INVESTIGATION INTO THE FEASIBILITY OF CONTINUOUSLY MONITORING REFINERY FLARES

Prepared by

CH2M HILL, INC.
1500 - 114th AVENUE S.E.
BELLEVUE, WASHINGTON 98004
206/453-5000

Prepared for

CALIFORNIA AIR RESOURCES BOARD
SACRAMENTO, CALIFORNIA

December 2, 1985

se5731/011/1

The statements and conclusions in this report are those of the contractor and not necessarily those of the State Air Resources Board. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

ABSTRACT

INVESTIGATION INTO THE FEASIBILITY OF CONTINUOUSLY MONITORING REFINERY FLARE EMISSION

This report is the result of an investigation into the feasibility of continuously monitoring refinery flare emissions. The study is divided into four main sections. The first is a literature search to determine previous work in the area. Two hundred abstracting and indexing services were searched. The second is a survey of 577 potential suppliers of waste gas flow and composition monitoring devices, potential suppliers of flare emission monitoring devices, and manufacturers of refinery flares. The third is a survey of refineries in the San Francisco and Los Angeles areas to determine current practices regarding monitoring flare emission. The fourth is the development of study designs to investigate methods to determine emissions of sulfur oxides, reduced sulfur, and nitrogen oxides from refinery flares with respect to feed gas monitoring, remote monitoring, and refinery process monitoring.

The study reveals that refineries do not routinely monitor flare emissions and few refineries monitor gas volumetric flow or composition of the waste gas to the flare. Two manufacturers' devices were discovered that appear suitable for further study for monitoring flare gas volumetric flow.

Study designs for the investigation of flare emissions using feed gas monitoring and remote monitoring equiment were developed. The basic approach for all of the study designs is to prove the operational use of the equipment on a pilot refinery flare facility before installing the proven equipment on an actual refinery operation. Refinery process monitoring using material-balance techniques is determined to be unworkable.

SUMMARY

The statements in this report are those of the contractor and not necessarily those of the State Air Resources Board. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

PROBLEM STATEMENT

Air pollution emissions from refinery flares are currently not being monitored in the state of California. Estimates of the air pollution emissions from these refinery flares are made through the use of emission factors which incorporate assumed emissions based upon assumed flare operation, combustion conditions, and frequency of use and relate to total refinery capacity. The magnitude of flare emissions has never been determined accurately because of the technical problems associated with flare emission monitoring. Some studies have been implemented recently using direct emission monitoring on a pilot flare, but the direct emission monitoring of a full-scale elevated refinery flare is impracticable.

APPROACH

This report is the result of an investigation into the feasibility of continuously monitoring refinery flare emissions. The study is divided into four main sections: a literature search to determine previous work in the area; a survey of suppliers of waste gas flow and composition monitoring devices, suppliers of emission monitoring devices, and manufacturers of refinery flares; a survey of refineries in the San Francisco and Los Angeles areas to determine current practices regarding monitoring flare emissions; and the development of study designs to investigate methods to determine emissions of SO_x, RS, and NO_x refinery flares with respect to feed gas monitoring, remote monitoring, and refinery process monitoring.

LITERATURE SEARCH

The literature search for this project was conducted using an online computerized reference system of over 200 abstracting and indexing services, standard reference texts, and previous in-house project experience.

SUPPLIER SURVEY

Suppliers and manufacturers of devices that could aid in determining pollutant emissions from refinery flares were

questioned through the use of surveys and followup phone calls. Three surveys were developed: for suppliers of flow and composition monitors, for suppliers of emission monitors, and for flare manufacturers.

Letters were sent to 273 suppliers of flow and composition monitoring devices, 285 suppliers of emission monitoring devices, and 19 companies that manufacture refinery flares. All positive responses were reviewed for applicability, and applicable information was used to develop study designs for improved methods of determining flare emissions.

Flow Monitoring. The many devices available to monitor flow of gaseous streams range from simple pressure indicators to highly sophisticated ultrasonic devices capable of monitoring several gas stream parameters. Several types of flowmeters have been installed in refinery flares. None of the flow measurement attempts have resulted in the accurate continuous monitoring of volumetric gas flow to the flare.

Composition Monitoring. Monitoring for total sulfur and reduced sulfur in flare feed gas streams is within the capacity of today's process monitors. Although continuous monitors are not in place on flare feed streams in California refineries, the technology is used in other refinery gas streams and other industries in spite of similar interferences. A total constituent monitoring program using gas chromatography techniques is not recommended.

Remote Monitoring. There is no commercially available instrument with proven ability to monitor flare emissions of SO_x, RS, or NO_x continuously and accurately. Two remote monitoring systems were identified that warrant further examination. These are the ultraviolet television recently purchased by the ARB and the Fourier transform infrared spectrometer.

REFINERY SURVEY

The refinery questionnaire was designed to survey the 26 refineries located within the Bay Area Air Quality Management District (BAAQMD) and the South Coast Air Quality Management District (SCAQMD) concerning flaring operations and flare monitoring practices.

Of the 26 refineries that were surveyed, 16 submitted responses. After reviewing the refinery responses received, the project staff and ARB staff visited four refineries to discuss monitoring capabilities further. Members of the project staff and ARB personnel also visited the Energy and Environmental Research Corporation (EER) facility in Irvine, California. EER is currently conducting a research program to determine the efficiency of, and to quantify the emissions from, industrial flares.

A total of 45 flares were reported as operating within the BAAQMD or the SCAQMD. Of these, 39 are elevated; 5 are ground flares; and 1 is a two-stage flare containing both ground and elevated elements.

There is a great deal of variation in flaring and monitoring practices among different refineries. Estimates of waste gas flows to the flares ranged from approximately 1 million standard cubic feet per year to two million standard cubic feet per day. Estimates of average hydrocarbon concentration ranged from 2 percent to 100 percent. Estimates of average sulfur compound composition ranged from zero to 6 percent. At least 24 process units were identified as being potential sources of gas to the flare. Gas flow to flares can be expected to have a highly variable composition and be very transient in operation. Virtually all refinery flare feed systems within the state of California contain some sort of vapor recovery system. Waste gas flow exceeding the capacity of the vapor recovery system and gas that is not condensable are sent to the flare.

Several refineries reported that they automatically monitor when a flare is on or off. This is done either by in-line pressure sensors or by remote optical monitoring. The recording of on/off monitoring may be of assistance in the derivation of new emission factors more specific to actual practice in California and, therefore, more accurate.

The material balances calculated by refineries do not seem to offer a promising approach for determining or estimating gas flow to the flare. The present level of accuracy of material balances is not sufficient to account for the small amount of gas that is flared.

STUDY DESIGNS

Study designs for the investigation of flare emissions using feed gas monitoring and remote monitoring equipment were developed. The basic approach was first to prove the operational use of the equipment on a pilot refinery flare facility before installing the equipment on an actual refinery operation. Refinery process monitoring using material-balance techniques has been determined to be unworkable.

A schedule of 2 months of pilot testing followed by 6 months of refinery testing was developed. The total time for these two studies to be run in series would take about 18 months. The total cost of the pilot and refinery testing is estimated to be about $516,000.

OPTIONS

Information was gathered from a wide range of sources on the technical and economic feasibility of monitoring air contaminant emissions from refinery flares. This information was evaluated and compared to the ARB's objectives to arrive at a recommended study program for the ARB to develop a practicable and reliable method of improving the ability to determine flare emissions from refinery operations.

The following are options that the ARB could proceed with to implement this study program:

1. Proceed with a study to develop emission factors to use with data from automatic on/off monitors to yield improved emission estimates compared to current methods.

2. Proceed with a study to attempt to identify reliable flow and composition monitoring equipment that can be used to correlate gas composition and flow to refinery flare emissions.

3. Proceed with a study to evaluate remote monitoring of refinery flare emissions.

4. Build upon the knowledge gained at the EPA-sponsored EER facility with respect to emission factors, rather than develop its own independently.

5. Attempt to conduct a pilot test program at the EER facility in conjunction with EER's ongoing flare emission testing program.

6. Implement the flare study first at a pilot flare test facility and then, if the program shows promise, at a refinery.

7. Limit the gas flow and composition monitoring equipment evaluated to devices that have demonstrated positive refinery history.

8. Limit the gas composition monitoring to total and reduced sulfur compounds. Total constituent analysis by online gas chromotography has low cost-effectiveness.

9. Evaluate the UVTV remote monitoring system further. The only other remote monitoring that may merit evaluation is the FTIR system.

Two areas of investigation requested by the ARB were judged to be unfeasible. These were:

1. Relating flare emissions to short-term mass balances around refinery process equipment.

2. Relating flare NO_x emissions to feed gas composition and flow.

CONTENTS

TABLES

FIGURES

A. INTRODUCTION

A. INTRODUCTION

A flare is a device that controls the emissions of hydrocarbons and other gases by combusting these materials in an open flame. Flares are commonly used to combust waste gases generated at refineries, oil production operations, chemical manufacturing plants, blast furnaces, coke ovens, and sanitary landfills. This report addresses the monitoring of emissions from refinery flares only.

The magnitude of flare emissions has never been accurately determined because of the technical problems associated with flare emission monitoring. An estimated 16 million tons of gases were flared in the U.S. in 1980.[1] Of this figure, approximately 2.1 million tons were flared by refineries. Typical flare combustion efficiency or ability to destroy the flared gas is above 98 percent.[2]

In 1984, the State of California received 617,800,000 barrels of crude oil for processing (12.9 percent of the total United States refinery crude oil throughput).[3,4] Assuming refinery operations are similar throughout the United States, approximately 14.8 tons of uncombusted flare gas are released daily from refineries in the State of California.

A flare is necessary for the safe operation of an oil refinery. Process upsets within the refinery occasionally cause a buildup of gas pressure within the process units. This gas must be vented immediately to avoid an explosion hazard. The volumes of waste gas vented during process upsets can be large enough to endanger human health and the environment. Because of this, flares are employed to destroy waste gas through combustion before these gases are released to the atmosphere.

There are significant differences between flaring practices in different refineries. Some refineries use flares solely as emergency devices. These flares are seldom used except

---

[1] Joseph et al. Evaluation of the Efficiency of Industrial Flare: Background-Experimental Design-Facility. EER, Irvine, California. 1983.

[2] Pohl et al. Evaluation of the Efficiency of Industrial Flares: Flare Head Design and Gas Composition. Irvine, California. 1985.

[3] Quarterly Oil Report, First Quarter 1985. California Energy Commission, Sacramento, California. June 1985.

[4] Petroleum Supply Annual. 1984. Energy Information Administration, Washington, D.C. 1985.

during major process upsets. Other refineries routinely use flares when they turn around (empty and clean) process units for reuse. Several flares are used to burn low-heating-value fuel continuously.

This report focuses on the monitoring of flares that are used on an emergency or other intermittent basis. The continuous flaring of low-heating-value fuel gas is generally accounted for as part of a refinery's overall emission inventory and is not considered in this study.

Flares are designed to ensure the safe, efficient combustion of refinery waste gases. Because flares are emergency devices, they are sized to handle any possible process upset. Two main types of flares are used: ground flares and elevated flares. Elevated flares are usually of a much higher capacity than ground flares, typically by a factor of 10.

Most refinery flares are elevated. A typical flare is elevated between 100 and 350 feet above grade. The height of a flare stack is designed to ensure that personnel at ground level are not exposed to dangerous levels of thermal radiation, of flare emissions, or of waste gas if the flare is not operating.

There are several ground flares in use within the state of California. In order to reduce radiant heat transfer, a ground flare is surrounded by a shroud of refractive material. In addition, the refineries prohibit entry into the area surrounding a ground flare without wearing protective clothing, even when the flare is not in operation. This is due to the sudden and unpredictable nature of flare operation.

Flare systems within the state of California are required to maintain nearly smokeless operation due to opacity regulations. The smokeless condition is most often obtained through the injection of steam directly into the base of the flame. Figure 1 shows a typical flare tip and steam injection system.

A schematic of a typical refinery flare and feed lines is shown in Figure 2. As stated previously, the flare is fed by several process streams. The process units typically contain pressure seals that release when the gases in the process unit reach a certain pressure. Most flare feed systems in California contain some sort of vapor recovery system to minimize the amount of gas sent to the flare. Any gas that bypasses the system is fed to the flare. Most flare systems contain water seals to prevent air from entering the manifolding system and forming potentially explosive mixtures. These water seals are usually located near the base of the flare. Gas that passes through the water seal is subsequently flared.

Defining the operating characteristics of a typical flare is difficult because flaring practices vary throughout the refinery industry. The term that best describes almost all flare operations is transient. Most flares are used only for emergencies and equipment turnaround. Because of this, the flow to a flare is intermittent. The gas flow to a flare can vary from zero to the design capacity of the flare in seconds although the latter figure is rarely, if ever, reached. Most flares are fed by a number of process streams of varying composition. At any given time, the flare may be fed by any number of different process streams in an unpredictable manner.

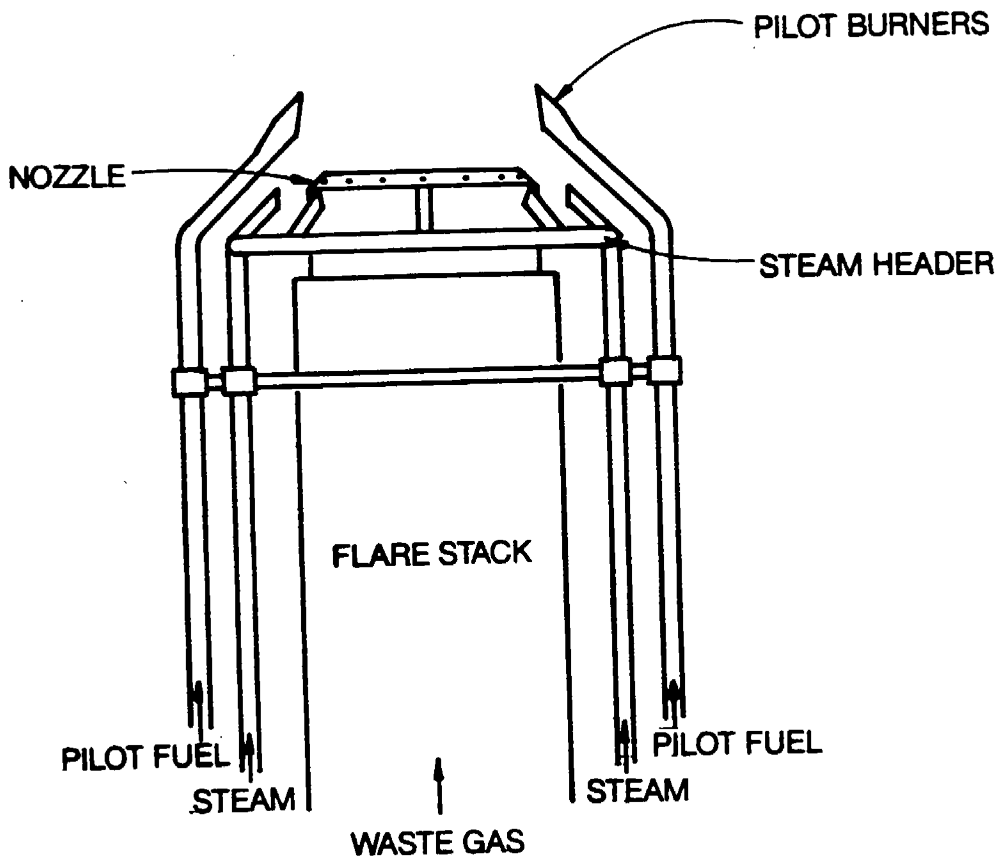

FIGURE 1

TYPICAL ELEVATED FLARE HEAD

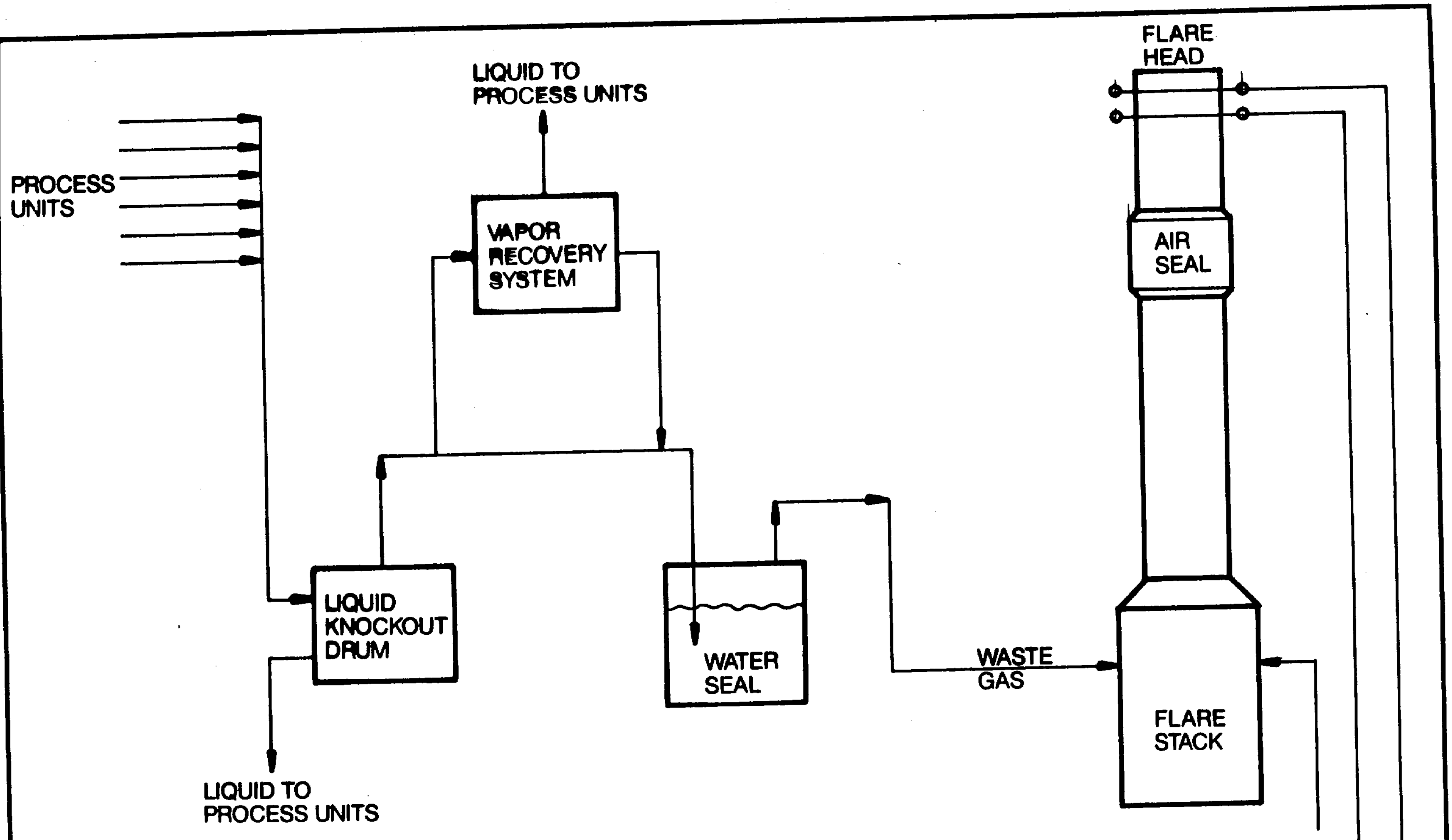

FIGURE 2

TYPICAL FLARE SYSTEM

CH2M HILL

B. SURVEY METHODOLOGY

B. SURVEY METHODOLOGY

Information on flare emission monitoring was collected from available literature, from monitoring device suppliers, and from surveys sent to California refineries. Followup information was received through telephone conversations, refinery visits, and visits to a flare test facility. This section details the methodology used to gather flare emission monitoring information.

1. LITERATURE REVIEW

The literature search was structured to isolate information on continuous monitoring systems by using key words and phrases to search a number of scientific and technical databases. The databases searched included the National Technical Information Service (NTIS), Standards and Specifications, United States Patent Abstracts, the Department of Energy Database, Compendex, Chemical Abstracts Search, Engineering Meetings, and the Federal Register. The key words and phrases used included flares(s), refinery, refineries, emission(s), continuous emission monitoring systems, test(s), testing, sense, sensing, monitor, monitoring, remote, continuous, sulfur, gas flow, total reduced sulfur, NO_x, SO_x, and combinations of the aforementioned words. Additional sources of information included standard reference texts and previous in-house project experience. The bibliographies of references obtained were searched for additional references. The literature search for this project was conducted using Lockheed's DIALOG, an online computerized reference tool that contains information from more than 200 abstracting and indexing services.

The literature search was designed to determine whether flare emission monitoring had been previously examined. Key words were used in such a way as to focus the search on information specifically concerning flares. A reference was deemed applicable if it included information on any type of flare monitoring, flare emission data, estimates of amounts flared, or information on flare operating procedures.

The literature search generated 37 references that are potentially applicable to flare monitoring. Of this number, 30 were reviewed by the project staff. Table 1 shows the references that were reviewed. Several references deemed to be potentially applicable are not available. These references are primarily private in-house reports, foreign reports, or private research. Table 2 shows the seven potentially applicable references that are unavailable. Relevant literature is summarized in Appendix A.

Table 1
REFERENCES REVIEWED BY PROJECT STAFF

1. Allen, Gerry D., Henry H. Chan, and Ron E. Wey. "Flare-Gas Recovery Success at Canadian Refineries." The Oil and Gas Journal. Vol. 81, No. 26. June 27, 1983. Pp. 79-84.

2. Coloff, S. G., M. Cooke, R. J. Drago, and S. F. Sleva. "Ambient Air Monitoring of Gaseous Pollutants." American Laboratory. July 1973. Pp 10-22.

3. Davis, B. C. "USEPA's Flare Policy: Update and Review." Chemical Engineering Progress. April 1985.

4. Exton, Reginald J. An Ultraviolet Video Technique for Visualization of Stock Plumes and for Measuring Sulfur Dioxide Concentration and Effluent Velocity. NASA Technical Paper 1014. 1977.

5. Haust, P. L., J. A. Hodgeson, and W. A. McClanny. "Air Pollution Monitoring by Advanced Spectroscopic Techniques." Science. Vol. 82. October 19, 1973.

6. Herget, W. F. Air Pollution: Ground-based Sensing of Source Emissions in Fourier Transform Infrared Spectroscopy. J. R. Fenaro and L. J. Busile, Eds. Academic Press. 1979.

7. Herget, W. F. "An Overview of the EPA Programs for Ground-Based Remote Sensing of Air Pollutants." SPIE. Vol. 195. 1979.

8. Herget, W. F., and J. D. Brasher. "Remote Fourier Transform Infrared Air Pollution Studies." Optical Engineering. Vol. 19, No. 4. 1980. Pp 508-514.

9. ————————. "Remote Measurements of Gaseous Pollution Concentrations Using a Mobile FTIR System." Applied Optics. Vol. 18. October 1979. Pp 3402-3420.

10. Herget, W. F., and W. D. Conner. "Instrumental Sensing of Stationary Source Emissions." Environmental Science and Technology. Vol. 11, No. 10. October 1977.

11. Joseph, D., J. Lee, C. McKinnon, R. Payne, and J. Pohl. Evaluation of the Efficiency of Industrial Flares: Background-Experimental Design Facility. Energy and Environmental Research Corp. 1982.

Table 1
(continued)

12. Kildal, H., and R. L. Byer. "Comparison of Laser Methods for the Remote Detection of Atmospheric Pollutants." Proc. IEEE. Vol. 59, No. 12. Pp. 1645.

13. Klett, M. G. "Refinery Flare Loading and Emissions Probed." Oil and Gas Journal. Vol. 77, No. 36. September 3, 1979. Pp. 108-110.

14. Lengelle, A., and L. Verdier. Gas Sampling and Analysis in Combustion Phenomena. NATO Advisory Group for Aerospace Research and Development, AGARDograph. No. 168. July 1973.

15. McDaniel, M. Flare Efficiency Study. Industrial Environmental Research Lab. Final Report. 1983.

16. Measures, R. M. Laser Remote Sensing--Fundamentals and Application.

17. Millan, M. M., S. J. Townsend, and J. Davies. Study of the Barringer Refractor Plate Correlation Spectrometer as a Remote Sensing Instrument. University of Toronto Institute for Aerospace Studies, UTIAS Report No. 146.

18. Persky, M. J., and L. R. Spellicy. Flare Efficiency Monitoring by Remote Infrared Sensing: A Feasibility Demonstration. Optimetrics, Inc. Final Report. 1984.

19. Pohl, J.H., R. Payne, and J. Lee. Evaluation of the Efficiency of Industrial Flares: Test Results. Energy and Environmental Research Corporation. 1984.

20. Pohl. et al. Evaluation of the Efficiency of Industrial Flares--Flare Head Design and Gas Composition, Energy and Environmental Research Corporation. 1985.

21. Prengle, W. H., et al. "Infrared Remote Sensing and Determination of Pollutants in Gas Plumes." Environmental Science and Technology. Vol. 7, No. 5. May 1973.

22. Romano, R. R. "Control Emissions with Flare Efficiency." Hydrocarbon Processing. Vol. 62, No. 10. October 1983. Pp. 79-80.

23. Schmidt, T. R. "Ground-Level Detector Tames Flare-Stack Flames." Chemical Engineering. April 11, 1977.

24. Seebold, J. G. "Practical Flare Design." Chemical Engineering. December 10, 1984.

Table 1
(continued)

25. Smalling, J. W., L. D. Braswell, L. C. Lynnworth, and D. Russell Wallace. "Flare Gas Ultrasonic Flow Meter." Proceeding of the Thirty-Ninth Annual Symposium on Instrumentation for the Process Industries. Department of Chemical Engineering of Texas A&M University. 1984.

