website, and retaining the tapes for a fixed time for purposes of review and research. This practice will not improve flare management. It may also be a source of distraction to the refinery and the District, and cause undue concern in community.
- It takes one or two minutes from stand-by status for a flare to reach peak efficiency.
- There is an efficiency design value for each of the 28 refinery flares. There remains some uncertainty in assessing flare efficiency in light of operator manual control and variance in flaring events. Downstream sampling might better assess the relationship of flare efficiency to operator control, but to date no method has been successfully developed.
- The ARC study found that the profile of non-combusted gases is similar to the profile of the fuel. At a recent flare stakeholder workshop, a CARB staff member noted that there is a similar relationship between internal combustion engine fuel composition and emissions.
- In September of this year a paper will be submitted at a combustion symposium in Vancouver that will update all of the studies on refinery flaring. The authors of these studies will attend to discuss the technical issues and assumptions. Chevron will share this study with the Council.
- Chevron schedules refinery equipment maintenance as far as possible out of the ozone season.

Eric Hengst
Staff Environmental Engineer
Valero Refinery

stated that flares are used as safety devices to combust excess gases within a refinery in the event of (a) emergency or malfunction situations, (b) start-ups and shutdowns of units within the refinery, and (c) routine operations which experience a slight but persistent fuel imbalance. There are limits on the extent to which refineries can recover these gases. Large process units contain complex equipment relating to reaction, fractionation and separation. Changing the operational pace of a unit affects fuel gas disposition to furnaces, boilers, and gas turbines. The recovered fuel may be degraded by a high percentage of hydrogen or nitrogen that had been contained in the process vessels. These gases must be purged before the unit is started up to avoid a major upset. Flare gas recovery must ensure quality so that the refinery fuel gas system is not jeopardized.

Dennis Bolt
Senior Bay Area Coordinator
WSPA

stated that WSPA's data should be used as the baseline for emission characterization. The assumptions used in filling in data gaps are based on years of refinery experience and professional judgment. In late 2001, in response to the District's concerns on flaring frequency, the refineries began to make process improvements that have reduced flaring events and voluntarily collect fuel flow data. The Tesoro Refinery had already started the process of installing compressors that recover some flare gases. While neither District staff nor the refineries were given sufficient time and data to prepare the TAD, collaboration between the operating community and the regulatory agency has led to discernable reductions in refinery emissions to a fraction of one ton a day. Only a flare-monitoring rule can suggest the next responsible regulatory steps, taking into account the broader context of refinery safety, operator judgment and associated societal costs.

WSPA is concerned over the District's overestimation of flare emissions, the persistent media problem concerning flaring, and the posting of the ARC study on the District's website. Issues of ozone attainment, pollutant transport and emission profiles must be accurately assessed and presented. The Advisory Council provides an ideal learning environment for all interested parties and its technical expertise is both welcome appreciated.

Chairperson Harley read a letter from Julia May, Staff Scientist, Citizens for a Better Environment (CBE), who could not attend today's meeting. She expressed concern over the following issues:

- the possible modification to the data contained in the TAD made at the urging of the refineries
- the possible modification of emission estimates without public review of raw flow rate data
- the proposal in the flare monitoring rule of daily rather than semi-continuous or continuous sampling, and use of calculations to estimate rather than trace gas methods to measure fuel flow
- the lack of an expeditious approach to the regulation and control of refinery flare emissions

Referring to the successful work of the Modeling Advisory Committee to the 2004 Ozone Plan, Mr. Altshuler suggested that a refinery flare advisory committee comprised of representatives of the District, industry and the public, be created for the discussion of the issues and resolution of misconceptions. Chairperson Harley stated that this suggestion and the broader issue of refinery flares would be discussed at the next Committee meeting because further information is needed. He requested staff to work with WSPA to arrange for a presentation from The Washington Group International. Mr. Souten requested the Council's input on flares at the earliest practical moment.

5. **Committee Member Comments/Other Business.** There were none.

6. **Time and Place of Next Meeting.** 9:30 a.m., Thursday , May 29, 2003, 939 Ellis Street, San Francisco, CA 94109.

7. **Adjournment.** 12:45 p.m.

James N. Corazza
Deputy Clerk of the Boards