26. Straitz, J. F., III. "Make the Flare Protect the Environment." Hydrocarbon Processing. October 1977.

27. Wormhoudt, J., ed. Infrared Methods for Gaseous Measurements: Theory and Practive. New York. Marcel Dekker, Inc. 1985.

28. Wu, Chung-you. "Are Your Flare Systems Adequate." Chemical Engineering. October 31, 1983.

29. No Author Given. Characterization of the EPRI Differential Absorption Lidar (DIAL) System. SRI International CA. December 1979.

30. No Author Given. "The War on Pollution." The Oil and Gas Journal. June 15, 1970.

Table 2
POTENTIALLY APPLICABLE REFERENCES NOT REVIEWED BY PROJECT STAFF

1. Chedaille, J., and Y. Braud. Measurements in Flames. Vol. 1. International Flame Research Foundation, Ijmuiden, Holland. (1972).

2. German Society of Petroleum Sciences and Coal Chemistry. "Developmental Low Pollutant Flares: Subproject 135-01, Analysis of Principles and Pollution Problems of Elevated Flares." Translated by Literature Research Company for EPA, TR-81-0119. (1981).

3. Gurs, K., and G. Schweizer. "Development of Low Pollutant Flares: Subproject 135-04, Determination of Hydrocarbon Emissions of Refinery Flares Using the Method of Comparative Absorption Measurements by Means of Laser." Translated by Literature Research Company for EPA, TR-81-0121 (1981).

4. Howes, J., et al. Draft Final Report an Development of Flare Emissions Measurement Methodology. EPA Contract No. 68-02-2682. Task Directive 118. August 14, 1981.

5. Lee, K. C., and G. M. Whipple. Waste Gas Hydrocarbon Combustion in a Flare. Union Carbide Corporation, South Charleston, West Virginia (1981).

6. Palmer, P. A. A Tracer Technique for Determining Efficiency of an Elevated Flare. E. I. DuPont de Nemours and Co., Wilmington, Delaware. (1972).

7. Siegel, K. D. Degree of Conversion of Flare Gas in Refinery High Flares. Thesis PhD. in Engr. Science, Chemical Engr. Dept., Univ. of Karlesruhe, Germany (February 1980).

2. SUPPLIER SURVEY

Suppliers and manufacturers of devices that could aid in determining pollutant emissions from refinery flares were investigated through the use of surveys and followup phone calls. Surveys were developed for suppliers of flow and composition monitors, for suppliers of emission monitors, and for flare manufacturers. Lists of potential suppliers were developed from many sources. All positive responses were reviewed for applicability, and the information gained was used to develop study designs for improved methods of determining flare emissions.

The survey letter sent to manufacturers of flow and composition monitors describes the wide range of conditions that could be encountered in the flare gas feed stream. Suppliers whose devices could be used for flare application were asked to describe the device and its capabilities. Suppliers of composition monitors were asked to describe detection and quantification capabilities for sulfur, hydrocarbon, and nitrogen compounds. In addition, cost and availability information was requested. Letters were sent to 273 potential suppliers of flow and composition monitoring devices.

The survey letter sent to manufacturers of emission monitoring equipment describes the operational characteristics of refinery flares and the technical difficulties of monitoring emissions from an open flare. Potential suppliers of appropriate devices were asked questions concerning capabilities, existing installations, equipment availability, and cost. Letters were sent to 285 suppliers of emission monitoring devices.

Survey letters were sent to 19 companies that manufacture refinery flares. Questions were asked concerning flow monitoring equipment successfully installed on refinery flares. In addition, information was requested on flare combustion efficiency or emission monitoring studies.

Lists of appropriate suppliers and manufacturers were developed through computer searches, buyers' catalogues, and equipment newsletters. The computer searches used Lockheed's DIALOG databases in addition to databases generated from telephone yellow pages and manufacturers' directory listings. Buyers' catalogues and equipment newsletters including Pollution Equipment News, Chemical Engineering Equipment Buyers Guide, Chemical Engineering Catalogue, and Pollution Engineering were reviewed for potential suppliers.

Lists of the companies surveyed are presented in Appendix B. Thirty-six responses containing information relevant to this project were received. Sixty-three responses containing no pertinent information were received and 349 companies did not respond. A summary of useful information in the responses is presented in Appendix B.

3. REFINERY SURVEY

A refinery questionnaire was designed to survey California refineries about flaring operations and flare monitoring practices. Early in the project a decision was made by the California Air Resources Board (ARB) staff to limit the scope of the survey to those refineries located within the Bay Area Air Quality Management District (BAAQMD) and the South Coast Air Quality Management District (SCAQMD). A list of all refineries located within those areas was developed by the project staff in conjunction with the ARB staff at meetings with representatives of the BAAQMD and the SCAQMD. A total of 26 refineries were identified through this process. A list of refineries that were surveyed is shown in Table 3.

The refinery survey was developed by the project staff with ARB staff review. The survey requested that the refineries answer specific questions concerning flare design, type of flare service, emission monitoring capabilities, feed gas monitoring capabilities, refinery processes served by flares, operational recordkeeping, estimated feed gas parameters, and the use of feed gas accumulators. The survey also requested from the refineries a schematic of their flaring systems and feed gas networks as well as information on their purge gas and control/compressor systems.

Of the 26 refineries surveyed, 16 submitted responses. Three of the refineries that submitted responses do not have operational flares. The number of flares in use at each of the other refineries ranges from one to eight. A summary matrix of the responses received is shown in Table 4. Based on the refinery responses received, the project staff selected five refineries to visit to discuss monitoring capabilities further. The five refineries selected had each indicated that some sort of flare monitoring had been either implemented or attempted. Four of the five refineries selected were actually visited by project staff and ARB staff.

The results of the refinery survey are found in Appendix C. Also in Appendix C are notes taken during the refinery visits by members of the project staff. Information gathered through the refinery survey and during the refinery visits was combined with information obtained via the literature search and equipment supplier survey to form the basis for the design of additional monitoring studies.

Table 3
REFINERIES SURVEYED

BAY AREA AIR QUALITY MANAGEMENT DISTRICT

Chevron USA, Inc.
P.O. Box 1272
Richmond, California 94802

Exxon Co., USA
Benecia Refinery
3400 East Second Street
Benecia, California 94510

Huntway Refining Company
P.O. Box 787
Benecia, California 94510

Pacific Refining Company
P.O. Box 68
Old Highway 40
Hercules, California 94547

Shell Oil Company
P.O. Box 711
Martinez, California 94553

Tosco Corporation
Avon Refinery
Martinez, California 94553

Union Oil Company of California
San Francisco Refinery
Rodeo, California 94572

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

ARCO Petroleum Products Company
Watson Refinery
1802 East Sepulveda
P.O. Box 6210
Carson, California 90749

Champlin Petroleum Co., Inc.
2402 East Anaheim Street
Wilmington, California 90744

Chevron USA
El Segundo Refinery
P.O. Box 97
El Segundo, California 90245

Table 3 (cont.)

De Menno-Kerdoon
2100 North Alameda
Compton, California 90222

Eco Petroleum Inc.
P.O. Box 2670
Long Beach, California 90801

Edgington Oil Company, Inc.
2400 East Artesia Boulevard
Long Beach, California 90805

Fletcher Oil and Refining Company
24721 South Main Street
P.O. Box 548
Carson, California 90745

Golden Eagle Refining Co., Inc.
21000 South Figueroa Street
P.O. Box 4886
Carson, California 90745

Golden West Refining Company
P.O. Box 2128
Santa Fe Springs, California 90670-0138

Huntway Refining Co.
P.O. Box 1257
Wilmington, California 90748

MacMillan Ring Free Oil Co., Inc.
2020 Walnut Avenue
Signal Hill, California 90808

Mobil Oil Corp.
3700 West 190th Street
Torrance, California 90503

Marlex Oil & Refinery, Inc.
1825 East Spring Street
Long Beach, California 90801

Newhall Refining Co., Inc.
P.O. Box 938
Newhall, California 91322

Paramount Petroleum Refining
14708 Downey Avenue
Paramount, California 90723

Table 3 (cont.)

Powerline Oil Co., Inc.
12354 East Lakeland
Santa Fe Springs, California 90670

Shell Oil Company
Wilmington Manufacturing Complex
P.O. Box 6249
Carson, California 90749

Texaco Refining & Marketing Inc.
Los Angeles Plant
2101 East Pacific Coast Highway
Wilmington, California 90744

Union Oil Company of California
Los Angeles Refinery
1660 West Anaheim Street
Wilmington, California 90744

District	Refinery	Number of Flares	Continuously Monitor Emissions	Keep Records of ON/OFF	Automatically Monitor ON/OFF	Monitor Feed Gas Flow	Monitor Feed Gas Composition	Estimated Feed Gas Flow	Estimated Feed Gas Composition	Use Feed Gas Accumulators	Sent Schematic
BAAQMD	Chevron	8[1]					2				X
	Exxon	4		X	X	X		X			X
	Huntway	1[3]						X	X		
	Pacific	1		X		X	4	X	X		X
	Shell	5[5]		X[6]		X[7]		X	X		
	Union	3[8]			X						
SCAQMD	ARCO	3			X[9]				X		X
	Chevron	6[10]		X[11]		12					X
	Edgington	0									
	Golden West	3[13]									
	Huntway	0									
	MacMillan Ring Free	0									
	Newhall	1		X		X		X	X		
	Shell	4[14]		X[15]	X[16]	17		X			
	Texaco	2		X	X[18]	X[19]	20	X	X		
	Union	4		X	X[21]					X[22]	

1 Chevron owns 11 flares, of which 8 are in use.

2 Chevron takes grab samples for chromatographic analysis once per week.

3 Huntway uses a ground flare.

Table 4
MATRIX OF REFINERY SURVEY RESPONSES

Table 4 (cont.)

[4]The BAAQMD has taken grab samples for chromatographic analysis.

[5]One of the five flares is a ground flare. One of the five flares continuously burns low-heating-value fuel.

[6]This response applies to only the continuously operating flare.

[7]This response applies to three of the five operating flares.

[8]One of the three flares is a ground flare.

[9]Color TV monitor in control room. System apparently does not automatically indicate when flare is operating.

[10]One of the six flares is a ground flare. One of the six flares is used continuously.

[11]Records are kept for one of the six flares.

[12]They are planning to install a test flow sensing device on one flare.

[13]One of the three flares is a ground flare.

[14]One of the four flares is a multi-stage flare containing both a ground flare and an elevated flare.

[15]Records kept for two of the four flares.

[16]A pressure sensor is used on two of the four flares.

[17]A flow device is to be installed on one flare in the near future.

[18]Actual ON/OFF monitoring is done visually. Each flare is equipped with thermocouples to indicate a flare flame out.

[19]Refinery has recently implemented a monitoring program to better identify the source of the flare gases.

[20]Occasional grab samples are taken for chromotographic analyses.

[21]Three of the four flares are automatically monitored.

[22]Two - 150,000 cubic foot vaporspheres are attached to three of the flare lines.

4. ENERGY AND ENVIRONMENTAL RESEARCH CORPORATION (EER) VISIT

Members of the project staff, along with a member of the staff of the California ARB, visited the EER facility in Irvine, California. EER is conducting a research program to determine the efficiency of combustion and to quantify the emissions from industrial flares.

The EER flare research facility consists of a pilot flare over which is suspended a line of five extractive probes. The system is designed so a variety of flare heads may be used. The line of probes may be moved horizontally and vertically, allowing the operator to adjust for flame position.

The EER research project included a search and summary of available information concerning flare design, operation, and monitoring and gaseous pollutant monitoring. This phase of the research project is discussed by EER in the Evaluation of the Efficiency of Industrial Flares: Background-Experimental Design-Facility, 1983, which was examined by members of the CH2M HILL project staff as part of the literature search. During the site visit, the project staff questioned EER personnel concerning the knowledge obtained as a result of the flare research project as well as future plans.

C. STUDY FINDINGS

C. STUDY FINDINGS

The activities described above were designed to gather a base of information sufficiently broad so that further research projects could be developed. The literature search provided information on flare operations, flare designs, flare efficiency, and the development of remote monitoring technologies. The equipment supplier survey provided information concerning the types of monitoring equipment currently available that may be applicable for flare monitoring. The refinery flare manufacturer's survey provided references and flow device supplier information. The refinery survey and visits provided information on refinery flare operations and on the current level of refinery flare monitoring. The EER site visit provided the project staff the opportunity to conceptually discuss an ongoing flare emission research project.

1. REFINERY OPERATIONS

Information concerning refinery flaring operations was obtained through the literature search, the refinery survey, visits to oil refineries, and discussions with refinery personnel. The information obtained indicates that there is a great deal of variation in flaring practices between different refineries.

Sixteen of the 26 refineries surveyed responded to the questionnaire as shown in Table 2. Three of these refineries reported that they did not operate flares. The other 13 refineries each reported from one to eight operating flares. A total of 45 flares were reported as operating within the BAAQMD or the SCAQMD. Of these, 39 were elevated, five were ground flares, and one was a two-stage flare containing both ground and elevated elements.

The refineries were asked to classify the type of flare service as either emergency, scheduled intermittent flow or blowdown, or continuous. Forty-two flares are used as emergency devices; 21 flares are used to combust scheduled intermittent flow or blowdown; and 5 flares are used continuously. While the flaring of small quantities of waste gas is fairly common, large-quantity emergency flaring is not a common occurrence. Flaring is commonly caused by leaks in pumps, seals, and valves within process units, by blowdown, and by equipment turnaround. While emergency flaring is often unavoidable, refineries attempt to minimize flaring because of the value of the lost hydrocarbons.

Most of the refineries surveyed did not indicate the frequency of flaring episodes. One refinery indicated one of its four flares had one episode per month, but the refinery could not supply a frequency for any of its other three flares. Many refineries indicated that the frequency of flaring was extremely variable. Refinery personnel indicated in discussions that emergency flaring occurred once every several months but that other types of flaring were much more common. At least 23 process units were identified as being potential sources of gas to the flare. These are presented in Table 5.

Of the 45 flares identified, 33 flares were dedicated to more than one process unit. Gas flow to these flares can be expected to have a highly variable composition. The remaining twelve flares are each dedicated to a single process unit, and the composition of the gas flow to these flares should be more constant; however, gas flows can still be highly variable.

The refineries surveyed were asked to estimate flare feed gas flowrate and composition. Of the 16 refineries that responded, seven provided an estimate of feed gas flow and six provided an estimate of feed gas composition. Estimates of flows ranged from approximately 1 million standard cubic feet per year (scfy) to 2 million standard cubic feet per day (scfd). These estimates represent average flows. Peak flows are substantially higher. The estimates of flare feed gas composition showed a similar variation. Estimates of hydrocarbon concentration ranged from 2 percent to 100 percent. Estimates of sulfur compound composition ranged from zero to 6 percent. These estimates represent average values. Higher feed gas concentrations of sulfur compounds are possible, depending upon the source of the gas.

Virtually all refinery flare feed systems within the state of California contain some sort of vapor recovery system. A vapor recovery system usually consists of a gas compressor located on a side stream off the main gas flow. The vapor recovery system diverts as much of the flow from the flare as it can handle. The resultant compressed gas is usually used as make-up fuel in the process units. Waste gas flow above the capacity of the vapor recovery system and gas that is not condensable are sent to the flare.

The flare gas header is not the only line that goes to the flare. Most refineries inject steam directly into the flame to maintain smokeless operation. Air and water may also be used to maintain the smokeless condition. Nearly smokeless operation is required for all refinery flares by State of California opacity regulations.

When not in use, most refinery flares are continuously purged with natural gas or some low-Btu waste gas. This is done to prevent oxygen from entering the system, an event which would

Table 5

POTENTIAL SOURCES OF FLARE GAS

Hydrogen Plant	Hydrotreating Units
Catalytic Cracking Units	Coking Units
Sulfur Plants	Dimersol Plants
Hydrofining Units	Storage Tanks
Fuel Gas Purge	Distillation Units
Platforming Units	Gas Recovery Units
Alkylation Units	Reforming Units
Sourwater Stripping Units	Loading and Unloading Operations
Crude Units	Hydrocracking Units
Lube Oil Dewaxing	Solvent Extraction Units
Cogeneration Units	DEA Regenerators
Aromatic Saturation Units	

create an explosion hazard. The nozzles of steam injectors on steam-assisted flares are purged with steam to prevent clogging.

2. FEED GAS MONITORING

Feed gas monitoring involves monitoring the flare feed gas stream for flow and composition information. This section reports the findings concerning feed gas monitoring.

Flow Monitoring. There are many devices available today to monitor flow of gaseous streams. They range from simple pressure indicators to highly sophisticated ultrasonic devices capable of monitoring several gas stream parameters. Flow monitoring devices, for the purpose of this study, will include those devices which gather information to determine gas stream velocity, volumetric flow, or mass flow and include devices which merely determine if flow is occurring.

A flow monitoring device must be able to operate under a wide range of conditions to be considered suitable for use in monitoring refinery flare gas streams. Table 6 lists general gas stream parameters typically encountered by refinery flares. In addition, the gas stream is usually highly corrosive and erosive.

Refinery operations must be considered when evaluating systems for monitoring flare feed gas streams. A flare is considered to be a safety valve for oil refineries. In addition to providing a safe means of gas disposal during minor process upsets and variations, flares are the primary means of gas relief during a major upset such as cooling water system failure, electrical outage, or fire. As a result, flare systems are designed to be simple, fail-safe systems with no moving parts, such as check valves, which could prevent or impede gas flow to the release point. Feed gas monitoring devices must conform with these standards.

Because of the ignitibility of gases fed to the flare, monitoring devices must be constructed to NEMA-7, Division 1, Group B, specifications for explosion-proof casings. In addition, seals should be absolute to prevent intrusion of ambient air.

Prior experience with flow monitoring in flare feed gas streams dictates that monitors should not have moving parts exposed to the gas stream. In addition, the accuracy should not depend on the physical shape of anything exposed to the gas stream. All objects are subject to erosion by the gas stream, and moving parts are easily plugged.

The wide variety of gases that could enter a refinery flare system presents a unique problem when attempting to determine

Table 6

FLARE FEED GAS PARAMETERS

Parameter	Range
Velocity	0.2 ft/sec. to 600 ft/sec.[a]
Temperature	Excursions to 160°C[b]
Pressure	Slightly above atmosphere (approximately 20" H_2O)[b]
MW	6 to 60[b]
Gas Stream Constituents:	
HC Compounds	C_1 to C_5[a]
H_2S	0 to 6%[c]

Note: the remainder of the gas stream may contain H_2, H_2O, CO, CO_2, N_2, NH_3, NO_x, SO_x.

[a]Joseph, et al. Evaluation of the Efficiency of Industrial Flares: Background - Experimental Design - Facility. EER, Irvine, California. 1983.

[b]Proceedings from 39th Annual Symposium on Instrumentation for the Process Industries, Flare Gas Ultrasonic Flow Meter. 1984.

[c]Refinery survey conducted by CH2M HILL, 1985.

volumetric flows. Flow monitoring devices are typically used in applications where the gas stream constituent makeup is relatively constant. In these cases, volumetric flow information is determined either by a combination of velocity measurements and known gas parameters (i.e., density, molecular weight, thermal conductivity) or by direct calibration of the velocity measuring instrument in the gas stream. Because of the variability of the feed gas stream to a refinery flare, gas stream parameters are usually not known, and direct calibration is not applicable.

In addition to the wide variety of gases potentially encountered, a flow device must be able to measure a wide range of flowrates. Flare feed gases could originate from leaking relief seals with very low flowrates or from a process upset causing a very high flow. The velocity of gas in the feed line typically varies from 0.2 to 600 feet per second, as shown in Table 6. This requires an instrument range of over 1,000 to 1. Commercial flow instruments typically are accurate over ranges of approximately 10 to 1.

Several general categories of flow monitoring devices are considered unsuitable for use in refinery flare feed gas lines. The following briefly outlines the device operating principle and reason for excluding the device from recommended studies.

- Vane anemometer - uses a windmill-like device and counts revolutions; has moving parts which have plugged in previous use.
- Turbine flowmeter - uses a turbine device and counts revolutions; moving parts.
- Venturi flowmeter - measures pressure drop across a constriction in the line; limited accuracy range.
- Orifice meter - measures pressure drop across a construction in the line; limited accuracy range.
- Area meter - holds a constant pressure drop across a constriction by varying the size of the constriction; has moving parts that could potentially block flow.
- Doppler flowmeter - senses frequency change caused by motion of particles or bubbles in the fluid; normally applicable to incompressible fluids (i.e., liquids).
- Dynamic flowmeter - measures dynamic forces on a fixed body in the flow stream; subject to erosion which would change the shape of the object.

General categories of devices which have potential uses for measuring flows in flare feed gas streams are presented below. A brief description of the operating principle and potential use is included.

- o Pressure tap measures either static or impact pressure in the gas stream; inexpensive device which could be used to determine if flow is occurring. A potential exists for plugging.

- o Pitot tube measures the difference between static pressure and impact pressure; inexpensive device which requires gas density information for velocity determination and could be used in pilot test systems where feed gas information is known. A potential exists for plugging.

- o Hot-wire or heated-thermocouple anemometer measures cooling effect of gases flowing across a heated element or heated thermocouple junctions; requires gas stream information including density and thermal conductivity for gas velocity determination. One manufacturer provides a combination device providing adequate information for mass flow determination. One installation exists in a California refinery, but calibration is not complete and records are not kept.

- o Ultrasonic flowmeter measures changes in sound speed of waves propagated through the gas; one device is presently installed in a Texas refinery to recorded mass flowrate information.

At the present time, no refinery within the state of California accurately monitors volumetric gas flow to its flares; however, several types of flowmeters have been installed in refinery flares. Several refineries reported that they measure flow using hot-wire anemometers. This type of flowmeter measures heat loss from the probe caused by the gas flow. To determine flow accurately, the thermal conductivity of the gas must be known.

One type of hot-wire anemometer mass flowmeter which can determine thermal conductivity has been installed in the flare stacks of one refinery. That refinery does maintain records of gas flow to the flare, but those records are based on output from venturi flowmeters installed in the same line. One refinery uses a velocity probe flowmeter, a Pitot-tube-based device, in the flare line as part of the refinery's accounting procedure. This flowmeter seems to work fairly well for larger flows, but it would not detect a small flow due to design limitations. All data from the flowmeter is kept in the refinery's records.

None of the flow measurement attempts have resulted in accurate continuous monitoring of volumetric gas flow to a flare. This is because information on feed gas properties is needed to accurately interpret flowmeter readings. The refineries that do monitor flow are usually attempting to reduce the amount of gas flared by maintaining tighter control over process operations. This requires information only on relative flow values, which the flow meters currently in place are able to provide.

Several refineries reported that they automatically monitor when the flare is on or off. This was done either by in-line pressure sensors or by remote optical monitoring. Three refineries use remote monitoring to control the use of steam to reduce opacity. A system in place at one refinery senses when smoke is evolved and adjusts the steam flow upward to correct the condition. Another system, in place at two refineries, senses the radiation from the flame and adjusts the steam flow accordingly. One refinery uses pressure sensors at the water seal to indicate when the flare is on or off. The system is not calibrated to provide flow information, but readings above a specific value indicate the flare is on. The sensor's output to a strip chart is recorded, but the records are not saved.

At the present time, automatic on/off monitoring is feasible and is being implemented by several refineries. However, no refineries report when the flare is on or off. Few refineries maintain long-term records of flare operations. Because on/off monitoring has been successfully field implemented, it is not necessary to study its feasibility. The recording of on/off monitoring may be of assistance in the derivation of new emission factors more specific to actual practice in California.

Constituent Monitoring. Refinery flare feed gas monitoring involves identifying and quantifying specific compounds in a gas stream. The purpose of identifying and quantifying specific compounds is to gather information which could be used in conjunction with emission factors and volumetric flow information to develop improved estimates of emissions from refinery flares.

As detailed in the Flow Monitoring section, composition monitoring devices for refinery flares should (1) not impede gas flow to the flare, (2) be constructed to appropriate NEMA-7 specifications, (3) not permit intrusion of ambient air, and (4) be able to withstand the corrosive, erosive nature of the gas stream described in Table 6. To be considered suitable for use in flare gas feed streams, a device must be able to identify and quantify a specific compound unaffected by the wide range of potential interferences from other compounds present in the stream.

Refinery flare emissions of concern include sulfur oxides (SO_x), reduced sulfur compounds (RS), and nitrogen oxides (NO_x). Prediction of emissions of SO_x requires knowledge of RS as well as total sulfur present in the feed stream. RS is normally present in the feed stream as hydrogen sulfide (H_2S). Prediction of RS emissions using H_2S feed rates is made by applying emission factors developed from combustion efficiency testing.

The emission of NO_x from refinery flares is one of the concerns of this project. The reaction of atmospheric oxygen and nitrogen to form NO is associated primarily with high temperature fuel-lean conditions. The NO produced by this mechanism is termed thermal NO because of its exponential temperature dependence. That is, NO is produced at exponentially higher rates as the temperature increases. NO_2 is formed by the further oxidation of NO, mostly after the combustion gases have left the flame. Fuel nitrogen is partially converted to NO_x, but the conversion rate is variable and depends somewhat upon temperature and flame conditions.

Reactions which have little significance in the overall combustion scheme are of importance in NO formation. Also, because refinery flares produce lazy, cool flames and because of the dependence of NO_x generation rate on combustion temperatures, it is expected that flares will give low emission rates of NO_x. This has been confirmed by pilot-scale tests.

Nitrogen oxide formation is temperature dependent, and that temperature is more correlated with the combustion characteristics and design of the flare tip than with the flowrate and composition of the gas going to the flare. There is little reason to believe that a correlation between gas flow and composition and NO_x production in the flame could be developed with any greater accuracy than that using conventional emission factors. It is not recommended that the ARB attempt to develop this sort of correlation with the same rigor as the investigation of SO_2 formation or H_2S destruction.

Monitoring for total sulfur and H_2S in flare feed gas streams is within the capacity of today's process monitors. Although continuous monitors were not reported to be in place on flare feed streams in California refineries, the technology is used in other refinery gas streams and other industries with similar interferences. In general, the method involves extracting a sample from the gas stream, and flow to the flare is not impeded.

H_2S can be directly detected by several techniques. Total sulfur is measured by oxidizing or pyrolizing all sulfur compounds and using the same techniques to detect the resultant SO_2 or H_2S. The following constituent monitoring techniques are recommended for further study.

- <u>Ultraviolet absorption</u>. Particulate matter is first filtered from the extracted gas sample. Analysis is based upon the continuous measurement of the ultraviolet absorption of H_2S at a wave length selected specifically for the application so as to avoid interferences.

- <u>Lead acetate</u>. The extracted gas sample is exposed to lead acetate treated paper tape. The resultant reaction forms a brown stain and the color change is detected with photocells.

- <u>Gold film</u>. The extracted gas sample passes over the gold film sensor. The sensor adsorbs and integrates the H_2S present in the sample. Amounts of H_2S present are proportional to the change in resistance across the film.

- <u>Photoionization</u>. The extracted gas sample passes through a photoionization cell. Molecules of H_2S are ionized by light energy from an ultraviolet light source and characterized by their ionization potential.

Gas chromotography (GC) techniques are not recommended for monitoring of H_2S or total sulfur in the feed stream. These techniques are expensive and are normally designed to detect a much wider range of compounds than called for here. Less expensive devices dedicated to detecting H_2S are quite accurate and are field proven. Total sulfur determinations using GC techniques would involve totaling quantities of all the sulfur compounds potentially present in the feed steam. The same objective can be obtained by oxidizing all sulfur compounds by using an oven and quantifying the resultant SO_2 with a dedicated device.

A total constituent monitoring program was considered but is not recommended. Total constituent monitoring could be used to supply gas stream information such as density and molecular weight to be used in conjunction with flow measurement devices to determine volumetric flow.

Total constituent monitoring is very expensive and would involve the use of multiple GC's with various detection devices. The system would have to be custom designed for this specific application and would include software designed to reduce the data and integrate it with information from the flow monitoring device. Although this system could be designed, it is beyond the scope of this study.

<u>Material Balance</u>. A material balance is an attempt to account for all the materials that are introduced to and leave from a system. Because refineries maintain material balances

for accounting purposes, they are sometimes used in an attempt to determine the amount of gas flared over a given period. Refineries calculate both an overall material balance and material balances of process units. The information that is available from material balances is the heating value and total amount of material lost from the process. That includes both gases flared and gases and liquids lost to fugitive emissions.

Based on current available emission factors, fugitive emissions and gases flared represent less than 1 percent of refinery throughput.[1] The material balances are generally not this accurate especially over a short time frame. Thus, estimates of flare emissions using material balances probably would not be representative. In addition, the data derived by material balances would not distinguish between gases sent to the flare and fugitive emissions.

For the reasons discussed above, the material balances calculated by refineries do not seem to offer a promising approach for determining or estimating gas flow to the flare. The present level of accuracy of material balances is not sufficient to account for the small amount of gas that is flared.

3. EMISSION DETERMINATION

Emission Factors. Estimates based on emission factors can be used to approximate emissions from an existing source or to predict emissions from a source not yet constructed. They have been developed from source tests, material balances, and engineering estimates for a wide variety of processes and sources. Because of this, they represent an average emission for each source category. The U.S. Environmental Protection Agency lists emission factors in its Compilation of Air Pollutant Emission Factors (AP-42).[2]

Emission factor estimates are included in AP-42 for emissions of sulfur oxides, carbon monoxide, total hydrocarbons,

---

[1]EPA Compilation of Air Pollutant Emission Factors, AP-42, U.S. Environmental Protection Agency, Office of Air and Waste management, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, Supplement 13, August 1982.

[2]Compilation of Air Pollutant Emission Factors, AP-42, U.S. Environmental Protection Agency, Office of Air and Waste Management, Office of Air Quality Planning and Standard, Research Triangle Park, North Carolina, Supplement 13, August 1982.

and nitrogen oxides from refinery vapor recovery systems and flaring. These factors are presented as mass emissions per thousand barrels of crude oil throughput. The factors have not been recently updated and do not consider California regulations which require the use of vapor recovery systems.

The South Coast (Los Angeles area) and the Bay Area (San Francisco area) Air Quality Management Districts have modified the AP-42 emission factors. These modifications reflect improved knowledge for certain pollutant emissions and include an emission factor for particulate matter. The South Coast Air Quality Management District also considers sulfur production and acid gas treating throughput when calculating emissions of sulfur compounds.

The emission factors presently in use are estimates of refinery flare emissions. They are calculated as a percentage of total crude oil processed by the refinery. The same emission factors are used for each refinery and do not consider the sulfur content of the crude oil processed or the type of processes in use at the refinery.

Improvements in existing emission factors could be made with information gained through on/off monitoring of refinery flares. Although these improvements are limited by a lack of volumetric flow and flare combustion efficiency information, emission factors could be made more specific to California refinery operations. They could reflect emissions as a function of specific refining methods in use at a refinery. Although no agency reporting and limited recording is presently undertaken at California refineries, automatic on/off monitoring is feasible and is in use at several refineries.

<u>Direct Emission Measurements</u>. Currently, emissions are not monitored on any refinery flare operating within the state of California. Flare emission monitoring presents a difficult problem because of the design and operating characteristics of flares. Flare emissions are currently estimated through the use of an emission factor based on the total refinery throughput.

Accurate direct emission measurements on a large elevated refinery flare are not feasible at the present time because of flare design and operation. Elevated flares are often over 100 feet above grade. One refinery had flares that were elevated 365 feet above grade. Flaring operations vary greatly with time and among different refineries. Emergency flaring can result in flame lengths of 100 feet or more. Routine flaring due to process leaks, thought to result in a significant percentage of flare emissions, can result in very small flame lengths. During flaring, the position of the flame fluctuates, even under calm conditions. Compounding this is the fact that an elevated flare stack is fully exposed to all weather conditions. Even if direct emission monitoring were feasible, installing and maintaining a monitoring system on a refinery flare would present tremendous logistical problems because of the size of the apparatus required and because refinery flares almost always remain online to receive emergency flaring.

Direct emission monitoring on a ground flare should be more feasible than monitoring on an elevated flare. Ground flares are surrounded by refractive material and shields. This provides a place to mount monitoring equipment as well as protecting the flame from wind. Inherent problems include the fact that monitoring equipment will be exposed to extremely high temperatures. In addition, because of the existence of the protective shrouding, ground flare efficiencies will probably not correlate well with elevated flare efficiencies. This is because the refractive material increases the residence time of, and decreases radiant heat loss from, a ground flare as opposed to what would be expected from an elevated flare.

A review of the available literature and of the work done by the Energy and Environmental Research Corporation (EER) reveals five previous research attempts to quantify flare emissions and combustion efficiencies through the use of direct emission measurements. These five studies were conducted by Palmer (1972); Siegel (1980); Lee and Whipple (1981); Howes, Hill, Smith, Ward, and Herget (1981); and the Chemical Manufacturers Association (1982). Siegel's work is the only study done on a full scale refinery flare. He concluded that the flare tested was between 97 and 100 percent efficient.

The Chemical Manufacturers Association (CMA) study was sponsored by both the CMA and the USEPA. It consisted of a John Zink STF-S-8 flare tip with an inner diameter of 8-5/8 inches. A 27-foot sample probe was suspended by crane over the flare flame. The study concluded that under conditions representative of industrial practices the combustion efficiencies in the flare plume were greater than 98 percent. Palmer used ethylene and a 1/2-inch-diameter flare. Lee and Whipple studied a bench-scale propane flare. Howes and others studied commercial flare heads but did not examine steam-assisted flares of the type that are used in a majority of California refineries.

The most detailed flare efficiency information currently available is a result of the research programs conducted by the CMA and by EER. The primary objective of the CMA research program was to "determine the combustion efficiency and hydrocarbon destruction efficiency for both air- and steam-assisted flares over a wide range of operating conditions that might be encountered in continuous low flow industrial applications." The suspended probe sampled emissions directly from the flare under conditions representing various flowrates, gas heating values, and steam-to-relief gas ratios. Table 7 shows the results of the CMA flare efficiency study.

The EER research program is a long term effort to determine the combustion efficiencies of small flare flames. In addition, the EER program attempts to determine how these flare efficiencies are influenced by various design and operating parameters. Through these efforts, it is hoped that the efficiencies of large industrial flares can be estimated.

The CMA flare efficiency study did not examine flaring conditions representative of the large gas flows that are seen by refinery flares during process upsets and shutdowns. Also, testing was found to be not feasible under an ambient wind velocity exceeding 5 miles per hour. This was due to the fact that it became impossible to maintain proper probe positioning. During this study, sulfur was selected as a tracer material to account for dilution. Three primary sources of sulfur in the relief gas were identified and flare emissions were analyzed for total sulfur as SO_2 using flame photometry. The attempt to use sulfur as a tracer was unsuccessful primarily due to difficulty encountered in quantifying and maintaining constant levels of sulfur in the relief gas. To develop an emission factor specific to refinery flares, further testing would be needed to better simulate refinery flare operating characteristics.

The EER flare facility consists of a pilot-scale flare equipped with a line of five suspended extractive probes. The initial stages of the research program consisted of the establishment of an initial database and the selection of gases and operating conditions. The basic flare test matrix allowed for variation of the following parameters: gas velocity, gas composition, steam flow, wind velocity, and whether or not a hood was used. Eventually, it was decided not to use a hood as it was not representative of normal industrial practices.

The test program was originally divided into four tasks. Task 1 was intended as a parameter screening study. Task 2 developed and verified measurement techniques. Task 3 involves the use of the measurement techniques developed by Task 2 on the parameters developed by Task 1, and Task 4 will involve the evaluation of the test data.

One of the gases chosen by EER for testing is hydrogen sulfide, which is often found in refinery flare gas. Hydrogen

Table 7
FLARE EFFICIENCY TEST RESULTS[a]

Test Number	Relief Gas Flow (SCFM)	Relief Gas Heating Value (Btu/SCF)	Steam-to-Relief Gas Ratio (lb/lb)	Combustion Efficiency (%)	Comments
Steam-assisted Flare Tests					
1	473	2,183	0.688	99.96	
2	464	2,183	0.508	99.82	
3	456	2,183	0.440	99.82	Incipient smoking flare
4	283	2,183	0	99.80*	Smoking flare
8	157	2,183	0	99.81*	Smoking flare
7	154	2,183	0.757	99.84	Incipient smoking flare
5	149	2,183	1.56	99.94	
67	148	2,183	0.725	--	Sampling probe in flare flame
17	148	2,183	0.926	99.84	
50	24.4	2,183	3.07	99.45	
56	24.5	2,183	3.45	99.70	
61	25.0	2,183	5.67	82.18	Steam-quenched flame
55	24.7	2,183	6.86	68.95	Steam-quenched flare
57	703	249	0.150	99.90	
11a	660	305	0	99.79	
11b	599	342	0	99.86	
11c	556	364	0	99.82	
59a	591	192	0	97.95	
59b	496	232	0	99.33	
60	334	298	0	98.92	
51	325	309	0.168	98.66	
16a	320	339	0	99.73	No smoke
16b	252	408	0	99.75	No smoke
16c	194	519	0	99.74	Incipient smoking flare
16d	159	634	0	99.78	Smoking flare
54	0.356	209	0	99.90	
23	0.494	267	0	100.01	
52	0.556	268	77.5	98.82	
53	0.356	209	123	99.40	
Air-assisted Flare Tests			Air Flow, Hi, Low, Off		
26	481.6	2,183	Hi	99.97	
65	159	2,183	Off	99.57*	Smoking flare; no air assistance
28	157	2,183	Hi	99.94	
31	22.7	2,183	Low	99.17	
66	639	158	Off	61.94	Detached flame observed
29a	510	168	Low	54.13	Detached flame; no air assistance
29b	392	146	Low	64.03	Detached flame; w/air assistance
64	249	282	Low	99.74	
62	217	153	Low	94.18	Flame slightly detached
63	121	289	Low	99.37	
33	0.714	83	Low	98.24	
32a	0.556	294	Low	98.94	
32b	0.537	228	Low	98.82	

*Not accounting for carbon present as soot.

[a]McDaniel, M. Flare Efficiency Study. Engineering Science, Inc. (NTIS No. PB-261644).

sulfide gas mixtures were tested on a small screening facility, and selected mixtures were analyzed on 3-inch pilot flare. Under stable flames, H_2S destruction efficiencies were found to be greater than 98 percent.

Remote Monitoring. Remote sensing uses the technique of examining the self-emitted electromagnetic energy from a gaseous pollutant for noncontact examination. The instrumentation involved in the remote sensing of flare emission utilizes spectroscopic principles to measure or analyze the interaction of light with the pollutants of interest. Spectroscopic techniques offer a potential means for the direct and continuous detection of pollutants in the gas phase without the need for intervening sampling apparatus.

Light waves are characterized by their wavelength and frequency. These waves exist in spectral regions ranging from gamma rays to microwaves. The spectral regions of primary concern in the remote sensing of refinery flare emission are the infrared and ultraviolet regions. Almost all major gaseous pollutants possess an infrared spectral signature, although for some species the ultraviolet spectral region affords greater sensitivity. Therefore, the presence of a given gaseous emission may be detected by looking for its characteristic band in the spectrum.

Consideration must be given to potential emission sources other than from the flare itself, such as radiance in the foreground, background, and the surrounding terrain or solar scattering. The relative contribution of each of the aforementioned items varies depending on the flare plume's temperature, gas concentrations, field of view, other contaminant sources in the area, and the solar angle. All remote monitors will be affected by background contaminant concentrations and any stray plumes that come between the monitor and the flare plume.

A major drawback to any remote monitoring device using UV or IR spectroscopy is that they are very sensitive to temperature. The UV and IR spectra produced by the compounds of interest consist of discrete bands of energy at certain wavelengths. In order to identify which compounds' band is being observed, it is necessary to know something of the temperature in order to determine its frequency and radiant intensity. Some methods do exist, however, to calculate the plume temperature based on the secondary characteristics of the spectral response or from plume modeling techniques. Another drawback to remote monitoring is the inability of any of the instruments to reliably detect H_2S at low concentrations because of its weak spectral response and the interference of water's spectral response.

All of the four types of instruments presented here have reported accuracies of about ±25 percent as compared to USEPA Method 6 when used on a steady-state powerplant stack.[1] No information is available on accuracy when used on a flare.

No oil refinery continuously monitors flare emissions by remote monitoring techniques. The survey respondents indicated that there is no commercially available instrument with the proven ability to continuously and accurately remotely monitor and measure flare emissions of SO_x, RS, or NO_x.

Instrumentation with the potential for remotely monitoring refinery flare emissions is presented below.

- <u>Matched Filter Correlation Spectroscope</u>. The matched-filter correlation spectroscope (MFCS), developed over 15 years ago, was one of the first commercially available remote sensing instruments for gaseous pollutants. Correlation spectroscopy is based upon the measurement of the degree of similarity between the molecular absorption spectrum of a chosen gas and the actual total absorption spectra of all gases seen by the instrument, a grating monochromator. The primary use of the instrument was to measure SO_2 and NO_2 by using scattered sunlight as the source of UV radiation. The MFCS, like other ultraviolet spectroscopic techniques, is restricted to daylight operation.

- <u>Gas Filter Correlation Radiometry</u>. Gas filter correlation radiometry (GFCR) is a single pollutant remote monitoring device which focuses the radiance of one constituent in a plume onto an infrared detector after being spectrally filtered and optically tuned at the desired frequency. This technique attempts to optimize measurement conditions for a particular combustion product.

  Although the GFCR technique can potentially be used for a variety of gases, test data are not available. Furthermore, no evidence was found of a GFCR used to specifically test refinery flare emissions.

  The EPA has had GFCR's built under contract for measurement of auto exhaust emissions and for in

---

[1] Herget, W. F., and W. D. Conner. Instrumental Sensing of Stationary Source Emissions. Environmental Science and Technology. October 1977.

situ smoke stack measurements. However, we were unable to find a GFCR which is commercially available.

- <u>Fourier Transform Infrared Spectrometer</u>. The Fourier transform infrared spectrometer (FTIR) potentially offers the capability of simultaneous, multipollutant remote monitoring. The basis of the FTIR operation is a light source telescope system which receives infrared signals from the flare plume. These signals are transmitted to an interferometer. The output of the interferometer is not directly usable for analysis; it must be Fourier transformed before it is recognizable as an infrared spectrum. In addition, the resultant spectrum must be "background" corrected and calibrated before it can be used to calculate emission gas concentrations, exit velocity, and flow data.

  The instrumentation can be operated by one person, and results can be determined while in the field. However, this device requires the support of a computer and has a total price of about $100,000, substantially more than other remote monitors.

  The EPA Remote Optical Sensing of Emissions (ROSE) system is a van-mounted, general purpose interferometer used for spectroscopic studies in the field. The ROSE system has been used for measuring a variety of pollutants in a variety of applications including monitoring CO and CO_2 from a flare at the CMA test facility. This test did not, however, attempt to measure SO_x, RS, or NO_x. Units are commercially available.

- <u>Ultraviolet Television</u>. The ultraviolet television (UVTV) system was developed in 1975 by the NASA/Langley Research Center. The UVTV produces a visible picture of the ultraviolet radiance where the plume appears darker than the background sky. UVTV has been used to monitor SO_2 emissions and velocity measurements for a variety of applications. The UVTV has the advantage of being able to measure effluent velocity by tracking fluctuations in the SO_2 concentrations as they move downstream. This can then be used to calculate total mass emission rates of SO_2.

  The UVTV system can be operated by one person, and results can be determined while in the field.

However, this instrument has not been used specifically for refinery flare emissions. The UVTV is limited to daytime use. UVTV's are currently available commercially and are most often used for low-temperature stack emissions.

The compliance division of the California AFB has purchased a Visiplume 121A Ultraviolet Absorption Television. The UVTV is scheduled to be delivered the first week of October 1985, and representatives will be at ARB in mid-October to conduct a training program.

The study revealed four instruments with the potential for measuring the concentrations of gaseous pollutants in a flare plume. Three of the instruments, the MFCS, the GFCR, and the UVTV, should give approximately the same results when monitoring SO_2. The ARB has specifically requested that the ultraviolet television be included in the design of a study to correlate SO_2 emissions as remotely monitored with those calculated from feed gas flowrate and feed gas sulfur content to the flare.

The FTIR has the potential to monitor SO_x and NO_x compounds. Although this system has not been tested specifically for these emission gases from a flare, the principles and methods of the FTIR system are well established, and the unit has been used in a number of field investigations.

Two instruments, the ultraviolet television and the Fourier transform infrared system, are recommended for further study.

D. STUDY DESIGN

D. STUDY DESIGN

As part of this investigation into the feasibility of continuous monitoring of refinery flares, ARB requested that studies be designed which might develop improved or new methods of determining emissions from refinery flares. Specifically, they asked that a study be designed for each of three categories: feed gas monitoring, refinery process monitoring, and remote monitoring. The studies designed for each of these categories are described below.

Emissions from refinery flares are presently estimated through the use of emission factors. Although limited improvements in existing emission factors could be made through on/off monitoring of refinery flares, a study was not designed for this type of monitoring. On/off monitoring is feasible and is presently in use at several refineries for monitoring internal operations.

1. STUDY 1 - FEED GAS MONITORING

The objective of the feed gas monitoring study is to attempt to demonstrate methods of continuously recording flowrates and compositions of feed gases to a refinery flare. Ideally, a correlation between feed gas conditions and actual flare emissions would be developed. To achieve the entire objective of this study will require an ambitious program. It is recommended that the ARB try to maximize the use of existing test facilities and flare emission monitoring programs to minimize costs.

The study design is described in three phases intended to be performed sequentially although portions of the other two studies may proceed in parallel with this study. Each phase is designed to provide a meaningful extension to the body of knowledge about flare emissions. This design allows ARB the flexibility to select those portions of the study that they feel require a level of effort that is appropriate for the amount of information received.

Two parameters are considered important in feed gas monitoring: feed gas flow and feed gas composition. Feed gas properties that are expected to have an impact on emissions were discussed earlier in this report. It was concluded that total sulfur and total reduced sulfur (RS), or an indicator of RS such as H_2S, were important feed gas parameters for prediction of SO_2 and RS emissions. It was also concluded that other gas properties such as nitrogen composition, heating value, and moisture content were probably much less important in determining emissions than were flare design and gas velocities. For this reason, no continuous monitoring of gas composition, other than total sulfur and H_2S, is contemplated.

Several proven devices are considered appropriate for continuous monitoring of H_2S and total sulfur in this application. Devices using ultraviolet absorption, lead acetate, gold film, and photoionization detection techniques are recommended for further investigation. H_2S can be measured directly by the these techniques. Total sulfur is measured by oxidizing or pyrolizing all sulfur compounds and using these techniques to detect the resultant SO_2 or H_2S. GC Technology is not recommended because of the availability of adequate dedicated devices which are less expensive.

Flow monitoring devices recommended for use in this study include pitot tubes, hot-wire anemometers, and ultrasonic flowmeters. Pitot tubes would be used as velocity calibration standards during the pilot study. Hot-wire anemometer and ultrasonic flowmeter techniques are the recommended mass flowrate detectors to be evaluated in the pilot and refinery tests.

Grab samples for constituent analysis will be taken during portions of the study to examine the composition of gas fed to the flare in the laboratory. Since rigorous online total constituent gas analysis would not be practicable or warranted in refinery feed gas monitoring, it is not included as part of the continuous monitoring study design.

It is recommended that the first step be a controlled pilot study using flow and composition monitoring devices co-located in a pilot flare feed header. This will demonstrate which devices are more reliable in a pilot flare environment. Using this experience, the design of actual refinery tests will be finalized to maximize information that can be obtained with minimum impact on refinery operation. Refinery tests will include attempts to monitor routine and emergency discharges to an actual refinery flare. Finally, the results of testing will be analyzed to determine if continuous flow and composition monitoring is practicable and, if so, what devices are the best candidates for such monitoring.

There are several good reasons to use a pilot facility for initial testing as compared to using an operating refinery:

- Refinery flares must be online at virtually all times, which means that any study that gathers data on an actual refinery flare must not interfere with the operability of the flare. A preliminary pilot test would allow an efficient, streamlined refinery study to be conducted, significantly reducing the amount of testing that would need to be done at an actual refinery installation.

- A pilot study will allow more controlled conditions to be used during testing. Gas flows and compositions can be monitored with good reliability. In an actual installation, if controlled gases were fed to a flare, there would always be the possibility that a process release would occur during testing and destroy the element of control and/or cause an overload of the flare capacity. If controlled feed gases were not added in a refinery study, there might be very long waits between flaring incidents, substantially prolonging the acquisition of data.

- The costs of feeding combustible gases to a flare increase with the square of the flare diameter. There is a strong cost incentive to take as much meaningful data as possible on smaller scale facilities.

Phase 1 - Pilot Plant Testing. This phase of study is designed to determine in a pilot unit the suitability of available feed gas flow and composition monitoring devices for application to the difficult problem of flare feed gas monitoring.

The selected flow and composition monitoring devices will be installed in a pilot facility where they can be compared against each other and known flows and composition in a controlled environment. Two potential facilities have been identified as candidates for testing the monitoring devices although neither facility has been contacted to discuss its willingness to participate in such a project. The two facilities are the John Zink Company's test facility in Tulsa, Oklahoma, and the EER facility located in Irvine, California.

The following tasks are involved in this pilot test:

- Selecting a suitable test facility and negotiating the cost of using the facility for testing.

- Procuring appropriate flow and composition monitoring devices and installing them in the test facility.

- Performing the test program. The program would consist of metering gases to the pilot flare at known, but widely varied, flowrates, compositions, and temperatures.

- The test matrix might include tests with gas mixtures of about four different molecular weights ranging from 10 to 60, at two different temperatures, and at three flowrates ranging from Mach numbers of about 0.01 to about 0.1.

- After testing, the results would be analyzed to determine which, if any, of the tested devices are suitable for continuous monitoring of flare feed gas flowrates and compositions. Criteria to be used for judging the devices include accuracy over the range of test conditions; precision, based on replicate runs; reliability; and ease of installation and maintenance. A technical memorandum will be written summarizing the results of Phase 1.

Phase 2 - Refinery Testing. In this phase, those flow and composition monitoring devices determined to be suitable in the pilot flare study would be installed in a flare at an operating refinery.

No refineries have been asked about the possibility of such testing; however, the study design is based on the assumption that a willing refinery could be located. The study is designed to minimize the impact on operations at the refinery, a feature that would certainly be important to refineries that consider allowing the study.

This study phase would attempt to monitor flare feed gas during "naturally occurring" flaring events in the refinery.

Ideally, this phase would also include simulated flaring events: feeding piped-in gases at known conditions to the refinery flare. However, this would be a very sensitive endeavor. The testing would need to be done at flowrates low enough that the flare capacity would not be significantly reduced in the event of a simultaneous process upset. Also, it may be difficult to find a suitable location in the flare header to add the gases. If gases were added upstream of the seal pot, the vapor recovery system may rob some of the gases, making the material balance difficult to close. Finally, the cost of piped-in gases would be significant in capital, operating, and liability costs.

Because of the difficulties involved in simulating flaring events in a refinery flare, the study design includes only monitoring of flaring events that occur in the refinery. It is recognized that this would require a longer study period to obtain a reasonable amount of data, but the simulation of flaring events does not seem practicable given the constraints identified above.

Performing this phase would involve the following tasks:

- Discuss the possibility of installing the gas flow and composition monitoring devices with candidate refineries and select the best candidate. The most suitable refineries would be those that have a large variety of processing units and have frequent releases to the flare.

- Procure appropriate gas flow and composition monitoring devices for the flare in the selected refinery. It is assumed that the monitoring from the pilot test can be used.

- Install the gas flow and composition monitoring devices at the refinery. The devices would be installed with automatic data logging equipment so the results of the study could be accumulated without operators onsite 24 hours per day. In addition, an automatic sampling device would be installed during the refinery flare gas monitoring task. The sampler would be programmed to draw a sample when flow to the flare is indicated. The sample would be collected in a gas sampling bag at a rate initially selected to fill the bag in about 10 to 15 seconds. If after 5 minutes there was continued flow to the flare, a second sample would be drawn. This process would be repeated until the flow to the flare ended or fell below a preset level. These samples would be analyzed at a laboratory as they were retrieved daily and would provide a calibration for gas composition measurements.

- Monitor the results of the study. Monitoring would include daily visits to the site to check the instruments for proper operation and to gather data. Monthly progress reports would be prepared to summarize the progress and to identify any problems encountered in the course of the monitoring. Although the total time period for monitoring would be determined dynamically based on continuing results, the level of effort for the study is projected to be 6 months of monitoring.

- Write a technical memorandum summarizing and analyzing the findings of the study. Draw conclusions, to the extent possible, regarding the practicality of monitoring feed gas flow to refinery flares.

Phase 3 - Correlation of Feed Gas Monitoring With Flare Emissions. Several studies have been attempted in the past, and at least one major study (EER) is in progress to directly measure the emissions from flares. Results and progress of these studies have been described earlier in this report. With the given state of the art, the accuracy of refinery flare emission estimates remains less than desirable.

The difficulties involved in measuring flare emissions have also been described earlier. These inherent difficulties cause any reasonable attempt at measuring flare emissions to be costly. As an example, the study performed by Chemical Manufacturers Association in 1982 cost about $200,000. The study was performed on pilot flares at the John Zink Company's facility in Tulsa, Oklahoma. The study addressed NO_x, CO, and total hydrocarbon emissions and used these parameters to estimate a hydrocarbon combustion efficiency for the flares. The study did not address sulfur compound combustion efficiency. The study was a major contribution to the body of knowledge about flare combustion efficiencies but cannot be readily extrapolated to combustion efficiencies in other situations.

The ongoing EER study being conducted in Irvine, California, has a reported budget of about $1,000,000 over a 5-year period. They have built a facility specially for testing of emissions from flares and have taken a very systematic approach to their study. It is possible that their results will be suitable for extending to refinery-scale flares.

It is recommended that ARB wait for results of the EER study and use those results in combination with the findings from the feed gas flow and composition investigations to develop better estimates about the extent and character of emissions from refinery flares.

The only activity recommended for flare emission monitoring is that progress of the EER study, and any other studies that may take place, be monitored for results that can be correlated with results of the feed gas monitoring study.

The feed gas information assembled in Phases 1 and 2 will be correlated with available flare combustion efficiency data such as developed at EER in an attempt to determine the likely extent of flare emissions in South Coast and Bay Area Air Quality Management Districts. This will represent a significant increase in knowledge about flare emissions as:

- It will be based on flow to flares located in California that meet applicable standards and are installed with vapor recovery systems in place. It is likely that the total feed rates are much lower in California than in the general population of refinery flares in the U.S. or the world.
- It will be based on a refinery which would tend to represent typical emissions from a general cross section of refineries.
- It will be based on feed gases from a refinery that uses a mix of crudes that is more typical of California refineries than the rest of the nation.

Having this more California-specific data on flare feed gas flow and character, combined with recent flare emission study results from other researchers (including results that will become available during the course of the feed gas monitoring study), will allow the development of much more reliable emission factors for California refinery flares.

2. STUDY 2 - REFINERY PROCESS MONITORING

Most refinery processing units are well instrumented to track the quantities of materials flowing in and out of each unit. In theory, this could provide the capability to determine by difference the amount of losses a process unit has and the resultant flow and composition of those losses, both liquid and gaseous. As previously discussed, using material balances to estimate flare emissions presents significant problems. These include the accuracy of material balances, the time frame involved with the balances, the inability to determine if the losses actually go the flare header or are lost in flanges, seals, etc., and the unknown effect of the vapor recovery system on flow and composition of gas to the flare.

If it is desired to pursue this study, material balance information available for each process unit in a refinery would be examined to see if it is of sufficient accuracy to determine the flare feed gas flow and composition by difference between inputs and outputs. These data would then be compared with those obtained from the feed gas monitoring equipment.

The overall objective would be to develop an emission factor for flares that is specific to the type of process units the flare serves. Thus, an attempt could be made to develop an emission factor for each refinery based on the types and capacities of processing units found in that refinery.

CH2M HILL does not recommend that this study be undertaken.

3. STUDY 3 - REMOTE MONITORING STUDY

The purpose of the remote monitoring study is to develop a testing protocol for correlating information available from remote monitoring technologies with actual emission from refinery flares. The remote monitoring study would use both direct emission monitoring data and feed gas data to examine the applicability of remote monitoring technologies to flare emission monitoring. Two systems were chosen for this study: a Fourier transform infrared spectrometer (FTIR) and, per ARB request, the Visiplume 121A ultraviolet absorption television.

The Visiplume monitoring system has already been budgeted by the ARB; therefore, additional capital costs will be minimal. The FTIR system was chosen from other remote monitors for several reasons. The FTIR has the potential to monitor SO_x and NO_x. An FTIR system (the EPA ROSE van) has been tested on a pilot flare and other sources. The equipment is commercially available.

The remote monitoring study consists of two separate phases: pilot testing and refinery testing. The pilot phase is designed to determine whether the remote monitoring systems can be calibrated to provide accurate information concerning known emissions from a pilot flare. It is also intended to determine the optimum operating conditions for remote monitoring systems and the effect of nonoptimum operating conditions on system output. Phase 1 is designed to be implemented simultaneously with ongoing feed gas monitoring and direct emission monitoring studies at a pilot flare facility. Potential savings in study costs could be realized if the pilot tests were conducted at the same time as the feed gas monitoring study, and experimental error could also be minimized.

The field testing phase is designed to determine the adaptability of remote monitoring systems to refinery conditions. Phase 2 requires the successful completion of Phase 1 and is designed to be implemented simultaneously with the feed gas monitoring study at an oil refinery.

<u>Phase 1 - Pilot Plant Testing</u>. After the appropriate equipment has been selected and obtained, Phase 1 is designed to be implemented at a pilot flare facility. The calibration of the Visiplume and FTIR systems requires the ability to determine actual emissions. This can be done through the control of sulfur content in the feed stream for SO_2 or by direct testing of emissions for SO_2 and NO_x. A key assumption in this study is that the UVTV and FTIR can interrogate the plume near enough the point of direct emissions testing that the concentration at the two points is identical.

The following summarizes the tasks involved with the implementation of Phase 1 for both systems.

- Procure appropriate FTIR remote monitoring equipment and schedule use of ARB's UVTV.

- Using manufacturer's recommendations, position the Visiplume and FTIR units in an optimal position. The system should be positioned such that sources of radiation other than the flare do not affect the operation of the instrument.

- Monitor the emissions from the pilot flare. The Visiplume UVTV will detect SO_2 and the FTIR will detect SO_2 and NO_x. These tests should be performed at the same time the flow and composition monitor studies are performed in order to test the equipment over a wide range of variables and to minimize experimental error.

- o Using the procedure discussed above use the Visiplume 121A and FTIR to measure the emissions of SO_2 and NO_x under nonoptimum conditions.
- o Compare the results of the remote monitoring of SO_x and NO_x with actual emissions.
- o Develop a technical memorandum summarizing the results of Phase 1.

Should Phase 1 results show that either or both of the remote monitoring systems can accurately determine the level of emissions from a pilot flare, then Phase 2 can be implemented on a full-scale refinery flare.

Phase 1 of the remote monitoring study should ideally take place simultaneously with the later stages of the pilot phase of the feed gas monitoring study to minimize costs and experimental error. In addition, for best results this study should not be implemented until the feasibility of direct emission measurements on a pilot flare has been demonstrated.

Phase 2 - Refinery Testing. This phase of the remote monitoring study is designed to determine if the monitoring systems that have the ability to accurately measure the emissions of a pilot flare can be used accurately on a full-scale refinery flare. Phase 2 should be implemented using only those remote monitoring systems that show satisfactory results in all steps of Phase 1 of this study.

The logistics involved in Phase 2 of the remote monitoring study are expected to be difficult. The field study must be done in an area where the flare is the sole source of emissions, in order to validate study results. Other sources within the refinery, as well as sources upwind of the refinery, may affect remote monitoring results. In addition, the study must be coordinated with refinery personnel. The feasibility of this has not been determined.

If Phase 2 is implemented, it should be done in conjunction with the feed gas monitoring study at an operating oil refinery. The FTIR system study is identical to the Visiplume system study. While the FTIR system can measure NOx emissions, it is impractical to attempt to correlate these emissions with feed stream information. Therefore, the accuracy of NOx monitoring cannot be determined on a full-scale refinery flare. The following summarizes the tasks involved with the implementation of Phase 2 for both systems.

- Determine the feasibility of monitoring the sulfur content in the flare feed gas stream. Much of this information should be obtainable from the feed gas monitoring study.

- Use the Visiplume 121A to study the position of the plume from the refinery flares under a range of weather, feed gas, and flame conditions to determine optimal positioning.

- Use the Visiplume to measure the emissions of SO_2 and the FTIR to measure SO_2 and NO_x emissions. Correlate the SO_2 data collected with the sulfur content in the feed stream. Compare the NO_x data collected to those calculated from emission factors and feed gas characteristics.

- Develop a technical memorandum summarizing the results of Phase 2.

4. COST ESTIMATE AND SCHEDULE

The cost estimates presented in this report have been prepared for guidance in project evaluation and implementation from information available at the time of the estimate. The final costs of the project will depend upon actual labor and materials costs, competitive market conditions, final project scope, implementation schedule, and other variable factors. As a result, the final project costs may vary from the estimates presented herein. Because of this, project feasibility must be carefully reviewed prior to making specific financial decisions to help ensure proper project evaluation and adequate funding.

The cost estimates presented herein have been developed from preliminary information without detailed plans or specifications. These costs are expected to be accurate within +40 to -20 percent. These percentages should be viewed as confidence limits and must not be confused with contingencies. Cost estimates were developed as follows:

- Major equipment costs were obtained by telephone quotations and survey information from suppliers or from other recent projects.

- Installation factors were applied to equipment costs to obtain estimates for direct field costs. These factors have been developed in-house based on similar projects.

- The cost of the Visiplume UVTV is not included.

Other pertinent assumptions regarding the capital cost estimates are:

- The EER or similar pilot test facility will be available for this study.
- Utilities, shelters, and access are existing to the battery limits.
- Sufficient plot area exists (site-specific plot plans were not developed).
- Costs for land, permits, taxes, insurance, and financial, legal, and administrative services were not included.
- No unusual site preparation or foundations are required.
- $150,000 is allocated for the gas flow and composition monitoring equipment.
- The gas flow and composition monitoring equipment can be reused in the refinery test portions of the study.
- The field personnel will be available in the local area of the test facilities and will require no extra living expenses.
- The project manager will not be from the test facilities areas and will require travel costs and living expenses while at the sites.
- Study 2, Refinery Process Monitoring, will not be performed.
- All costs are presented without contingency.

The proposed schedule as shown in Figure 3 was developed based on 2 months of field pilot testing and 6 months of field refinery testing. The tests are designed so that both the remote monitoring and the feed gas monitoring studies could occur simultaneously. Both tests will require an estimated 3 months to procure the needed equipment, make arrangements with the test facility for use, and install the necessary equipment. It was assumed that a minimum of a month would be necessary after the pilot test before the refinery test would begin.

FIGURE 3
SUGGESTED SCHEDULE
REFINERY FLARE EMISSION STUDY

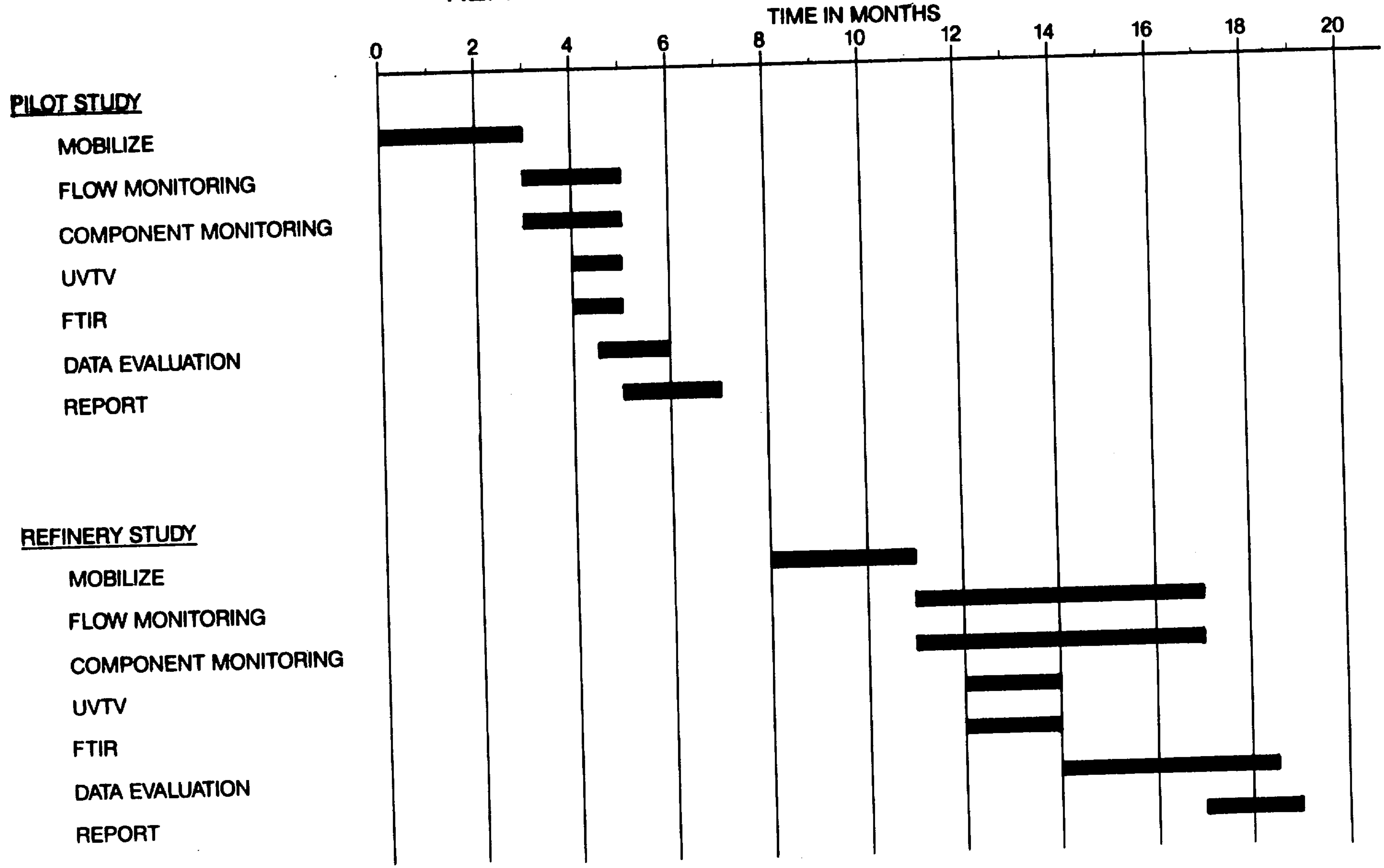

Table 8
ESTIMATED COSTS OF STUDIES

Study	Labor ($)	Equipment and Expenses ($)	Totals ($)
PILOT TEST			
o Feed Gas Monitoring	56,000	176,000	232,000
o FTIR/UVTV	24,000	106,000	130,000
REFINERY TEST			
o Feed Gas Monitoring	68,000	31,000	99,000
o FTIR/UVTV	44,000	11,000	55,000
		TOTAL	516,000

se5732/048/1

APPENDIX A

Appendix A
SUMMARY OF RELEVANT LITERATURE

1. Allen, A. D., H. H. Chan, and R. E. Wey. "Flare-Gas Recovery Success at Canadian Refineries." The Oil and Gas Journal. Volume 81; No. 26. June 27, 1983. Pp. 79-84.

This article discusses flare gas recovery systems that reduce the amount of gas flared at Shell's Canadian refineries. The composition of typical flare gases from two refineries is shown in Table A-1, taken from the article.

2. Coloff, S. G., M. Cooke, R. J. Drago, and S. F. Sleva. "Ambient Air Monitoring of Gaseous Pollutants. American Laboratory. July 1973. Pp. 10-22.

This article discusses the operational theory of devices that are used to monitor SO_2, CO, photochemical oxidants, hydrocarbons, and NO_2. The article has value as a generic discussion of air pollutant measurements but gives little insight into the problems associated with flare monitoring.

3. Davis, B. C. "U.S. EPA's Flare Policy: Update and Review." Chemical Engineering Progress. April 1985.

This article discusses current EPA flare policy and ongoing research programs. The article recommends the establishment of flame stability as the basis for determining whether a flare is efficient.

4. Exton, Reginald J. An Ultraviolet Video Technique for Visualization of Stock Plumes and for Measuring Sulfur Dioxide Concentration and Effluent Velocity. NASA Technical Paper 1014. 1977.

This paper details an investigation of absorption spectroscopy utilizing a video sensing technique as a means of visualizing SO_2 concentrations and effluent velocity. The absorption of SO_2 is measured in the ultraviolet region by using the sky (scattered sunlight) as a background source. It was concluded that the video absorption technique is an attractive method for remotely determining both SO_2 concentration and plume velocity with the same instrument.

Table A-1
TYPICAL REFINERY FLARE GAS COMPOSITION

	Refinery A 1977	Refinery B 1978
Nitrogen	4.4	3.0
Carbon dioxide	0.5	1.2
Carbon monoxide	0.5	0.4
Hydrogen	31.8	35.3
Hydrogen sulfide	2.1	3.0
Methane	15.4	23.3
Ethane	11.4	3.5
Ethylene	1.0	0.7
Propane	11.0	8.3
Propylene	5.4	3.6
Butane	9.3	9.8
Butylene	2.1	1.8
Pentane	3.8	4.2
Hexane (etc.)	1.0	1.9
Total	100.0	100.0
Mole wt	26.5	24.7
Low heating value (Btu/scf)	1340	1250
High heating value (Btu/scf)	1465	1370

5. Haust, P. L., J. A. Hodgeson, and W. A. McClenny. "Air Pollution Monitoring by Advanced Spectroscopic Techniques." Science. Volume 82. October 19, 1973.

This article discusses the current and future role of spectroscopic methods in meeting the requirements for the measurement of air pollutants in the gas phase. The article concludes that there are individual techniques which are capable of measuring a single pollutant or group of pollutants; however, there is no single spectroscopic technique or instrument that fulfills all monitoring needs.

6. Herget, W. F. Air Pollution: Ground-Based Sensing of Source Emissions in Fourier Transform Infrared Spectroscopy. J. R. Feraro and L. J. Busile, eds. Academic Press. 1979.

This study discusses Herget's ongoing research into the feasibility of using a ground-based Fourier transform infrared spectrometer to sense source emissions. At the time the report was written, the FTIR system had not been used on flares. The remote monitoring of flare emissions using an FTIR system was first studied in 1983. An FTIR system is included in the remote monitoring study in this report.

7. Herget W. F. "An Overview of the EPA Programs for Ground-Based Remote Sensing of Air Pollutants." SPIE Vol. 195. 1979.

This paper discusses two instruments, a mobile lidar system for plume opacity measurements and a mobile Fourier transform interferometer system for multiple gas concentration measurements, in routine use in the EPA remote sensing program. Laser Doppler velocimeter gas-filter correlation, ultraviolet television, and infrared television are also discussed as potential instruments under evaluation for surveillance or enforcement activities.

8. Herget, W. F., and J. D. Brasher. "Remote Fourier Transform Infrared Air Pollution Studies." Optical Engineering. Volume 19, No. 4. 1980. Pp. 508-514.

This article discusses the EPA ROSE (Remote Optical Sensing of Emissions) System, a commercial Fourier transform interferometer system installed in a van, used to make long-path absorption and single-end emission measurements of gaseous concentrations at a variety of pollutant sources. This paper described the interferometer system and results of recent measurements of jet engine, brick kiln, gypsum pond and industrial stack emissions.

9. Herget, W. F., and J. D. Brasher. "Remote Measurements of Gaseous Pollution Concentrations Using a Mobile FTIR System." Applied Optics. Volume 18. October 1979. Pp. 3402-3420.

This article gives a detailed description of the EPA ROSE system including a description of equipment used, system calibration, and system operation. In addition, examples of the spectral data collected and complete descriptions of measurements taken at a number of different types of pollutant sources are included.

10. Herget W. F., and W. D. Conner. "Instrumental Sensing of Stationary Source Emissions." Environmental Science and Technology. Vol. 11, No. 10. October 1977.

This article discusses and compares five methods of remote monitoring: infrared gas-filter correlation radiometry (GFCR), Fourier transform infrared spectoscopy, ultraviolet matched-filter correlation spectroscopy (MFCS), infrared television (IRTV), and ultraviolet television (UVTV).

11. Joseph, D., J. Lee, C. McKinnon, R. Payne, and J. Pohl. Evaluation of the Efficiency of Industrial Flares: Background Experimental Design--Facility. Energy and Environmental Research Corp. Irvine, California. August 1983.

This report provides a discussion of the experimental design and the design of test facilities for a research program to attempt to quantify the emissions from and the efficiencies of, industrial flares. Of particular value in the report is a fairly detailed discussion of the current state of knowledge concerning refinery flare emissions.

12. Kildal, H., and R. L. Byer. "Comparison of Laser Methods for the Remote Detection of Atmospheric Pollutants." Proc. IEEE. Volume 50, No. 23. December 1971. Pp. 1645.

This article discusses and compares three laser methods of remote air pollution detection. Raman backscattering, resonance backscattering, and resonance absorption. Theoretical expressions are derived for the minimum detectable pollutant concentration, and in each case the depth resolution and the problems of interference, pump depletion, and background noise are discussed. Also included is a discussion of possible laser sources and numerical examples of the detectabilities based on present technology.

13. Klett, M. A. "Refinery Flare Loading and Emissions Probed." The Oil and Gas Journal. Volume 77, No. 36. September 3, 1979. Pp. 108-110.

This article discusses refinery flaring practices for 1973 to 1974. Results are based upon survey responses from 17 refineries located nationwide. Data are given on estimated feed gas concentrations and on estimated flare emissions.

14. Lengella, A., and L. Verdier. Gas Sampling and Analysis in Combustion Phenomena. NATO Advisory Group for Aerospace Research and Development. AGARDograph No. 168. July 1973.

This article discusses methods of gas analysis including gas phase chromatography, mass spectrometry, and chemical analysis by absorption of electromagnetic radiations. The document is geared primarily toward the aerospace industries. It does not discuss applications to open flames such as flares.

15. McDanial, M. Flare Efficiency Study. Engineering Science, Inc. (NTIS No. PB-261644).

This report summarizes a flare efficiency study conducted by ESI at the John Zink Company in June 1982. Flares were found to be greater than 98 percent efficient when operated under normal industrial conditions. The test procedure involved the use of an extractive sampling device suspended over the flare by support cables and a hydraulic crane.

16. Measures, R. M. Laser Remote Sensing--Fundamentals and Applications.

This report discusses laser remote sensing of gaseous pollutants. This report concludes that lidar systems can be used to undertake pollution surveillance measurements as well as map the dispersion of trace pollutants from various kinds of emission sources.

17. Millan, M. M., S. J. Townsend, J. Davies. Study of the Barringer Refractor Plate Correlation Spectrometer as a Remote Sensing Instrument. University of Toronto Institute for Aerospace Studies, UTIAS Report No. 146.

This report discusses the study of the Barringer refractor plate remote sensor which utilizes correlation spectroscopy. An evaluation of the instrument's performance includes a discussion of the mechanical, electrical, and optical behavior of the spectrometer.

18. Persky, M. J. and R. L. Spellicy. Flare Efficiency Monitoring by Remote Infrared Sensing: A Feasibility Demonstration. Optimetrics, Inc. Final Report. 1984.

This report gives the results of an evaluation of the use of passive infrared (IR) methods to remotely monitor the efficiency of a flare. The EPA ROSE (Remote Optical Sensing of Emissions) system, a Fourier transform infrared (FTIR) system, was used to observe the gaseous exhaust products from a small-scale industrial flare under a wide range of conditions. The study indicates that IR methods are applicable to the problem of combustion efficiency monitoring. Recommendations for additional work to improve and verify the methodology were also included in the report.

19. Pohl, J. H., R. Payne and J. Lee. Evaluation of the Efficiency of Industrial Flare: Test Results. Energy and Environmental Research Corporation. 1984.

This document is a continuation of the research program first presented by Joseph et al. in 1982. The report presents measurements of the combustion efficiency of large pilot-scale flares. These results were correlated with a ratio

factor relating the heating value of the gas with that needed to maintain a stable flame. Other parameters studied included flame length, entrainment into the flame, and lift-off distances.

20. Pohl et al. Evaluation of the Efficiency of Industrial Flares - Flare Head Design and Gas Composition, Energy and Environmental Research Corporation, Irvine, California. 1985.

This report discusses the continuation of EER's research into flare efficiencies and emissions. This phase of the program takes the parameters derived in previous reports and examines the effect on flare emissions of variations in flare head design and gas composition.

21. Prengle, W. H., et al. "Infrared Remote Sensing and Determination of Pollutants in Gas Plumes" Environmental Science & Technology Vol. 7, No. 5. May 1973.

This article presents the results of work on the application and development of quantitative methods for the determination of pollutants from emission source by remote sensing combining intrated rediometry and spectroscopy.

22. Romano, R. R. "Control Emissions with Flare Efficiency." Hydrocarbon Processing. Volume 62, No. 10. October 1983. Pp. 78-80.

This article discusses an EPA and Chemical Manufacturers Association project to quantify flare efficiencies under differing operating conditions. A single extractive probe was suspended by crane above the flame. Flares were found to be over 98 percent efficient when operated under normal industrial conditions.

23. Schmidt, T. R. "Ground-Level Detector Tames Flare-stack Flames." Chemical Engineering. April 11, 1977.

This article discusses Shell Development Company's use of an optical radiation sensor coupled to the flare gas control system to proportion steam injection that promotes clean, smokeless combustion. This system measures the radiant-heat energy from base of the flame with a ground-level sensor and sends a signal back to the control valve which proportions the steam flow. This system has been used in various operations ranging from a ground-level flare to a flare stack 350 feet high.

24. Seebold, J. A. "Practical Flare Design." Chemical Engineering. December 10, 1984.

This article discusses some of the design considerations associated with flare installation and operation. The article provides some general discussion of industrywide flaring practices.

25. Smalling, J. W., L. D. Braswell, L. C. Lynnworth, and D. Russell Wallace. "Flare Gas Ultrasonic Flor Meter." Proceeding of the Thirty-Ninth Annual Symposium on Instrumentation for the Process Industries. Department of Chemical Engineering of Texas A&M University. 1984.

This article describes an ultrasonic flowmeter that has been developed to measure flow velocity, sound speed, and mass flowrate of petrochemical and refinery flare gases. The flowmeter described has the ability to detect extremely low velocity flow and has a rangeability of 1000:1.

26. Straitz, J. F., III. "Make the Flare Protect the Environment." Hydrocarbon Processing. October 1977.

This article discusses the design and operational considerations associated with flares. Included in the article was a brief discussion of measurements done on a pilot-scale flare which gave a +99 percent combustion efficiency. These measurements for unburned hydrocarbons were taken at the tip of the visible flare flame.

27. Wormhoudt, J., ed. Infrared Methods for Gaseous Measurements: Theory and Practice. New York. Marcel Dekker, Inc. 1985.

Chapter 1 of this book discusses the detailed modeling of the Fourier transform infrared (FTIR) emission spectrum of a waste gas flare. An assessment of the sensitivity of remote high-resolution infrared emission measurements to source parameters such as temperature, molecular species concentrations, soot loading, and dimensional scale was made.

28. Wu, Chung-you. "Are Your Flare Systems Adequate." Chemical Engineering. October 31, 1983.

This article discusses methods for ensuring that flare systems are adequate for expected loadings. The article offers insight into flare operations, but it contains no information regarding flare monitoring.

29. Characterization of the EPRI Differential Absorption Lidar (DIAL) System. SRI International CA. December 1979.

This article discusses a study conducted on the Electric Power Research Institute (EPRI) Differential Absorption Lidar (DIAL) system. The lidar system was used to measure NO_2.

The measurements were found to agree with the inside monitors operated by other agencies.

30. No Author Given. "The War on Pollution." The Oil and Gas Journal. June 15, 1970.

The article discusses, in very general terms, the contribution to air pollution from oil refineries. Much of the article is devoted to automobile emissions and their effect on the environment.

APPENDIX B

Letter to feed stream monitoring
equipment suppliers

CH2M HILL Engineers Planners Economists Scientists

July 1, 1985

M19581.B0

Dear Sirs:

CH2M HILL is conducting a study for the California Air Resources Board to determine the availability of feasible, cost-effective devices to continuously monitor refinery flares. Flare monitoring could include monitoring emissions from flares, monitoring gases going to the flares, or simply monitoring to determine whether the flare is on or off.

To be considered applicable for refinery flare monitoring, a device must be able to withstand exposure to the conditions of the feed gas system for all potential operating parameters, including variations in the temperature, moisture content and pH of the feed gas stream. A feed gas flow or composition monitor would be exposed to high concentrations of various hydrocarbons and sulfur compounds. Water vapor and nitrogen would be expected to make up to zero to 10 percent of the gas flow. Under rare operating conditions, hydrogen sulfide concentrations of up to 50 percent may be flared.

In addition, because flares generally function as emergency release devices, a flow or composition monitor must not diminish the flow-through capacity of the flare or of any feed lines that run to the flare. A monitoring device may be placed on the flare feed line itself or on each of the lines leading from the process units to the flare feed line.

On behalf of the California ARB, we are contacting firms that may be able to supply equipment that can monitor flow or composition of feed gases to refinery flares. Please provide us with information on the following questions.

1. Are any of the devices manufactured by your firm capable of continuously monitoring the gas feed rate to a flare without obstructing the gas flow? If so, please describe these devices.

2. Do the flow measuring devices described require calibration for specific gases? If so, can they be recalibrated by refinery personnel?

3. Are any of the devices manufactured by your firm capable of continuously monitoring the composition of a flare

CH2M HILL, INC. Seattle Office 1500 - 114th Ave. S.E., Bellevue, Washington
P.O. Box 91500, Bellevue, Washington 98009-2050 206.453.5000

feed stream without obstructing the gas flow. If so, please describe these devices.

4. Are the composition monitoring devices described in question 3 capable of performing any of the following functions:

   - Detecting the presence of sulfur
   - Quantifying the amount of sulfur present
   - Detecting the presence of hydrocarbons
   - Differentiating between specific hydrocarbon compounds
   - Quantifying the concentration of hydrocarbons present
   - Detecting the presence of nitrogen compounds
   - Quantifying the concentration of nitrogen compounds present

Please include any appropriate technical information, including information on costs and availability of the equipment discussed.

Please mail responses to:

CH2M HILL
1500 114th Avenue SE
P.O. Box 91500
Bellevue, Washington 98009-2050
Attn: Ed Powell

We appreciate your assistance in this study.

Sincerely,

Ed Powell

Ed Powell
Air Quality Engineer

lw:se5703U

Letter to emission monitoring suppliers

CH2M HILL

Engineers
Planners
Economists
Scientists

July 1, 1985

M19581.B0

Dear Sirs:

CH2M HILL is conducting a study for the California Air Resources Board to determine the availability of feasible, cost-effective devices to continuously monitor refinery flares. Flare monitoring could include monitoring emissions from flares, monitoring gases to the flares, or simply monitoring to determine whether the flare is on or off.

Emission monitoring of refinery flares presents unique technical difficulties due to the configuration of most flares and the intermittency of the flame. Refinery flares in operation today are elevated for safety reasons. Most flares do not operate continuously and, during operation, the location of the flame is not constant. The flame length and the temperature and orientation of the flame may vary due to the composition of the flared gases, the amount of gas flared, and ambient meteorological conditions. To be considered applicable for flare emission monitoring, a device must be able to compensate for these variable conditions or must provide refinery personnel with the ability to compensate.

On behalf of the California ARB, we are contacting firms that may be able to supply equipment that can monitor flare emissions. Please provide information on the following questions.

1. Does your company provide equipment that is capable of directly or remotely monitoring any air contaminant emissions from refinery flares?

2. Has your company ever supplied equipment for the direct or remote monitoring of emissions from refinery flares that was successfully installed and operated?

Please provide information on availability and cost of this equipment and any appropriate technical information.

CH2M HILL, INC. Seattle Office 1500 - 114th Ave. S.E., Bellevue, Washington
P.O. Box 91500, Bellevue, Washington 98009-2050 206.453.5000

Please mail responses to:

CH2M HILL
1500 114th Avenue SE
P.O. Box 91500
Bellevue, Washington 98009-2050
Attention: Ed Powell

We appreciate your assistance.

Sincerely,

Ed Powell

Ed Powell
Air Quality Engineer

lw:se5703T

CH2M HILL
Engineers
Planners
Economists
Scientists

July 2, 1985

M19581.B0

Dear Sirs:

CH2M HILL is conducting a study for the California Air Resources Board to determine the availability of feasible, cost-effective devices to continuously monitor refinery flares. Flare monitoring could include monitoring emissions from flares, monitoring gases going to the flares, or simply monitoring to determine whether the flare is on or off.

Because flares present unique monitoring difficulties, we are surveying flare manufacturers to determine if any are aware of any monitoring that may have been implemented on their flares. It is believed that flare manufacturers may be able to provide insights into the problems associated with flare monitoring not available from other sources.

Please provide us with information on the following questions.

1. Do you provide monitoring equipment with your flares to continuously determine if they are on or off? Do you know of anyone who has successfully installed monitoring equipment on one of your flares to continuously determine if it is on or off? If so, please describe monitoring methods. Are any of these methods more accurate or reliable than the others?

2. Are you aware of any continuous gas flow measurement devices that have been successfully used to monitor the gas feed rate to flares manufactured by your company? If so, please describe typical devices and manufacturers. Are any of these devices more accurate or reliable than the others?

3. Are you aware of any successful attempts to quantify the combustion efficiency of flares manufactured by your company? If so, can the emissions of carbon monoxide, oxides of nitrogen, oxides of sulfur, and particulate matter be quantified or related to combustion efficiency?

CH2M HILL, INC. Seattle Office 1500-114th Ave. S.E., Bellevue, Washington
P.O. Box 91500, Bellevue, Washington 98009-2050 206.453.5000

4. Are you aware of any successful attempts to monitor the emissions from flares of the pollutants forementioned through the use of direct or remote monitoring techniques? Has your company investigated the use of such monitoring techniques on flares? If so, please discuss the results of such an investigation.

Please include any appropriate technical information, including cost and availability of the monitoring equipment if known.

Please mail responses to:

CH2M HILL
1500 - 114th Avenue SE
P. O. Box 91500
Bellevue, Washington 98009-2050
Attn: Ed Powell

We appreciate your assistance.

Sincerely,

Ed Powell

Ed Powell
Air Quality Engineer

pa/se5703V

Appendix B

Table B-1

MANUFACTURER'S SURVEY--NO RESPONSE

ACO Pacific, Incorporated
AGF Incorporated
Acme Engineering Products, Incorporated
Acoustic Emission Leak Locators, Corporation
Acoustic Emission Technology Corporation
Accuracy Systems, Incorporated
Accusonic Division, ORE Incorporated
Acurex Corporation, Source Evaluation and Analysis Division
Advanced Dynamics
Advanced Systems Division, Mine Safety Appliances Company
Aerodyne Controls Corporation
Aerodyne Products Corporation
Aerzen USA Corporation
Air Dimensions, Incorporated
Air Monitor Company
Airco Industrial Gases, Division of Airco, Inc.
Allen Test Products Division, The Allen Group, Inc.
Allied Corporation
Ambi, Incorporated
American Bristol Industries
American Meter, The Singer Company
American Sigma, Incorporated
American Surplus Trading
Ametek, Incorporated, Schutte and Koerting Division
Analect Instruments, Division of Laser Precision Corporation
Andros Analyzers, Inc.
Antares Engineering Incorporated
Antek Instruments, Inc.
Applied Materials, Inc.
Arcco Instrument Company, Incorporated

Atomic Products Corporation
Aurora Technical Services, Limited
Autocon, Inc., Subdivision of Camco, Inc.
Automated Valve Systems, Incorporated
Avicon Corporation

BGI Incorporated
B & L Industries
BPN Associates Incorporated
BVS Incorporated
Baird Corporation
Baseline Industries
Basic Environmental Engineering, Incorporated
Becker, J. L., Company
Belmar Safety Equipment, Incorporated
Bentley Nevada Corporation
Biogas of Colorado, Incorporated
Bio-Gas Detector Corporation
Bowers, Daniel L. Company, Incorporated
Brooks Instrument Division, Emerson Electric Company
Byron Instruments Incorporated
Burrell Corporation
Butler Controls

CCS Communications Control Incorporated
CEA Instruments, Incorporated
CSE Corporation
CSI
CS_3 Incorporated
Cadillac Meter Company
Calibrated Instruments, Incorporated
California Alloy Company
Cambridge Filter Corporation
Campbell, J. A., Company
Cardinal Controls, Incorporated
Catalyst Research Corporation

Centent Company
Chatham Controls Corporation
Chatlos Systems, Incorporated
Check-It Electronics Corporation
Chem-Tec Equipment Company
Chicago Pneumatic Tool Company
Cimex Company, Incorporated
Clarktron Products Incorporated
Cleveland Controls, Incorporated
Climatronics Corporation
Clippard Instrument Laboratory, Incorporated
Coen Company
Columbia Scientific Industries Corporation
Combustion Engineering, Incorporated
Computer Instruments Corporation
Com-Trol Incorporated
Contraves-Goerz Corporation
Control Instruments Corporation
Controlled Energy Systems Corporation
Controlled Environment Equipment Corporation
Controlotron Corporation
Crane/Pro-Tech Instrument
Curieco

D & G Industries
Daniel Industries, Incorporated
Datatest, Incorporated
Delphian Corporation
Delta F. Corporation
Demaray Scientific Instrument Ltd.
Despatch Industries Incorporated
Devco Engineering Incorporated
Developmental Sciences, Incorporated
Dexter Research Center, Incorporated
Dieterich Standard Corporation

Diversified Electronics, Incorporated
Dresser Industries, Incorporated
DuPont Company, Instrument Systems
Dynadyne, Incorporated
Dynamation Incorporated
Dynasonics, Incorporated

EG&G, Environmental Equipment Division
ERDCO Engineering Corporation
Ebtron, Incorporated
Eck & Krebs Scientific Laboratory Glass Apparatus, Inc.
Econics Corporation
Electro-Flow Controls, Incorporated
Energetics Science
Energy Efficiency Systems
Energy Technology & Control Corporation
Engineered Products Company
Enterra Instrumentation Technologies
Environmental Systems, Division of Environmental
Tectonics, Corp.
Envisage Environmental, Incorporated
Epcon Industrial Systems, Incorporated
Ernst, John C., Company, Incorporated
Evapograph
Extranuclear

Fischer and Porter Company
Fisher Controls International, Incorporated
Fisher Scientific Company
Flaregas Corporation
Flow Engineering Systems Division
Fluid Data, Incorporated
Fox Valve Development Corporation
Foxboro Analytical--ARCAS
Foxboro Company, The
Fuel Efficiency, Incorporated

GC Industries, Incorporated
GCA Technology Division
G-R Electric Manufacturing Company
G.T. Acoustical Technologies
Garsite Products, Incorporated
Gas Tech, Incorporated
Gas Technologies
Gateway Scientific Incorporated
General Electric Company
Geomet Technologies, Incorporated
Gollob Analytical Service
Goodway Tools Corporation
Gow-Mac Instrument Company
Gulton Industries

HTE Incorporated
Hague International
Hamilton Company
Hays Fluid Controls Division, Zurn Industries, Incorporated
Hays-Republic Corporation
Hitran Corporation
Hoffer Flow Controls
Horiba Instruments, Incorporated
Houston Atlas Incorporated
Hydronics Engineering Corporation

IFD Technology
ION Track Instruments, Incorporated
Ideal Gas Products, Incorporated
Independent Equipment Corporation
Industrial Diagnostic Systems & Services
Industronics Incorporated
Instrumentation Laboratory Incorporated
Integrated Flow Systems, Incorporated

International Ecology Systems Corporation
Interscan Corporation
Inventron Industries, Incorporated

JPC Consultants
Jerman Waterworks Supply Company
Jordan Valve, Division of Richards Industries, Incorporated

KLD Associates, Incorporated
KVB Incorporated
Kay-Ray, Incorporated
Kelleher, Kelleher & Thompson
Kemco Engineering Corporation
Kent Meter Sales Incorporated
Kernco Instruments Company, Incorporated
Kessler, Walter H., Company, Incorporated
Kin-Tek Laboratories Incorporated
Krohne-America Incorporated

LND, Incorporated
Labeco-Laboratory Equipment Corporation
Lab Safety Supply Company
Law, R. E., Instrument Incorporated
Lear Siegler, Incorporated
Leco Corporation
Lesker, Kurt J., Company
Liebert Corporation
Liquid Controls Corporation
Liston, Edwards Incorporated
Lotel Incorporated
Lumidor Safety Products/E.S.P., Incorporated
Lynn Products Company

MDT Corporation
MEECO
MKS Instruments, Incorporated
M and W Systems
Magnetics & Controls, Incorporated
Maloney Crawford Corporation
Manchester Corporation
Manning Technologies, Incorporated
Marlow Industries Incorporated
Mast Development Company
Mateson Chemical Corporation
Matheson Gas Products
Max Machinery, Incorporated
Maxon Corporation
McFarland TTN Corporation
McGill, Incorporated
McLoughlin Industries, Incorporated
Medicor, Incorporated
Med-Science Electronics, Incorporated
Metrix Instrument Company
Micrographic Technology, Incorporated
Microsensor Technology Incorporated
Microwave Sensors, Incorporated
Mock, Clif., Company, Incorporated
Modern Engineering Company, Incorporated
Monitek, Incorporated
Monitor Labs Incorporated
Moore Products

NAPP, Incorporated
NGS Associates Incorporated
NL Industries, Incorporated
NUS Corporation
National AirOil Burner Company, Incorporated
Neotronics N.A., Incorporated

Neutronics, Incorporated
New Brunswick Scientific Company
New Jersey Meter Company, Division of Motomco, Incorporated
Niagara Scientific Incorporated
Noral, Incorporated
Northwest Laboratories of Seattle, Incorporated
Nova Analytical Systems, Incorporated
Nuclear Research Corporation

Occupational Health & Safety Products
Omega Engineering, Incorporated, An Omega Group Company
Orange Research, Incorporated
Orbisphere Laboratories
Orion Research, Incorporated
Oxbridge, Incorporated
Oxequip Health Industries
Ozone Research & Equipment Corporation

PCI Ozone Corporation
PACI Incorporated
Pal General, Incorporated
Pan American Systems Corporation
Pas Engineering Incorporated
Peabody Engineering Corporation
Perkin-Elmer Corporation, Applied Science Division
Perkin-Elmer Corporation, Instrument Group
Perry Equipment Corporation
Photomation Incorporated
Phys-Chemical Research Corporation
Plant Specialties, Incorporated
Polysonics Incorporated
Power Plus Corporation
Precision Flow Devices, Incorporated
Prime Manufacturing Corporation
Princeton Sensors, Incorporated

Process & Instruments Corporation
Pump Measure Control, Incorporated
Puregas, General Cable Apparatus Division
Puritan-Bennett Corporation

Quality Control Equipment Company

RSAI/RADECO
Radian Corporation
Radiomatic Instruments
Radiometer America, Incorporated
Ramcon Environmental Corporation
Ramsey Lake Industrial Ltd.
Rees-Memphis
Research Appliance Company
Robertshaw Controls Company, Control Systems Division
Robertshaw Controls Company, Industrial Instrumentation Group
Rockwell International Corporation
Rolfite Company
Rolock, Incorporated
Rosemount Incorporated
Royce Equipment Company, Combustion & Monitoring Systems Division

Salwico, Incorporated
Sam, Dick Industries, Incorporated
Sampo Corporation of America
Sargent-Welch Scientific Company
Scanivalve Corporation
Schmidt Instrument Company
Science Pump Corporation
Scientific Gas Products Ashland Chemical Company
Scientific International, Incorporated
Scott Aviation, A Division of A-T-O Incorporated

Sensor Manufacturing Corporation
Sensors, Incorporated
Serv-I-Quip, Incorporated
Severn Science Ltd.
Sieger Gasalarm
Sierra Instruments, Incorporated
Sierra-Misco, Incorporated
Sierra Monitor Corporation
Signet Scientific Company
Sinclair Scientific Incorporated
Sirco Products Ltd.
Smith Meter Division, Geosource Incorporated
Sohio Predictive Maintenance Services
Sonic Development Corporation
Sparton Corporation
Sperry Corporation Flight Systems
Stauff Corporation
Suburban Gas & Engineering
Sweet, J. W., Company
Sybron Analytics

TOTCO Division
Tech-Line Instruments
Technical Services, Incorporated
Texas Instruments, Incorporated
Texas Nuclear
The Stackmatch Company, Incorporated
Theta Sensors Incorporated
Thermal Instrument Company, Incorporated
Thermco Instrument Corporation
Thermo Electric Company, Incorporated
Thermo Electron Instruments
Thermometrics, Incorporated
Thermotron Industries
Tideland Signal Corporation
Timeter Group

Tracor, Incorporated
Twin Rivers Engineering, Incorporated
Tylan Corporation

UTI Instruments Company
Ulvac North America Corporation
Uniloc Division, Rosemount, Incorporated
United Titanium, Incorporated
Universal Flow Monitors, Incorporated
Universal Sensors & Devices

Valco Instruments Company
Valmont Industries Incorporated
Varian Associates
Varian, Palo Alto Instrument Division
Veco International, Incorporated
Vermont Automation Company, Incorporated
Versa Products Company, Incorporated
Vickery-Simms, Incorporated, A Standco Company
Victoreen, Incorporated

Ward International
Warren Automatic Tool Company
Warren Communication, A Unit of General Signal
Waters Associates
Wet Tip Gas Meter Company
Witcar Industries, Incorporated

Yokogawa Corporation of America

Table B-2

MANUFACTURER'S SURVEY--

RESPONSE WITH NO PERTINENT INFORMATION

American Gas & Chemical Company, Ltd.
Ametek, Thermox Instruments Division
Anderson Samplers, Incorporated
Automation Products, Incorporated

Barnant Corporation
Baush & Lomb (now Milton-Roy)
Bendix Aerospace, Environmental Systems Division
Brailsford & Company, Incorporated
Bristol Babcock, Incorporated
Bristol Engineering Company
Bruel & Kjaer Instruments, Incorporated

Chemical Process Equipment
Cosa Instrument Corporation

Del Mar Scientific, Incorporated
DeZURIK, A Unit of General Signal
Dionex
Dwyer Instruments, Inc.
Dynatron, Inc.

ENMET Corporation
Edwards Engineering Corporation
Engelhard Industries

General Monitors, Incorporated

Hazards Research Corporation
Hewlett Packard

IMC Instruments, Incorporated
ITT Barton Instruments
Industrial Air Products
Industrial Safety and Security Company
International Sensor Technology

Jacoby-Tarbox Corporation
Japan Electric Manufacturers Agency, Incorporated

Kaye Instruments, Incorporated

Lockwood & McLorie, Incorporated

MDA Scientific, Incorporated
MG Industries
Meter Equipment Manufacturing, Incorporated
Monitor Manufacturing

National Draeger, Incorporated

Pacer Industries, Incorporated
Panasonic
Physical Acoustics Corporation
Pierberg
Powers Process Controls
Process Combustion Corporation

Racal Airstream, Incorporated
Rexnord, Gas Detection Products

SKC-West, Incorporated
Safety Equipment Company
Sirchie Finger Print Laboratories
Sparling Instruments Company, Incorporated
Staplex

Teledyne Geotech
Temescal, A Division of the BOC Group, Incorporated
The Balancing Company, Incorporated

United Technologies/Bacharach, Incorporated

Vacuum General
Vitec

Wager, Rogert H., Company, Incorporated
Wallace Fisher Instrument Company, Incorporated
Waukee Engineering Company
Western Enterprises
Wisa Precision Pumps, USA, Incorporated

Xertex Corporation

Table B-3

MANUFACTURER'S SURVEY
RESPONSE WITH PERTINENT INFORMATION

FLOW MONITORING

Agar Instrumentation

Badger Meter
Bailey Controls Company
Barton Instruments

Electronic Flo-meters, Incorporated

Flow Technology
Fluid Components, Incorporated

Halliburton Services

J-TEC Associates, Incorporated

Kurz Instruments, Incorporated

Leeds and Northrup Company

Neptune Measurement Company

Panametrics

Ramapo Instrument Company, Incorporated

Teledyne Hastings-Raydist
Thermal Instrument Company

CONSTITUENT MONITORING

Analytical Instrument Development, Incorporated
Analytical Instruments Corporation
ANARAD, Incorporated
Astro Resources International Corporation

Beckman Industrial

CVC Products

HNu Systems, Incorporated

Inficon (Leybold-Heraeus, Incorporated)
Infrared Industries, Incorporated

Jerome Instrument Corporation

Table B-3
(Continued)

Process Analyzers

SYBRON Analytical Products Division

Teledyne Analytical Instruments
Texas Analytical Controls
Tracor Atlas, Inc.

Western Research

FLARE MANUFACTURERS

Hirt combustion Engineers

John Zink Company

Pilgrim Steel Company

Shirco, Inc.

Table B-4
MANUFACTURER'S SURVEY RESPONSE SUMMARY

FLOW MONITORING:

Flow Sensing Principle	Cost Range	Turndown Ratio Represents (Accuracy Range)	Previous Refinery Use	Comments
pitot tube/pressure sensor	low	10:1	YES	can use stacked sensors to improve range
orifice	low	4:1	YES	
venturi	low	20:1	YES	
vane/turbine anemometer	low-med	50:1	YES	purging systems available
vortex shedding	med	40:1	YES	requires very straight flow; poor below 20 fps; typically for small pipe
hot-wire	med	1000:1	YES	one can compensate for variation in gas constituents
dynamic flowmeter	med	10:1	no response	
doppler flowmeter	no response	no response	no response	received information on devices for incompressible flow only
ultrasonic flowmeter	med	500:1		

se5732/049/1

Table B-4
(Continued)

CONSTITUENT MONITORING

Detection Monitoring	Cost Range	Detection Range	Previous Refinery Use	Comments
ultraviolet absorption (UV)	med	ppm - %	YES	
reaction to lead acetate	med	ppb - 100%	YES	
gold film	med	ppb - 100 ppm	YES	new in 1985
photionization	med	ppb - 100%	YES	
diffusion/adsorption	med	ppm - %	YES	interference with hydrogen, methyl mercoptan, dimethyl sulfide, and dimethyl disulfide
gas chromotography	high	ppm - %	YES	requires a detector

NOTE: This summary reflects vendor's claims

Cost Range: low <$3,000
medium $3,000 - $20,000
high >$20,000

se5732/049/2

APPENDIX C

NOTES FROM REFINERY VISITS

Members of the project staff, along with a member of the staff of the California ARB, visited four refineries located within the BAAQMD and the SCAQMD during the week of August 5, 1985. The intent of the refinery visits was to discuss with refinery personnel both flare monitoring and flare operations. Subjects discussed included: the extent of feed gas flow monitoring and details concerning specific equipment used, the implementation of any feed gas composition monitoring, conditions under which flaring occurs, the control of the smoke suppression systems, the ability of refinery material balances to calculate short-term flare emissions, and general refinery operations. Of particular interest were details concerning the success or failure of any previous attempt at flare emission monitoring or flare feed gas monitoring. The refineries visited were chosen based upon the responses received to the refinery survey. The refineries chosen all indicated the implementation of some sort of monitoring program.

REFINERY A

At Refinery A, we met with a senior process engineer. Refinery A is the smallest of the four refineries visited by the project staff. At Refinery A we examined one flare, elevated 235 feet above grade. A flare knockout drum, containing 5 inches of water, is located at the base of the flare.

A velocity probe flowmeter is located in the flare line and is used for refinery accounting. The flowmeter seems to work fairly well, but its range is only for larger flows. A pressure transducer was installed with the original refinery equipment, but it will not detect a small leak. At the present time the refinery is getting recommendations for additional flowmeters. Records are kept of when the flare is on or off. Flare operation is monitored by a remote television camera.

As with most refineries, the composition of gases to the flare can vary greatly. Ventings to the flare may be caused by relief valves, pressure-controlled ventings, fugitive leaks, and purging with sweet gas. Gases have to be sampled for composition analysis from the flare knockout drum by the BAAQMD. Of particular concern is hydrogen sulfide, which ranges in concentrations from a few parts per million (ppm) to 2 percent.

REFINERY B

At Refinery B we met with a staff engineering technician in the Environmental Affairs Department. At Refinery B we examined four flares. Two of the flares were designated "main" flares, and they receive over 90 percent of the gas flared. These main flares were elevated 365 feet above grade. Two additional flares were connected to specific process units. Flare knockout drums are located at the bases of three of the four flares.

To maintain smokeless operation, the use of steam is controlled through the use of infrared cameras. Upon the detection of smoke, the cameras signal a control unit to increase the flow of steam to the flare. A manual override gives refinery personnel the ability to adjust the flow of steam. The system has been in place several years and seems to work well.

Refinery B automatically monitors all flares to determine whether the flare is on or off. This monitoring is done by venturi-type flow sensors. This system has operated without any serious problems. Data on when the flare is on or off are automatically recorded by computer. Refinery B maintains records of how much waste gas goes to the flare. The composition of flare feed gas has never been determined.

REFINERY C

At Refinery C we met with the manager of environmental conservation and a process engineer in the Environmental Conservation Department. We examined five flares at Refinery C: one ground flare and four elevated flares. Three of the flares were used for multiple processes, and two flares were dedicated to specific process units.

To maintain smokeless operation, the use of steam is controlled through the use of a photocell. The photocell senses the magnitude of the flame, and a controller automatically inputs the proper amount of steam.

Refinery C maintains two type of monitoring equipment on three of the five flares. Two flare feed lines are monitored using a Fluid Components, Inc. (FCI), hot thermistor. The FCI device indicates a change in relative flow, but it is not used to quantify flow. Both of these FCI devices are located in the flare feed line upstream of the gas recovery system. One flare feed line is monitored by an annubar system, which does have the ability to quantify flow. This flare is dedicated to one process unit and is operated almost continuously to burn low-BTU fuel.

REFINERY D

At Refinery D we met with the manager of environmental conservation and several process engineers. We examined four flares at Refinery D: three elevated flares and one two-stage flare containing both a ground element and an elevated element. All of the flares at Refinery D service multiple process units. To maintain smokeless operation, the use of steam is controlled by a method similar to that used by Refinery C.

On two of the four flares, pressure sensors have been installed. These pressure sensors output data to a strip chart. With knowledge of the flaring operation, these data could generate a record of when the flare is on or off. Currently, these data are immediately discarded by the refinery. Refinery personnel plan to install FCI flow sensors on selected flare lines. While the resultant flow measurements will be absolute, the monitors should be able to identify trends and unusual conditions.

Shell Oil Company • **Shell Chemical Company**
A Division of Shell Oil Company

Wilmington
Manufacturing Complex
P O Box 6249
Carson, California 90749

Telephone (213) 835-5611

July 12, 1985

CHZM Hill
1500 - 114th Avenue, S.E.
P. O. Box 91500
Bellevue, WA 98009-2050

Dear Sirs:

Enclosed is the California Air Resources Board Refinery Flare Survey for Shell's Wilmington Manufacturing Complex in Carson, California.

The responses are based on available information and reflect only the operations at the Wilmington Manufacturing Complex.

If you have any questions or would like additional information, please call me at (213) 513-2026.

Very truly yours,

Cynthia U. Graham

C. U. Graham, Manager
Environmental Conservation

CUG/ols

Enclosure

BFG8519306

CALIFORNIA AIR RESOURCES BOARD
REFINERY FLARE SURVEY

This survey is part of a study to determine the availability of feasible, cost-effective devices to continously monitor flares. Flare monitoring could include monitoring emissions from flares, monitoring gases going to the flares, or simply monitoring to determine whether the flare is on or off.

We understand that some answers will be estimates, but we feel that the refineries have the best information available to make these estimates. You are encouraged to refer to other departments within your company to obtain the most complete answers. Feel free to use extra pages to complete your answer if necessary. We appreciate your participation in this survey.

Refinery Name: Wilmington Manufacturing Complex

Mailing Address: Shell Oil Company
P.O. Box 6249
Carson, Ca 90749

Person to contact concerning flare operations:

Name: C. U. Graham

Title: Manager, Environmental Conservation

Please answer the following questions about operational flares at your facility:

How many flares are in use at your facility? 4

Type of flare(s)?

	1	2	3	4
Ground	☐	☒	☐	☐
Elevated	☒	☒	☒	☒

Manufacturer and model:

1. John Zinc S-TF-S-20
2. Multi-jet ground type (ground) National Airoil type NRC (elevated)
3. John Zinc STF-30S
4. John Zinc STF-SA-30S

Type of service:

	1	2	3	4
Continuous flow	☐	✓	✓	✓
Scheduled intermittent flow or blowdown	✓	✓	✓	✓
Emergency release	✓	✓	✓	✓

How do you determine if the flare is on or off?

	1	2	3	4
Visual	☑	☐	☐	☑
Automatic	☐	☑	☑	☐

If automatic indicators are used, describe the equipment used:

1.
2. pressure sensor
3. pressure sensor
4.

Do you monitor the quantity of waste gases going to the flare? Yes ☑ No ☐

If yes, describe the equipment used:

1. none
2. pressure sensor / flow device to be installed in near future
3. none
4. none

If no, do any other refineries owned by your company? unknown Yes ☐ No ☐

Do you monitor the composition of waste gases going to the flare? Yes ☐ No ☑

If yes, please describe the equipment used:

1.
2.
3.
4.

If no, do any other refineries owned by your company? unknown Yes ☐ No ☐

Please estimate the potential magnitude of hydrocarbon emissions from your facility if flares were not used as a pollution control device:

1.
2.
3.
4.

Estimate the following feed gas parameters:

	1	2	3	4
Flow Rate:		estimated 2MMSCFD	estimated 2MMSCFD	0
Average flow rate	0			
or				
Volume per episode				
Frequency of episode	1/mo.			
Composition: unknown				
Total hydrocarbons (%)				
Sulfur compounds (%)				
Moisture (%)				
Air (%)				

THE FOLLOWING QUESTIONS ARE FOR THOSE REFINERIES THAT USE FEED GAS ACCUMULATORS TO ATTAIN FLARING CONDITIONS:

What type of vessel is used for each flare and what is the volume of that vessel?

1. knock-out pot(s) only
2. staging vessel + knockout pot(s) only
3. knock-out pot(s) only
4. knock-out pot(s) only

Under what conditions does flaring occur when using feed gas accumulators?

1.
2.
3.
4.

Do you measure, either periodically or continuously, the volumes, temperatures, or pressures of the materials which are accumulated in each vessel.? If yes, please describe equipment used:

1.
2.
3.
4.

Please include a schematic, if available, of your flaring system and feed gas network. Include information on your purge gas and control/compressor system, if available.

THANK YOU FOR YOUR COOPERATION.

Return to: CH2M HILL
1500 — 114th Ave. S.E.
P.O. Box 91500
Bellevue, WA 98009-2050

Maffuccio
ager
Los Angeles Plant

Texaco USA

PO Box 817
2101 East Pacific Coast Highway
Wilmington CA 90748
213 835 8261

July 15, 1985

Mr. Ed Powell
CH2M HILL INC.
1500 114th Avenue, S.E.
Bellevue, WA 98004

Subject: Emissions from Refinery Flares -- Texaco's Los Angeles Plant

Dear Mr. Powell:

Attached as requested by the June 7, 1985 letter from Mr. Dean Simeroth of CARB is the completed Refinery Flare Survey for Texaco's Los Angeles Plant located at 2101 E. Pacific Coast Highway in Wilmington, California.

If there are any questions concerning this matter, please contact Mr. R. M. Stockdale at (213) 513-2485.

Yours very truly,

D. J. Maffuccio EAA

RMS:rmm

Attachment

CALIFORNIA AIR RESOURCES BOARD
REFINERY FLARE SURVEY

This survey is part of a study to determine the availability of feasible, cost-effective devices to continously monitor flares. Flare monitoring could include monitoring emissions from flares, monitoring gases going to the flares, or simply monitoring to determine whether the flare is on or off.

We understand that some answers will be estimates, but we feel that the refineries have the best information available to make these estimates. You are encouraged to refer to other departments within your company to obtain the most complete answers. Feel free to use extra pages to complete your answer if necessary. We appreciate your participation in this survey.

Refinery Name: Texaco Refining & Marketing Inc. - Los Angeles Plant

Mailing Address: 2101 E. Pacific Coast Highway
Wilmington, CA 90744

Person to contact concerning flare operations:

Name: R. M. Stockdale

Title: Project Engineer - Environmental, Health & Safety Dept.

Please answer the following questions about operational flares at your facility:

How many flares are in use at your facility? 2

Type of flare(s)?

	1	2	3	4
Ground	☐	☐	☐	☐
Elevated	☒	☒	☐	☐

Manufacturer and model:

1. John Zink Model STF-S-30
2. John Zink Model STF-S-30
3.
4.

Type of service:

	1	2	3	4
Continuous flow	☐	☐	☐	☐
Scheduled intermittent flow or blowdown	☒	☒	☐	☐
Emergency release	☒	☒	☐	☐

Do you monitor flare emissions for any of the following pollutants?
(Please write YES or NO in each space.)

	1	2	3	4
SO_x	No	No	___	___
Reduced sulfur	No	No	___	___
NO_x	No	No	___	___
Hydrocarbons	No	No	___	___

If yes, describe the equipment used:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

THE FOLLOWING QUESTIONS ARE INCLUDED TO OBTAIN GAS STREAM INFORMATION WHICH COULD BE USED TO EVAULATE FEASIBILITY OF NEW DEVICES ENTERING THE MARKETPLACE.

Describe the refinery processes which feed gases to the flare.

1. See Attachment 1

2. ______________________________

3. ______________________________

4. ______________________________

Do you keep records of when the flare is on or off? Yes [X] No [ ]

If yes, who keeps these records? X Dedicated employee
___ Automatic recording

If no, do any other refineries owned by your company? Yes [ ] No [ ]

How do you determine if the flare is on or off?

	1	2	3	4
Visual	[X]	[X]	[ ]	[ ]
Automatic	[X]	[X]	[ ]	[ ]

If automatic indicators are used, describe the equipment used:

1. Presence of waste gases in flare is monitored visually at the
2. Hydrogen Complex control room using TV screens. Each flare is
3. equipped with thermocouples whose output can trigger an alarm
4. to indicate a flare flame out.

Do you monitor the quantity of waste gases going to the flare? Yes [X] No [ ]

If yes, describe the equipment used:

1. See Attachment 1
2.
3.
4.

If no, do any other refineries owned by your company? Yes [ ] No [ ]

Do you monitor the composition of waste gases going to the flare? Yes [ ] No [X]

If yes, please describe the equipment used:

1. Occasional grab samples are obtained and analyzed using a gas
2. chromatograph for a compositional breakdown. These analyses
3. are done to attempt to identify the source of the flare gases.
4.

If no, do any other refineries owned by your company? Yes [ ] No [X]

Please estimate the potential magnitude of hydrocarbon emissions from your facility if flares were not used as a pollution control device:

1. Based on average flow rate during plant operation as shown on the
2. following page and average hydrocarbon composition of 35% as
3. determined from occasional flare gas samples, hydrocarbon
4. emissions from refinery if flares were shut down would be
approximately 1770 Lbs/Hr.

Estimate the following feed gas parameters: (Average flow rate and composition of waste gases to refinery flare based on 1984-85 operation. Includes DCU coke drum blowdown.)

	1	2	3	4
Flow Rate:				
Average flow rate	56000 SCFH			
or				
Volume per episode				
Frequency of episode				
Composition:				
Total hydrocarbons (%)	35			
Sulfur compounds (%)	0.3			
Moisture (%)	ND*			
Air (%)	1			

*Not determined

THE FOLLOWING QUESTIONS ARE FOR THOSE REFINERIES THAT USE FEED GAS ACCUMULATORS TO ATTAIN FLARING CONDITIONS: Not applicable to LAP or any other Texaco refinery.

What type of vessel is used for each flare and what is the volume of that vessel?

1. ______
2. ______
3. ______
4. ______

Under what conditions does flaring occur when using feed gas accumulators?

1. ______
2. ______
3. ______
4. ______

Do you measure, either periodically or continuously, the volumes, temperatures, or pressures of the materials which are accumulated in each vessel.? If yes, please describe equipment used:

1. ______
2. ______
3. ______
4. ______

Please include a schematic, if available, of your flaring system and feed gas network. Include information on your purge gas and control/compressor system, if available.

THANK YOU FOR YOUR COOPERATION.

Return to: CH2M HILL
1500 — 114th Ave. S.E.
P.O. Box 91500
Bellevue, WA 98009-2050

from TEXACO - WILMINGTON

Attachment 1

CARB REFINERY FLARE GAS SURVEY

(1) Describe the refinery processes which feed gases to the flare.

All refinery flare gases vent to a common flare line. The flare gas flow is directed to one of the two flares by adjusting the water seals in the flare knock out drums. The flares serve as pressure relief for the Delayed Coking Unit (DCU), Fluid Catalytic Cracking Unit (FCCU), Crude Unit, Alkylation Unit, Hydrocracking Unit (HCU), Hydrogen Generation Unit (HGU), Nos. 1-3 Catalytic Reforming Units (CRU), Nos. 1-3 Hydrotreating Units (HTU), Cogeneration Units and Fuel Gas System.

The flares also served as an outlet for venting of the gases from the DCU Coke Drum blowdown which occurs twice per day. On June 13, 1985, Texaco commenced operation of a Flare Gas Recovery System designed primarily to recover this stream. This system which consists of a 200 MSCFH compressor will also recover gases from the refinery flare gas line when the blowdown is not at peak flow. The DCU blowdown represented about 44000 SCFH of the estimated 56000 SCFH flare gas flow rate shown on page 4 of this questionnaire. The recovered flare gases are routed to a DEA absorber for removal of H_2S and then to the refinery fuel gas system.

(2) Equipment used to monitor quantity of waste gases to the flare.

Hot wire anemometer flow measurement devices were recently installed downstream of each flare knockout drum. These flow measurement devices have only been operational for six months and thus we cannot comment on their accuracy or reliability. The output from these flow measurement devices is monitored at the Hydrogen Complex Control Room. However, the output is not connected to a chart recorder or documented on the daily operational log.

Additionally, flare probes have been installed on the flare lines from all major refinery process units. These probes which use the annubar technique have not proved reliable for determination of volumetric flow rates from the units. Instead they are used to indicate if there is a flow from the unit in order to trace unidentified flare gas sources.

Shell Oil Company

P. O. Box 711
Martinez, California 94553
Telephone. 228-6161

July 12, 1985

CH$_2$M Hill
Attn: Ed Powell
1500 - 114th Ave. S.E.
P. O. Box 91500
Bellevue, WA 98009-2050

Gentlemen:

In response to your request we have completed the California Air Resources Board Refinery Flare Survey. In addition, please find attached a flow diagram of the flare systems identified in the survey as Numbers 1 and 2. This flow diagram depicts the associated liquid knockout vessels, purge gas facilities, and flare gas recovery compressors.

It has been our privilege to participate in your survey.

Very truly yours,

C. W. Crowder

C. W. Crowder
Technical Superintendent
Martinez Manufacturing Complex

CWC:ka

SSD4 BD OS/ka (7/11/85)

CALIFORNIA AIR RESOURCES BOARD
REFINERY FLARE SURVEY

This survey is part of a study to determine the availability of feasible, cost-effective devices to continously monitor flares. Flare monitoring could include monitoring emissions from flares, monitoring gases going to the flares, or simply monitoring to determine whether the flare is on or off.

We understand that some answers will be estimates, but we feel that the refineries have the best information available to make these estimates. You are encouraged to refer to other departments within your company to obtain the most complete answers. Feel free to use extra pages to complete your answer if necessary. We appreciate your participation in this survey.

Refinery Name: SHELL OIL COMPANY

Mailing Address: P.O. BOX 711

MARTINEZ, CA 94553

Person to contact concerning flare operations:

Name: D. F. OBENAUER

Title: ENVIRONMENTAL ENGINEER

Please answer the following questions about operational flares at your facility:

How many flares are in use at your facility? 5

Type of flare(s)?

	1	2	3	4	5
Ground	[X]	[ ]	[ ]	[ ]	[ ]
Elevated	[ ]	[X]	[X]	[X]	[X]

Manufacturer and model:

1. SHELL OIL DESIGN, MULTI JET
2. JOHN ZINK, STF-SA-42/30
3. JOHN ZINK, STF-S-24C
4. JOHN ZINK, STF-U-66
5. JOHN ZINK, STF-U-8

Type of service:

	1	2	3	4	5
Continuous flow	[ ]	[ ]	[ ]	[X]	[ ]
Scheduled intermittent flow or blowdown	[ ]	[ ]	[ ]	[ ]	[X]
Emergency release	[X]	[X]	[X]	[ ]	[ ]

Do you monitor flare emissions for any of the following pollutants?
(Please write YES or NO in each space.)

	1	2	3	4	5
SO_x	N	N	N	N	N
Reduced sulfur	N	N	N	N	N
NO_x	N	N	N	N	N
Hydrocarbons	N	N	N	N	N

If yes, describe the equipment used:

1. NA
2. NA
3. NA
4. NA
5. NA

THE FOLLOWING QUESTIONS ARE INCLUDED TO OBTAIN GAS STREAM INFORMATION WHICH COULD BE USED TO EVAULATE FEASIBILITY OF NEW DEVICES ENTERING THE MARKETPLACE.

Describe the refinery processes which feed gases to the flare.

1. Lube Hydrotreater, Distillate Saturation Unit, Crude Unit, Vacuum Flasher, Gas Oil Hydrotreater, Naphtha Hydrotreater, Catalytic Reformer, Hydrocracker, Sats
2. Gas Plant, Hydrogen Plant, Catalytic Cracking Unit, Catalytic Feed Hydrotreater, Catalytic Gasoline Hydrotreater, Alkylation Unit. 1/
3. FLEXICOKING* Unit, Steam Methane Reformer, Sulfur Recovery Plant, Dimersol Plant.
4. FLEXICOKING* Unit.
5. LPG Tank car/tank truck loading and unloading operations.

* Registered Trademark, U.S. Patent Office

Do you keep records of when the flare is on or off? 2/ Yes [X] No [ ]

If yes, who keeps these records? ___ Dedicated employee
_X_ Automatic recording

If no, do any other refineries owned by your company? 3/ Yes [ ] No [ ]

1/ The combined units provide feed gases to both Flare Nos. 1 and 2.

2/ Response applies to Flare No. 4 only.

3/ Responses to this survey concern only the Martinez Mfg. Complex. We are unaware of the practices at our other refineries.

How do you determine if the flare is on or off?

	1	2	3	4	5
Visual	[X]	[X]	[X]	[X]	[X]
Automatic	[ ]	[ ]	[ ]	[ ]	[ ]

If automatic indicators are used, describe the equipment used:

1. NA
2. NA
3. NA
4. NA
5. NA

Do you monitor the quantity of waste gases going to the flare? Yes [X] No [ ]

If yes, describe the equipment used:

1. Fluid components, Inc., Model 12-64-4-R, hot thermistor 1/
2. Fluid components, Inc., Model 12-64-4-R, hot thermistor 1/
3. No
4. Annubar, Model No. ANF-86
5. No

If no, do any other refineries owned by your company? 2/ Yes [ ] No [ ]

Do you monitor the composition of waste gases going to the flare? Yes [ ] No [X]

If yes, please describe the equipment used:

1. NA
2. NA
3. NA
4. NA

If no, do any other refineries owned by your company? 2/ Yes [ ] No [ ]

Please estimate the potential magnitude of hydrocarbon emissions from your facility if flares were not used as a pollution control device:

1. Refer to first question on following page.
2. Refer to first question on following page.
3. Refer to first question on following page.
4. Refer to first question on following page.
5. Refer to first question on following page.

1/ This sensor provides an indication of change in flow rate only and is incapable of providing a quantitative measurement.

2/ Responses to this survey concern only, the Martinez Mfg. Complex. We are unaware of the practices at our other refineries.

Estimate the following feed gas parameters:

Flow Rate:	1	2	3	4	5
Average flow rate	500 M LB/YR	1 MM LB/YR	15 M SCFD	2MM SCFD	38M SCFD
or					
Volume per episode					
Frequency of episode					
Composition:					
Total hydrocarbons (%)	87	87	88	2	100
Sulfur compounds (%)	Negl.	Negl.	1	Negl.	0
Moisture (%)	0	0	4	3	0
Air (%)	0	0	0	0	0

THE FOLLOWING QUESTIONS ARE FOR THOSE REFINERIES THAT USE FEED GAS ACCUMULATORS TO ATTAIN FLARING CONDITIONS:

What type of vessel is used for each flare and what is the volume of that vessel?

1. ______
2. ______
3. ______
4. ______

Under what conditions does flaring occur when using feed gas accumulators?

1. ______
2. ______
3. ______
4. ______

Do you measure, either periodically or continuously, the volumes, temperatures, or pressures of the materials which are accumulated in each vessel.? If yes, please describe equipment used:

1. ______
2. ______
3. ______
4. ______

Please include a schematic, if available, of your flaring system and feed gas network. Include information on your purge gas and control/compressor system, if available.

THANK YOU FOR YOUR COOPERATION.

Return to: CH2M HILL
1500 — 114th Ave. S.E.
P.O. Box 91500
Bellevue, WA 98009-2050

EXXON COMPANY, U.S.A.
3400 EAST SECOND ST. BENICIA, CALIFORNIA 94510

June 28, 1985

Mr. Ed Powell
CH_2M Hill, Inc.
1500-114th Avenue, S.E.
P.O. Box 91500
Bellevue, WA 98009-2050

Dear Mr. Powell:

Enclosed is our reply to your refinery flare survey for the California Air Resources Board. All information requested is accurate and up-to-date. Please note that all information labelled "Exxon Proprietary" is to be regarded as confidential.

If you have any more questions, please contact Wah Y. Cheong at (707)745-7730.

Very truly yours,

Lynnette L. Gerald

Lynnette L. Gerald
Section Supervisor
Environmental, Offsites and
Energy Section

LLG:WYC:fl
Enclosure

CALIFORNIA AIR RESOURCES BOARD
REFINERY FLARE SURVEY

This survey is part of a study to determine the availability of feasible, cost-effective devices to continously monitor flares. Flare monitoring could include monitoring emissions from flares, monitoring gases going to the flares, or simply monitoring to determine whether the flare is on or off.

We understand that some answers will be estimates, but we feel that the refineries have the best information available to make these estimates. You are encouraged to refer to other departments within your company to obtain the most complete answers. Feel free to use extra pages to complete your answer if necessary. We appreciate your participation in this survey.

Refinery Name: Exxon Co., USA

Mailing Address: Benicia Refinery
3400 E. Second Street
Benicia, CA 94510

Person to contact concerning flare operations:

Name: Wah Y. Cheong

Title: Process Contact Engineer

Please answer the following questions about operational flares at your facility:

How many flares are in use at your facility? 4

Type of flare(s)?

	1	2	3	4
Ground	☐	☐	☐	☐
Elevated	X	X	X	X

Manufacturer and model:

1. John Zink, STF-SA 48 S
2. John Zink, STF-SA 48 S
3. John Zink, STF-LH 127-30HF
4. John Zink, STF-V-16

Type of service:

	1	2	3	4
Continuous flow	☐	☐	☐	☐
~~Scheduled intermittent flow~~ or blowdown	X	X	☐	X
Emergency release	X	X	X	X

Do you monitor flare emissions for any of the following pollutants?
(Please write YES or NO in each space.)

	1	2	3	4
SO_x	NO	NO	NO	NO
Reduced sulfur	NO	NO	NO	NO
NO_x	NO	NO	NO	NO
Hydrocarbons	NO	NO	NO	NO

If yes, describe the equipment used:

1. __________
2. __________
3. __________
4. __________

THE FOLLOWING QUESTIONS ARE INCLUDED TO OBTAIN GAS STREAM INFORMATION WHICH COULD BE USED TO EVALUATE FEASIBILITY OF NEW DEVICES ENTERING THE MARKETPLACE. Exxon Proprietary

Describe the refinery processes which feed gases to the flare.

1. Hydrocracker, sulfur plants, hydrogen plants, cat feed hydrofiner, alkylation, pipestill, powerformer, cat unit, coker, storage tanks, loading racks
2. Same as #1
3. Butane storage tank, fuel gas purge
4. Sulfur gas unit, tail gas letdown

Do you keep records of when the flare is on or off? Yes [X] No [ ]

If yes, who keeps these records?
____ Dedicated employee
X Automatic recording

If no, do any other refineries owned by your company? Yes [ ] No [ ]

How do you determine if the flare is on or off?

	1	2	3	4
Visual	☐	☐	☐	☐
Automatic	X	X	X	X

If automatic indicators are used, describe the equipment used:

1. Flow data recorded by IBM-1800
2. Flow data recorded by IBM-1800
3. Flow data recorded by IBM-1800
4. Flow data recorded by IBM-1800

Do you monitor the quantity of waste gases going to the flare? Yes [X] No [ ]

If yes, describe the equipment used:

1. Venturi flow meter. Agar mass flow meter
2. Agar mass flow meter, Venturi flow meter
3. Venturi flow meter
4. Not completely monitored

If no, do any other refineries owned by your company? Yes [ ] No [ ]

Do you monitor the composition of waste gases going to the flare? Yes [ ] No [X]

If yes, please describe the equipment used:

1.
2.
3.
4.

If no, do any other refineries owned by your company? Yes [ ] No [ ] Not available

Please estimate the potential magnitude of hydrocarbon emissions from your facility if flares were not used as a pollution control device:

1. NOT AVAILABLE
2.
3.
4.

NORTH
↓

Estimate the following feed gas parameters:

Flow Rate:	1	2	3	4
Average flow rate (million ft.)	391/yr	77/yr	1.18/yr	41/yr
or				
Volume per episode				
Frequency of episode				

Composition: NOT MONITORED				
Total hydrocarbons (%)				
Sulfur compounds (%)				
Moisture (%)				
Air (%)				

THE FOLLOWING QUESTIONS ARE FOR THOSE REFINERIES THAT USE FEED GAS ACCUMULATORS TO ATTAIN FLARING CONDITIONS:

What type of vessel is used for each flare and what is the volume of that vessel?

1. Water seal drum 19,000ft^3
2. Water seal drum 13,500ft^3
3. No accumulator used
4. Water seal drum 310ft^3

Under what conditions does flaring occur when using feed gas accumulators?

1. Flare header pressure greater than 15 inches of water
2. Flare header pressure greater than 15 inches of water
3. N/A
4. Flare header pressure greater than 6 inches of water

Do you measure, either periodically or continuously, the volumes, temperatures, or pressures of the materials which are accumulated in each vessel.? If yes, please describe equipment used:

1. Pressure maintained by fluid hydraulic head
2. Pressure maintained by fluid hydraulic head
3. N/A
4. Pressure maintained by fluid hydraulic head

Please include a schematic, if available, of your flaring system and feed gas network. Include information on your purge gas and control/compressor system, if available.

THANK YOU FOR YOUR COOPERATION.

Return to: CH2M HILL
1500 — 114th Ave. S.E.
P.O. Box 91500
Bellevue, WA 98009-2050

CALIFORNIA AIR RESOURCES BOARD
REFINERY FLARE SURVEY

This survey is part of a study to determine the availability of feasible, cost-effective devices to continously monitor flares. Flare monitoring could include monitoring emissions from flares, monitoring gases going to the flares, or simply monitoring to determine whether the flare is on or off.

We understand that some answers will be estimates, but we feel that the refineries have the best information available to make these estimates. You are encouraged to refer to other departments within your company to obtain the most complete answers. Feel free to use extra pages to complete your answer if necessary. We appreciate your participation in this survey.

Refinery Name: PACIFIC REFINING COMPANY

Mailing Address: P.O. BOX 68
OLD HIGHWAY 40
HERCULES, CA 94547

Person to contact concerning flare operations:

Name: R. D. EMLING

Title: SENIOR ENGINEER

Please answer the following questions about operational flares at your facility:

How many flares are in use at your facility? ______

Type of flare(s)?

	1	2	3	4
Ground	☐	☐	☐	☐
Elevated	☒	☐	☐	☐

Manufacturer and model:

1. JOHN ZINC COMPANY STF-S-30 FLARE
2. ______
3. ______
4. ______

Type of service:

	1	2	3	4
Continuous flow	☐	☐	☐	☐
Scheduled intermittent flow or blowdown	☐	☐	☐	☐
Emergency release	☒	☐	☐	☐

Do you monitor flare emissions for any of the following pollutants?
(Please write YES or NO in each space.)

	1	2	3	4
SO_x	NO			
Reduced sulfur	NO			
NO_x	NO			
Hydrocarbons	NO			

If yes, describe the equipment used:

1.
2.
3.
4.

THE FOLLOWING QUESTIONS ARE INCLUDED TO OBTAIN GAS STREAM INFORMATION WHICH COULD BE USED TO EVAULATE FEASIBILITY OF NEW DEVICES ENTERING THE MARKETPLACE.

Describe the refinery processes which feed gases to the flare.

1. CRUDE AND VACUUM DISTILLATION UNITS, VISBREAKER, GAS RECOVERY UNIT, UNIFINER/PLATFORMER, HYDROCRACKER.
2.
3.
4.

Do you keep records of when the flare is on or off? Yes [X] No [ ]

If yes, who keeps these records?
___ Dedicated employee
X Automatic recording

If no, do any other refineries owned by your company? Yes [ ] No [ ]

How do you determine if the flare is on or off?

	1	2	3	4
Visual	[X]	[ ]	[ ]	[ ]
Automatic	[ ]	[ ]	[ ]	[ ]

If automatic indicators are used, describe the equipment used:

1. ____
2. ____
3. ____
4. ____

Do you monitor the quantity of waste gases going to the flare? Yes [X] No [ ]

If yes, describe the equipment used:

1. VELOCITY PROBE FLOWMETER
2. ____
3. ____
4. ____

If no, do any other refineries owned by your company? Yes [ ] No [ ]

Do you monitor the composition of waste gases going to the flare? Yes [X] No [ ]

ON OCCASIONAL BASIS.

If yes, please describe the equipment used:

1. A GRAB SAMPLE OF THE GAS IS TAKEN AND RUN ON A GAS CHROMATOGRAPH.
2. ____
3. ____
4. ____

If no, do any other refineries owned by your company? Yes [ ] No [ ]

Please estimate the potential magnitude of hydrocarbon emissions from your facility if flares were not used as a pollution control device:

1. APPROXIMATELY 500 MSCFH OF EMERGENCY RELEASE GAS FROM PROCESS
2. UNITS. 8,333 SCFM X 5 = CAPACITY
3. ____
4. ____

Estimate the following feed gas parameters:

Flow Rate:	1	2	3	4
Average flow rate				
or				
Volume per episode	45 MSCFH			
Frequency of episode	80 DAYS/YR.			
	3600 x 24	84,000 SCF		
Composition:				
Total hydrocarbons (%)	98.5%			
Sulfur compounds (%)	<1.5%			
Moisture (%)				
Air (%)				

THE FOLLOWING QUESTIONS ARE FOR THOSE REFINERIES THAT USE FEED GAS ACCUMULATORS TO ATTAIN FLARING CONDITIONS: NOT APPLICABLE

What type of vessel is used for each flare and what is the volume of that vessel?

1. ____________________
2. ____________________
3. ____________________
4. ____________________

Under what conditions does flaring occur when using feed gas accumulators?

1. ____________________
2. ____________________
3. ____________________
4. ____________________

Do you measure, either periodically or continuously, the volumes, temperatures, or pressures of the materials which are accumulated in each vessel.? If yes, please describe equipment used:

1. ____________________
2. ____________________
3. ____________________
4. ____________________

Please include a schematic, if available, of your flaring system and feed gas network. Include information on your purge gas and control/compressor system, if available.

THANK YOU FOR YOUR COOPERATION.

Return to: CH2M HILL
1500 — 114th Ave. S.E.
P.O. Box 91500
Bellevue, WA 98009-2050

HUNTWAY REFINING COMPANY

1651 Alameda Street
Wilmington, California 90744
(213) 518-4000

June 17, 1985

Mr. Ed Powell
CH_2M HILL
1500 114th Avenue, S.E.
P.O. Box 91500
Bellevue, WA 98009-2050

Dear Mr. Powell,

The Huntway Refining Company at Wilmington is a relatively small, asphalt-producing refinery. We neither own nor operate any type of flare at our refinery, therefore none of the questions on the attached questionnaire are applicable to us. Please feel free to contact me if you require any further information.

Sincerely,

R.L. Monson

R.L. Monson
Manager of Operations

RLM:ll
Attachment

CALIFORNIA AIR RESOURCES BOARD
REFINERY FLARE SURVEY

This survey is part of a study to determine the availability of feasible, cost-effective devices to continously monitor flares. Flare monitoring could include monitoring emissions from flares, monitoring gases going to the flares, or simply monitoring to determine whether the flare is on or off.

We understand that some answers will be estimates, but we feel that the refineries have the best information available to make these estimates. You are encouraged to refer to other departments within your company to obtain the most complete answers. Feel free to use extra pages to complete your answer if necessary. We appreciate your participation in this survey.

Refinery Name: Huntway Refining Co.

Mailing Address: P.O. Box 1257
Wilmington, CA. 90748

Person to contact concerning flare operations:

Name: Bob Monson

Title: Manager of Operations

Please answer the following questions about operational flares at your facility:

How many flares are in use at your facility? NONE

Type of flare(s)?

	1	2	3	4
Ground	☐	☐	☐	☐
Elevated	☐	☐	☐	☐

Manufacturer and model:

1. ________
2. ________
3. ________
4. ________

Type of service:

	1	2	3	4
Continuous flow	☐	☐	☐	☐
Scheduled intermittent flow or blowdown	☐	☐	☐	☐
Emergency release	☐	☐	☐	☐

Do you monitor flare emissions for any of the following pollutants?
(Please write YES or NO in each space.)

	1	2	3	4
SO_x	____	____	____	____
Reduced sulfur	____	____	____	____
NO_x	____	____	____	____
Hydrocarbons	____	____	____	____

If yes, describe the equipment used:

1. ____
   ____
2. ____
   ____
3. ____
   ____
4. ____
   ____

THE FOLLOWING QUESTIONS ARE INCLUDED TO OBTAIN GAS STREAM INFORMATION WHICH COULD BE USED TO EVAULATE FEASIBILITY OF NEW DEVICES ENTERING THE MARKETPLACE.

Describe the refinery processes which feed gases to the flare.

1. ____
   ____
2. ____
   ____
3. ____
   ____
4. ____
   ____

Do you keep records of when the flare is on or off? Yes ☐ No ☐

If yes, who keeps these records? ____ Dedicated employee
____ Automatic recording

If no, do any other refineries owned by your company? Yes ☐ No ☐

How do you determine if the flare is on or off?

	1	2	3	4
Visual	☐	☐	☐	☐
Automatic	☐	☐	☐	☐

If automatic indicators are used, describe the equipment used:

1. ______
2. ______
3. ______
4. ______

Do you monitor the quantity of waste gases going to the flare? Yes ☐ No ☐

If yes, describe the equipment used:

1. ______
2. ______
3. ______
4. ______

If no, do any other refineries owned by your company? Yes ☐ No ☐

Do you monitor the composition of waste gases going to the flare? Yes ☐ No ☐

If yes, please describe the equipment used:

1. ______
2. ______
3. ______
4. ______

If no, do any other refineries owned by your company? Yes ☐ No ☐

Please estimate the potential magnitude of hydrocarbon emissions from your facility if flares were not used as a pollution control device:

1. ______
2. ______
3. ______
4. ______

Estimate the following feed gas parameters:

Flow Rate:	1	2	3	4
Average flow rate				
or				
Volume per episode				
Frequency of episode				
Composition:				
Total hydrocarbons (%)				
Sulfur compounds (%)				
Moisture (%)				
Air (%)				

THE FOLLOWING QUESTIONS ARE FOR THOSE REFINERIES THAT USE FEED GAS ACCUMULATORS TO ATTAIN FLARING CONDITIONS:

What type of vessel is used for each flare and what is the volume of that vessel?

1. __________
2. __________
3. __________
4. __________

Under what conditions does flaring occur when using feed gas accumulators?

1. __________
2. __________
3. __________
4. __________

Do you measure, either periodically or continuously, the volumes, temperatures, or pressures of the materials which are accumulated in each vessel.? If yes, please describe equipment used:

1. __________
2. __________
3. __________
4. __________

Please include a schematic, if available, of your flaring system and feed gas network. Include information on your purge gas and control/compressor system, if available.

THANK YOU FOR YOUR COOPERATION.

Return to: CH2M HILL
1500 — 114th Ave. S.E.
P.O. Box 91500
Bellevue, WA 98009-2050

Received 6/24/85

CALIFORNIA AIR RESOURCES BOARD
REFINERY FLARE SURVEY

This survey is part of a study to determine the availability of feasible, cost-effective devices to continously monitor flares. Flare monitoring could include monitoring emissions from flares, monitoring gases going to the flares, or simply monitoring to determine whether the flare is on or off.

We understand that some answers will be estimates, but we feel that the refineries have the best information available to make these estimates. You are encouraged to refer to other departments within your company to obtain the most complete answers. Feel free to use extra pages to complete your answer if necessary. We appreciate your participation in this survey.

Refinery Name: EDGINGTON OIL COMPANY, INC.

Mailing Address: 2400 EAST ARTESIA BLVD.
LONG BEACH, CA 90805

Person to contact concerning flare operations:

Name: J. N. LEE

Title: SUPERVISING PROCESS ENGINEER

Please answer the following questions about operational flares at your facility:

How many flares are in use at your facility? 0

Type of flare(s)?	1	2	3	4
Ground	☐	☐	☐	☐
Elevated	☐	☐	☐	☐

Manufacturer and model:

1. ______
2. ______
3. ______
4. ______

Type of service:	1	2	3	4
Continuous flow	☐	☐	☐	☐
Scheduled intermittent flow or blowdown	☐	☐	☐	☐
Emergency release	☐	☐	☐	☐

Do you monitor flare emissions for any of the following pollutants?
(Please write YES or NO in each space.)

	1	2	3	4
SO_x	____	____	____	____
Reduced sulfur	____	____	____	____
NO_x	____	____	____	____
Hydrocarbons	____	____	____	____

If yes, describe the equipment used:

1. ____
____
2. ____
____
3. ____
____
4. ____
____

THE FOLLOWING QUESTIONS ARE INCLUDED TO OBTAIN GAS STREAM INFORMATION WHICH COULD BE USED TO EVALUATE FEASIBILITY OF NEW DEVICES ENTERING THE MARKETPLACE.

Describe the refinery processes which feed gases to the flare.

1. ____
____
2. ____
____
3. ____
____
4. ____
____

Do you keep records of when the flare is on or off? Yes ☐ No ☐

If yes, who keeps these records? ____ Dedicated employee
____ Automatic recording

If no, do any other refineries owned by your company? Yes ☐ No ☐

How do you determine if the flare is on or off?

	1	2	3	4
Visual	☐	☐	☐	☐
Automatic	☐	☐	☐	☐

If automatic indicators are used, describe the equipment used:

1. ____________________
2. ____________________
3. ____________________
4. ____________________

Do you monitor the quantity of waste gases going to the flare? Yes ☐ No ☐

If yes, describe the equipment used:

1. ____________________
2. ____________________
3. ____________________
4. ____________________

If no, do any other refineries owned by your company? Yes ☐ No ☐

Do you monitor the composition of waste gases going to the flare? Yes ☐ No ☐

If yes, please describe the equipment used:

1. ____________________
2. ____________________
3. ____________________
4. ____________________

If no, do any other refineries owned by your company? Yes ☐ No ☐

Please estimate the potential magnitude of hydrocarbon emissions from your facility if flares were not used as a pollution control device:

1. ____________________
2. ____________________
3. ____________________
4. ____________________

Estimate the following feed gas parameters:

Flow Rate:	1	2	3	4
Average flow rate	______	______	______	______
or				
Volume per episode	______	______	______	______
Frequency of episode	______	______	______	______
Composition:				
Total hydrocarbons (%)	______	______	______	______
Sulfur compounds (%)	______	______	______	______
Moisture (%)	______	______	______	______
Air (%)	______	______	______	______

THE FOLLOWING QUESTIONS ARE FOR THOSE REFINERIES THAT USE FEED GAS ACCUMULATORS TO ATTAIN FLARING CONDITIONS:

What type of vessel is used for each flare and what is the volume of that vessel?

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Under what conditions does flaring occur when using feed gas accumulators?

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Do you measure, either periodically or continuously, the volumes, temperatures, or pressures of the materials which are accumulated in each vessel.? If yes, please describe equipment used:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Please include a schematic, if available, of your flaring system and feed gas network. Include information on your purge gas and control/compressor system, if available.

THANK YOU FOR YOUR COOPERATION.

Return to: CH2M HILL
1500 — 114th Ave. S.E.
P.O. Box 91500
Bellevue, WA 98009-2050

Received 7/1/85

CALIFORNIA AIR RESOURCES BOARD
REFINERY FLARE SURVEY

This survey is part of a study to determine the availability of feasible, cost-effective devices to continously monitor flares. Flare monitoring could include monitoring emissions from flares, monitoring gases going to the flares, or simply monitoring to determine whether the flare is on or off.

We understand that some answers will be estimates, but we feel that the refineries have the best information available to make these estimates. You are encouraged to refer to other departments within your company to obtain the most complete answers. Feel free to use extra pages to complete your answer if necessary. We appreciate your participation in this survey.

Refinery Name: Huntway Refining Company

Mailing Address: P.O. 787 Benicia Cal 94510

Person to contact concerning flare operations:

Name: Charles R Basset

Title: Manager of Operations

Please answer the following questions about operational flares at your facility:

How many flares are in use at your facility? 1

Type of flare(s)?

	1	2	3	4
Ground	☒	☐	☐	☐
Elevated	☐	☐	☐	☐

Manufacturer and model:

1. McGill Incorporated – Crude Tk. Vapor Recovery
2.
3.
4.

Type of service:

	1	2	3	4
Continuous flow	☐	☐	☐	☐
Scheduled intermittent flow or blowdown	☒	☐	☐	☐
Emergency release	☐	☐	☐	☐

Do you monitor flare emissions for any of the following pollutants?
(Please write YES or NO in each space.)

	1	2	3	4
SO_x	NO	___	___	___
Reduced sulfur	NO	___	___	___
NO_x	NO	___	___	___
Hydrocarbons	NO	___	___	___

If yes, describe the equipment used:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

THE FOLLOWING QUESTIONS ARE INCLUDED TO OBTAIN GAS STREAM INFORMATION WHICH COULD BE USED TO EVAULATE FEASIBILITY OF NEW DEVICES ENTERING THE MARKETPLACE.

Describe the refinery processes which feed gases to the flare.

1. FIVE (5) CRUDE TANKS ARE NAT. GAS (PG&E) BLANKETED - THESE GASES ARE FED TO THE
2. GROUND FLARE DURING FRESH CRUDE OIL IMPORTING
3. ______________________________
4. ______________________________

Do you keep records of when the flare is on or off? Yes ☐ No ☒

If yes, who keeps these records? ___ Dedicated employee
___ Automatic recording

If no, do any other refineries owned by your company? Yes ☐ No ☒

Estimate the following feed gas parameters:

Flow Rate:	1	2	3	4
Average flow rate	280 CFM			
or				
Volume per episode				
Frequency of episode				
Composition:				
Total hydrocarbons (%)	36.5			
Sulfur compounds (%)	0.17			
Moisture (%)				
Air (%)	<2			

THE FOLLOWING QUESTIONS ARE FOR THOSE REFINERIES THAT USE FEED GAS ACCUMULATORS TO ATTAIN FLARING CONDITIONS:

What type of vessel is used for each flare and what is the volume of that vessel?

1. _____
2. _____
3. _____
4. _____

Under what conditions does flaring occur when using feed gas accumulators?

1. _____
2. _____
3. _____
4. _____

Do you measure, either periodically or continuously, the volumes, temperatures, or pressures of the materials which are accumulated in each vessel.? If yes, please describe equipment used:

1. _____
2. _____
3. _____
4. _____

Please include a schematic, if available, of your flaring system and feed gas network. Include information on your purge gas and control/compressor system, if available.

THANK YOU FOR YOUR COOPERATION.

Return to: CH2M HILL
1500 — 114th Ave. S.E.
P.O. Box 91500
Bellevue, WA 98009-2050

Received 7/1/85

CALIFORNIA AIR RESOURCES BOARD
REFINERY FLARE SURVEY

This survey is part of a study to determine the availability of feasible, cost-effective devices to continously monitor flares. Flare monitoring could include monitoring emissions from flares, monitoring gases going to the flares, or simply monitoring to determine whether the flare is on or off.

We understand that some answers will be estimates, but we feel that the refineries have the best information available to make these estimates. You are encouraged to refer to other departments within your company to obtain the most complete answers. Feel free to use extra pages to complete your answer if necessary. We appreciate your participation in this survey.

Refinery Name: Golden West Refining Company

Mailing Address: P.O. Box 2128
Santa Fe Springs, CA 90670-0138

Person to contact concerning flare operations:

Name: D. B. Ayer

Title: Director - Laboratory and Environmental Affairs

Please answer the following questions about operational flares at your facility:

How many flares are in use at your facility? 3

Type of flare(s)?

	1	2	3	4
Ground	☐	☐	☒	☐
Elevated	☒	☒	☐	☐

Manufacturer and model:

1. John Zink STF-SA30S Smokeless Flare
2. John Zink STF-S30C Smokeless Field Flare
3. Western Products, Inc. burners, arrangement no. 720-U
4.

Type of service:

	1	2	3	4
Continuous flow	☐	☐	☐	☐
Scheduled intermittent flow or blowdown	☐	☐	☒	☐
Emergency release	☒	☒	☒	☐

Do you monitor flare emissions for any of the following pollutants?
(Please write YES or NO in each space.)

	1	2	3	4
SO_x	NO	NO	NO	___
Reduced sulfur	NO	NO	NO	___
NO_x	NO	NO	NO	___
Hydrocarbons	NO	NO	NO	___

If yes, describe the equipment used:

1. ____________________

2. ____________________

3. ____________________

4. ____________________

THE FOLLOWING QUESTIONS ARE INCLUDED TO OBTAIN GAS STREAM INFORMATION WHICH COULD BE USED TO EVAULATE FEASIBILITY OF NEW DEVICES ENTERING THE MARKETPLACE.

Describe the refinery processes which feed gases to the flare.

1. atmospheric and vacuum distillation, catalytic reforming, hydrocracking, gas recovery, cat. cracking
2. HF alkylation
3. tank vapors, (alternate for gasoline loading terminal vapors)
4. ____________________

Do you keep records of when the flare is on or off? Yes ☐ No ☒

If yes, who keeps these records? ____ Dedicated employee

____ Automatic recording

If no, do any other refineries owned by your company? Yes ☐ No ☒ we own no other refineries

How do you determine if the flare is on or off?

	1	2	3	4
Visual	☒	☒	☒	☐
Automatic	☐	☐	☐	☐

If automatic indicators are used, describe the equipment used:

1. ______
2. ______
3. ______
4. ______

Do you monitor the quantity of waste gases going to the flare? Yes ☐ No ☒

If yes, describe the equipment used:

1. ______
2. ______
3. ______
4. ______

If no, do any other refineries owned by your company? Yes ☐ No ☒ we own no. other refineries

Do you monitor the composition of waste gases going to the flare? Yes ☐ No ☒

If yes, please describe the equipment used:

1. ______
2. ______
3. ______
4. ______

If no, do any other refineries owned by your company? Yes ☐ No ☒ we own no. other refineries

Please estimate the potential magnitude of hydrocarbon emissions from your facility if flares were not used as a pollution control device:

1. ______
2. ______
3. ______
4. ______

Estimate the following feed gas parameters:

Flow Rate:	1	2	3	4
Average flow rate	______	______	______	______
<u>or</u>				
Volume per episode	______	______	______	______
Frequency of episode	______	______	______	______
Composition:				
Total hydrocarbons (%)	______	______	______	______
Sulfur compounds (%)	______	______	______	______
Moisture (%)	______	______	______	______
Air (%)	______	______	______	______

THE FOLLOWING QUESTIONS ARE FOR THOSE REFINERIES THAT USE FEED GAS ACCUMULATORS TO ATTAIN FLARING CONDITIONS:

What type of vessel is used for each flare and what is the volume of that vessel?

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Under what conditions does flaring occur when using feed gas accumulators?

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Do you measure, either periodically or continuously, the volumes, temperatures, or pressures of the materials which are accumulated in each vessel.? If yes, please describe equipment used:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Please include a schematic, if available, of your flaring system and feed gas network. Include information on your purge gas and control/compressor system, if available.

THANK YOU FOR YOUR COOPERATION.

Return to: CH2M HILL
1500 — 114th Ave. S.E.
P.O. Box 91500
Bellevue, WA 98009-2050

Union 76 Division: Western Region

Union Oil Company of California
San Francisco Refinery, Rodeo, California 94572
Telephone (415) 799-4411

UNION 76

Arthur L. Felderman
Chief Refinery Engineer

July 2, 1985

ALF-148

Mr. Ed Powell
CH2M Hill, Inc.
1500 - 114th Avenue, S.E.
Bellevue, Washington 98004

Dear Mr. Powell:

CALIFORNIA AIR RESOURCES BOARD REFINERY FLARE SURVEY

Attached, as requested by the California Air Resources Board, is the completed Refinery Flare Survey.

Please direct any questions to Mr. Dale Iverson at (415) 799-4411.

Very truly yours,

A. L. FELDERMAN
Chief Refinery Engineer

DGI/pec

Attachment

CALIFORNIA AIR RESOURCES BOARD
REFINERY FLARE SURVEY

This survey is part of a study to determine the availability of feasible, cost-effective devices to continously monitor flares. Flare monitoring could include monitoring emissions from flares, monitoring gases going to the flares, or simply monitoring to determine whether the flare is on or off.

We understand that some answers will be estimates, but we feel that the refineries have the best information available to make these estimates. You are encouraged to refer to other departments within your company to obtain the most complete answers. Feel free to use extra pages to complete your answer if necessary. We appreciate your participation in this survey.

Refinery Name: Union Oil Company of California

Mailing Address: San Francisco Refinery
Rodeo, California 94572

Person to contact concerning flare operations:

Name: Dale G. Iverson

Title: Environmental Control Engineer

Please answer the following questions about operational flares at your facility:

How many flares are in use at your facility? 3

Type of flare(s)?	1	2	3	4
Ground	☐	☐	☒	☐
Elevated	☒	☒	☐	☐

Manufacturer and model:

1. John Zink - EEF-OS-54C
2. John Zink - STF-SA-42C
3. John Zink - Unknown
4.

Type of service:	1	2	3	4
Continuous flow	☐	☐	☐	☐
Scheduled intermittent flow or blowdown	☐	☐	☐	☐
Emergency release	☒	☒	☒	☐

Do you monitor flare emissions for any of the following pollutants?
(Please write YES or NO in each space.)

	1	2	3	4
SO_x	No	No	No	
Reduced sulfur	No	No	No	
NO_x	No	No	No	
Hydrocarbons	No	No	No	

If yes, describe the equipment used:

1.

2.

3.

4.

THE FOLLOWING QUESTIONS ARE INCLUDED TO OBTAIN GAS STREAM INFORMATION WHICH COULD BE USED TO EVAULATE FEASIBILITY OF NEW DEVICES ENTERING THE MARKETPLACE.

Describe the refinery processes which feed gases to the flare.

1. Unicracking, Reforming, Delayed Coker, Unifining, Distillation, Lube Dewaxing, Aromatic Saturation, Sulfur Removal
2. Dual Solvent Extraction
3. Reforming, Unifining, Distillation
4.

Do you keep records of when the flare is on or off? Yes ☐ No ☒

If yes, who keeps these records? ____ Dedicated employee
____ Automatic recording

If no, do any other refineries owned by your company? Yes ☐ No ☐ Not known

How do you determine if the flare is on or off?

	1	2	3	4
Visual	[X]	[X]	[X]	[ ]
Automatic	[X]	[X]	[X]	[ ]

If automatic indicators are used, describe the equipment used:

1. Thermocouple sensor to alarms - verified by visual observation
2. Ditto above
3. Ditto above
4.

Do you monitor the quantity of waste gases going to the flare? Yes [ ] No [X]

If yes, describe the equipment used:

1.
2.
3.
4.

If no, do any other refineries owned by your company? Yes [ ] No [ ] not known

Do you monitor the composition of waste gases going to the flare? Yes [ ] No [X]

If yes, please describe the equipment used:

1.
2.
3.
4.

If no, do any other refineries owned by your company? Yes [ ] No [ ] not known

Please estimate the potential magnitude of hydrocarbon emissions from your facility if flares were not used as a pollution control device:

1. No basis for estimate.
2.
3.
4.

Estimate the following feed gas parameters: No basis for estimates.

Flow Rate:	1	2	3	4
Average flow rate				
<u>or</u>				
Volume per episode				
Frequency of episode				

Composition:				
Total hydrocarbons (%)				
Sulfur compounds (%)				
Moisture (%)				
Air (%)				

THE FOLLOWING QUESTIONS ARE FOR THOSE REFINERIES THAT USE FEED GAS ACCUMULATORS TO ATTAIN FLARING CONDITIONS: Not applicable.

What type of vessel is used for each flare and what is the volume of that vessel?

1. ______
2. ______
3. ______
4. ______

Under what conditions does flaring occur when using feed gas accumulators?

1. ______
2. ______
3. ______
4. ______

Do you measure, either periodically or continuously, the volumes, temperatures, or pressures of the materials which are accumulated in each vessel.? If yes, please describe equipment used:

1. ______
2. ______
3. ______
4. ______

Please include a schematic, if available, of your flaring system and feed gas network. Include information on your purge gas and control/compressor system, if available.

THANK YOU FOR YOUR COOPERATION.

Return to: CH2M HILL
1500 — 114th Ave. S.E.
P.O. Box 91500
Bellevue, WA 98009-2050

Union 76 Division: Western Region
Union Oil Company of California
Los Angeles Refinery, Wilmington, California 90744
Telephone (213) 513-7600

ENV-361/85

UNION 76

July 10, 1985

George A. Walker
Chief Refinery Engineer

REVISED

Mr. Ed Powell
CH2M Hill, Inc.
1500 114th Ave., S. E.
Bellevue, Washington 98004

CARB REFINERY FLARE SURVEY
LOS ANGELES REFINERY

Enclosed is our response to the California Air Resources Board Refinery Flare Survey.

Please call me at (213) 513-7601 if you have any questions on this questionnaire.

Yours very truly,

E. F. Langevin

E. F. LANGEVIN, Supervisor
Environmental Affairs

JSClarke/mmt
2997E

CALIFORNIA AIR RESOURCES BOARD
REFINERY FLARE SURVEY

This survey is part of a study to determine the availability of feasible, cost-effective devices to continously monitor flares. Flare monitoring could include monitoring emissions from flares, monitoring gases going to the flares, or simply monitoring to determine whether the flare is on or off.

We understand that some answers will be estimates, but we feel that the refineries have the best information available to make these estimates. You are encouraged to refer to other departments within your company to obtain the most complete answers. Feel free to use extra pages to complete your answer if necessary. We appreciate your participation in this survey.

Refinery Name: Unocal Corporation Los Angeles Refinery

Mailing Address: 1660 W. Anaheim Street
Wilmington, California 90744

Person to contact concerning flare operations:

Name: S. G. Steach

Title: Utilities Engineer

Please answer the following questions about operational flares at your facility:

How many flares are in use at your facility? 4

Type of flare(s)?

	1	2	3	4
Ground	☐	☐	☐	☐
Elevated	☒	☒	☒	☒

Manufacturer and model:

1. John Zink STF-S-36
2. John Zink STF-S-36
3. John Zink STF-S-36
4. John Zink STF-S-10

Type of service:

	1	2	3	4
Continuous flow	☐	☐	☐	☐
Scheduled intermittent flow or blowdown	☐	☐	☐	☐
Emergency release	☒	☒	☒	☒

Do you monitor flare emissions for any of the following pollutants?
(Please write YES or NO in each space.)

	1	2	3	4
SO_x	No	No	No	No
Reduced sulfur	No	No	No	No
NO_x	No	No	No	No
Hydrocarbons	No	No	No	No

If yes, describe the equipment used:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

THE FOLLOWING QUESTIONS ARE INCLUDED TO OBTAIN GAS STREAM INFORMATION WHICH COULD BE USED TO EVALUATE FEASIBILITY OF NEW DEVICES ENTERING THE MARKETPLACE.

Describe the refinery processes which feed gases to the flare.

* 1. FCC, Alkylation, Reforming, Gas Treating, Sulfur, LPG Loading Rack, Unisol

2. Hydrocracking

3. Crude Distillation, Hydrotreating, Reforming

4. Butane Storage

Do you keep records of when the flare is on or off? Yes [X] No [ ]

If yes, who keeps these records? ____ Dedicated employee
_X_ Automatic recording

If no, do any other refineries owned by your company? Yes [ ] No [ ]

*REVISED

How do you determine if the flare is on or off?

	1	2	3	4
Visual	☐	☐	☐	☒
Automatic	☒	☒	☒	☐

If automatic indicators are used, describe the equipment used:

1. Flow switches in relief lines, anemometer in flare stack
2. Flow switches in relief lines, anemometer in flare stack
3. Flow switches in relief lines, anemometer in flare stack
4.

Do you monitor the quantity of waste gases going to the flare? Yes ☐ No ☒

If yes, describe the equipment used:

1.
2.
3.
4.

If no, do any other refineries owned by your company? Yes ☐ No ☒

Do you monitor the composition of waste gases going to the flare? Yes ☐ No ☒

If yes, please describe the equipment used:

1.
2.
3.
4.

If no, do any other refineries owned by your company? Yes ☐ No ☒

Please estimate the potential magnitude of hydrocarbon emissions from your facility if flares were not used as a pollution control device:

1. (See attached)
2.
3.
4.

We are not able to answer this question since we do not have flow meters in the relief system and do not sample the gas.

Estimate the following feed gas parameters:

Flow Rate:	1	2	3	4
Average flow rate				
or				
Volume per episode				
Frequency of episode				
Composition:				
Total hydrocarbons (%)				
Sulfur compounds (%)				
Moisture (%)				
Air (%)				

THE FOLLOWING QUESTIONS ARE FOR THOSE REFINERIES THAT USE FEED GAS ACCUMULATORS TO ATTAIN FLARING CONDITIONS:

What type of vessel is used for each flare and what is the volume of that vessel?

1. Vaporsphere: 150,000 CU FT
2. Vaporsphere: (Common to #1)
3. Vaporsphere: 150,000 CU FT
4. ______

Under what conditions does flaring occur when using feed gas accumulators? (See attached)

1. ______
2. ______
3. ______
4. ______

Do you measure, either periodically or continuously, the volumes, temperatures, or pressures of the materials which are accumulated in each vessel.? If yes, please describe equipment used:

1. Sphere level recorder
2. Sphere level recorder
3. Sphere level recorder
4. N/A

Please include a schematic, if available, of your flaring system and feed gas network. Include information on your purge gas and control/compressor system, if available.

THANK YOU FOR YOUR COOPERATION.

Return to: CH2M HILL
1500 — 114th Ave. S.E.
P.O. Box 91500
Bellevue, WA 98009-2050

from Union Oil / Wilmington

Q. Under what conditions does flaring occur when using feed gas accumulations?

A. Flaring occurs only during the following situations

- Emergency hydrocarbon release
- Improper equipment operation
- Vapor recovery system out of service for maintenance

Under normal operating conditions hydrocarbons in the relief system are recovered. When flaring occurs due to improper equipment operation steps are taken to correct the situation as quickly as possible.

Q. Please estimate the potential magnitude of hydrocarbon emissions from your facility if flares were not used as a pollution control device.

A. Under normal operating conditions no hydrocarbon emissions would occur. We have no means of determining the quantity of hydrocarbon emissions which would occur due to improper equipment operation. In the case of emergency release each flare is designed to handle the following quantities of hydrocarbons.

#1	450,000 lb/HR
#2	420,000 lb/HR
#3	320,000 lb/HR
#4	6,000 lb/HR

ARCO Petroleum Products Company
Watson Refinery
1801 East Sepulveda Boulevard
Mailing Address: Box 6210
Carson, California 90749-6210
Telephone 213 548 8000

N. E. Pennels
Refinery Manager

EEC 263-85
File

July 11, 1985

Mr. E. Powell
CH2M Hill, Inc.
1500 - 114th Ave., S.E.
P. O. Box 91500
Bellevue, WA 98009-2050

Gentlemen:

ARCO Petroleum Products Company - Watson Refinery is responding to the June 7, 1985 California Air Resources Board Survey on flares conducted by CH2M Hill, Inc. The attached questionnaire reflects current flare operating practices.

All Watson Refinery flares were constructed according to the American Petroleum Institute Recommended Practices No. 520 - "Design and Installation of Pressure - Relieving Systems in Refineries" and No. 521 "Guide for Pressure Relieving and De-Pressuring Systems". Example drawings of flare and flare equipment have been provided (API, McGill, Inc.). Flares are operated according to current industry and ARCO practices. Thorough manuals, specific to each of the three Watson Refinery flares, provide guidelines on operation and maintenance. If you have any questions please contact Mr. W. T. Roberts at (213) 548-8042.

Very truly yours,

N. E. Pennels

PLA/dt
attachments

CALIFORNIA AIR RESOURCES BOARD
REFINERY FLARE SURVEY

This survey is part of a study to determine the availability of feasible, cost-effective devices to continously monitor flares. Flare monitoring could include monitoring emissions from flares, monitoring gases going to the flares, or simply monitoring to determine whether the flare is on or off.

We understand that some answers will be estimates, but we feel that the refineries have the best information available to make these estimates. You are encouraged to refer to other departments within your company to obtain the most complete answers. Feel free to use extra pages to complete your answer if necessary. We appreciate your participation in this survey.

Refinery Name: ARCO Petroleum Products Company - Watson Refinery

Mailing Address: 1801 E. Sepulveda P.O. Box 6210
Carson, CA 90749

Person to contact concerning flare operations:

Name: W. T. Roberts

Title: Manager, Environmental

Please answer the following questions about operational flares at your facility:

How many flares are in use at your facility? 3

Type of flare(s)?

	1	2	3	4
Ground	☐	☐	☐	☐
Elevated	☒	☒	☒	☐

Manufacturer and model:

1. John Zinc Model STF - S-30 Light Gas Seal - 33 Steam Jets
2. John Zinc Model STF - 24 Light Gas Seal - 27 Steam Jets
3. John Zinc Model STF - S - 24
4.

Type of service:

	1	2	3	4
Continuous flow	☐	☐	☐	☐
Scheduled intermittent flow or blowdown	☐	☐	☐	☐
Emergency release	☒	☒	☒	☐

Do you monitor flare emissions for any of the following pollutants?
(Please write YES or NO in each space.)

	1	2	3	4
SO_x	No	No	No	
Reduced sulfur	No	No	No	
NO_x	No	No	No	
Hydrocarbons	No	No	No	

If yes, describe the equipment used:

1.

2.

3.

4.

THE FOLLOWING QUESTIONS ARE INCLUDED TO OBTAIN GAS STREAM INFORMATION WHICH COULD BE USED TO EVAULATE FEASIBILIT/ OF NEW DEVICES ENTERING THE MARKETPLACE.

Describe the refinery processes which feed gases to the flare.

1. Hydrocracker Flare - Hydrocracker, Reforming, Desulfurization

2. F. C. C. Flare - Fluid Catalytic Cracking Unit, DEA Regenerators

3. Coker Flare - Coker Units, DEA Regenerators, Alkylation

4.

Do you keep records of when the flare is on or off? Yes ☐ No ☒

If yes, who keeps these records? ____ Dedicated employee
____ Automatic recording

If no, do any other refineries owned by your company? Yes ☐ No ☐

How do you determine if the flare is on or off?

	1	2	3	4
Visual	[X]	[X]	[X]	[ ]
Automatic	[X]	[X]	[X]	[ ]

If automatic indicators are used, describe the equipment used:

1. Color TV Monitor in Control Room
2. Color TV Monitor in Control Room
3. Color TV Monitor in Control Room
4. Color TV Monitor in Control Room

Do you monitor the quantity of waste gases going to the flare? Yes [ ] No [X]

If yes, describe the equipment used:

1. ______
2. ______
3. ______
4. ______

If no, do any other refineries owned by your company? Yes [ ] No [X]

Do you monitor the composition of waste gases going to the flare? Yes [ ] No [X]

If yes, please describe the equipment used:

1. ______
2. ______
3. ______
4. ______

If no, do any other refineries owned by your company? Yes [ ] No [X]

Please estimate the potential magnitude of hydrocarbon emissions from your facility if flares were not used as a pollution control device:

1. Hydrocarbon estimates are highly speculative and vary greatly.
2. Every effort is made to reduce flaring to emergency cases only.
3. Magnitude varies from maximum capacity of the flare to small
4. episodes. Composition may be hydrocarbon, sulfur compounds, hydrogen, etc.

Estimate the following feed gas parameters:

	1	2	3	4
Flow Rate:				
Average flow rate	Ø	Ø	Ø	
or				
Volume per episode	Variable	Variable	Variable	
Frequency of episode	Variable	Variable	~~Variable~~	
Composition: Mole %				
Total hydrocarbons (%)	100	97.0	94.0	
Sulfur compounds (%)	Ø	3.0	6.0	
Moisture (%)	Ø	Ø	Ø	
Air (%)	Ø	Ø	Ø	

THE FOLLOWING QUESTIONS ARE FOR THOSE REFINERIES THAT USE FEED GAS ACCUMULATORS TO ATTAIN FLARING CONDITIONS:

What type of vessel is used for each flare and what is the volume of that vessel?

1. N/A
2.
3.
4.

Under what conditions does flaring occur when using feed gas accumulators?

1.
2.
3.
4.

Do you measure, either periodically or continuously, the volumes, temperatures, or pressures of the materials which are accumulated in each vessel.? If yes, please describe equipment used:

1.
2.
3.
4.

Please include a schematic, if available, of your flaring system and feed gas network. Include information on your purge gas and control/compressor system, if available.

THANK YOU FOR YOUR COOPERATION.

Return to: CH2M HILL
1500 — 114th Ave. S.E.
P.O. Box 91500
Bellevue, WA 98009-2050

Chevron

Chevron U.S.A. Inc.
P.O. Box 97, El Segundo, CA 90245

Manufacturing Department
El Segundo Refinery
C.P. Mehlum
General Manager
D.E. Tormey
Manager, Operations
G.N. Lenz
Manager, Technical
W.R. Dawdy
Manager, Maintenance
A.S. Pitzer III
Manager, Employee Relations

July 11, 1985

Refinery Flare Questionnaire

Mr. Ed Powell
CH_2M Hill Inc.,
1500 114th Avenue S. E.
P.O. Box 91500
Bellevue, WA 98009-2050

Dear Mr. Powell:

Attached is the El Segundo Refinery's response to the refinery flare questionnaire. We understand that you are acting as a consultant to the California Air Resources Board on this issue. Attachment 1 covers Flares 1 through 4 and Attachment 2 covers Flares 5 and 6. Also attached are simplified diagrams of our flare systems.

We could not accurately respond to the questions regarding feed gas parameters. The flow rate and composition of streams going to flares can change dramatically from incident to incident depending on the equipment involved. This makes it extremely difficult to estimate these parameters.

If you have any questions, please contact Mr. C. W. Aarni at (213) 615-5285.

Very truly yours,

GAM:ffr/20.232

ATTACHMENT 1

CALIFORNIA AIR RESOURCES BOARD
REFINERY FLARE SURVEY

This survey is part of a study to determine the availability of feasible, cost-effective devices to continously monitor flares. Flare monitoring could include monitoring emissions from flares, monitoring gases going to the flares, or simply monitoring to determine whether the flare is on or off.

We understand that some answers will be estimates, but we feel that the refineries have the best information available to make these estimates. You are encouraged to refer to other departments within your company to obtain the most complete answers. Feel free to use extra pages to complete your answer if necessary. We appreciate your participation in this survey.

Refinery Name: Chevron U.S.A. - El Segundo Refinery

Mailing Address: P. O. Box 97
El Segundo, CA 90245

Person to contact concerning flare operations:

Name: C. W. Aarni

Title: Environmental Specialist

Please answer the following questions about operational flares at your facility:

How many flares are in use at your facility? 6

Type of flare(s)?

	1	2	3	4
Ground	☐	☐	☐	☐
Elevated	☒	☒	☒	☒

Manufacturer and model:

1. Flour stack with John Zink Model STF SA-36S Tip
2. John Zink stack with STF SA-S Tip
3. John Zink stack with Flaregas 48" FS smokeless tip
4. John Zink stack and STF-S-12 smokeless tip

Type of service:

	1	2	3	4
Continuous flow	☐	☐	☒	☐
Scheduled intermittent flow or blowdown	☐	☐	☐	☐
Emergency release	☒	☒	☒	☒

Do you monitor flare emissions for any of the following pollutants?
(Please write YES or NO in each space.)

	1	2	3	4
SO_x	No	No	No	No
Reduced sulfur	No	No	No	No
NO_x	No	No	No	No
Hydrocarbons	No	No	No	No

If yes, describe the equipment used:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

THE FOLLOWING QUESTIONS ARE INCLUDED TO OBTAIN GAS STREAM INFORMATION WHICH COULD BE USED TO EVAULATE FEASIBILITY OF NEW DEVICES ENTERING THE MARKETPLACE.

Describe the refinery processes which feed gases to the flare.

1. Fluid catalytic cracker, catalytic reformer, fuel gas system and sour water stripper.
2. Delayed coker
3. Naptha hydrotreater, gas oil hydrotreater, gas oil hydrocracker and distillation plant, steam methane reformer (hydrogen plant) and mid distillate hydrotreater.
4. Amonnia and hydrogen sulfide removal plant and gas treating plant (H_2S recovery).

Do you keep records of when the flare is on or off? Yes ☐ No ☐ No for 1,3 & 4. Yes for 2.

If yes, who keeps these records? x Dedicated employee
___ Automatic recording

If no, do any other refineries owned by your company? Yes ☐ No ☒

How do you determine if the flare is on or off?

	1	2	3	4
Visual	x	x	x	x
Automatic				

If automatic indicators are used, describe the equipment used:

1.
2.
3.
4.

Do you monitor the quantity of waste gases going to the flare? Yes [ ] No [x]

If yes, describe the equipment used:

1. We are planning to install a test flow sensing device on this flare.
2.
3.
4.

If no, do any other refineries owned by your company? Yes [ ] No [x]

Do you monitor the composition of waste gases going to the flare? Yes [ ] No [x]

If yes, please describe the equipment used:

1.
2.
3.
4.

If no, do any other refineries owned by your company? Yes [ ] No [x]

Please estimate the potential magnitude of hydrocarbon emissions from your facility if flares were not used as a pollution control device:

1. It is currently not possible to accurately estimate the volume of gas released
2. to flares. Previous estimates have assumed that 0.19% of the average crude run
3. is lost through flaring (EPA publication AP-42).
4.

Estimate the following feed gas parameters:

This information can not be accurately determined for these flares.

	1	2	3	4
Flow Rate:				
Average flow rate	______	______	______	______
<u>or</u>				
Volume per episode	______	______	______	______
Frequency of episode	______	______	______	______
Composition:				
Total hydrocarbons (%)	______	______	______	______
Sulfur compounds (%)	______	______	______	______
Moisture (%)	______	______	______	______
Air (%)	______	______	______	______

THE FOLLOWING QUESTIONS ARE FOR THOSE REFINERIES THAT USE FEED GAS ACCUMULATORS TO ATTAIN FLARING CONDITIONS:

What type of vessel is used for each flare and what is the volume of that vessel?

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Under what conditions does flaring occur when using feed gas accumulators?

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Do you measure, either periodically or continuously, the volumes, temperatures, or pressures of the materials which are accumulated in each vessel.? If yes, please describe equipment used:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Please include a schematic, if available, of your flaring system and feed gas network. Include information on your purge gas and control/compressor system, if available.

THANK YOU FOR YOUR COOPERATION.

Return to: CH2M HILL
1500 — 114th Ave. S.E.
P.O. Box 91500
Bellevue, WA 98009-2050

ATTACHMENT 2

CALIFORNIA AIR RESOURCES BOARD
REFINERY FLARE SURVEY

This survey is part of a study to determine the availability of feasible, cost-effective devices to continously monitor flares. Flare monitoring could include monitoring emissions from flares, monitoring gases going to the flares, or simply monitoring to determine whether the flare is on or off.

We understand that some answers will be estimates, but we feel that the refineries have the best information available to make these estimates. You are encouraged to refer to other departments within your company to obtain the most complete answers. Feel free to use extra pages to complete your answer if necessary. We appreciate your participation in this survey.

Refinery Name: Chevron U.S.A. - El Segundo Refinery

Mailing Address: P. O. Box 97
El Segundo, CA 90245

Person to contact concerning flare operations:

Name: C. W. Aarni

Title: Environmental Specialist

Please answer the following questions about operational flares at your facility:

How many flares are in use at your facility? ______

Type of flare(s)?

	1	2	3	4
Ground	☒	☐	☐	☐
Elevated	☐	☒	☐	☐

Manufacturer and model:

1. Flaregas low level ground flare system, Series GFS-80.
2. Flaregas elevated flare system, Series FS-42/100
3. ______
4. ______

Type of service:

	1	2	3	4
Continuous flow	☐	☐	☐	☐
Scheduled intermittent flow or blowdown	☐	☐	☐	☐
Emergency release	☒	☒	☐	☐

Do you monitor flare emissions for any of the following pollutants?
(Please write YES or NO in each space.)

	1	2	3	4
SO_x	No	No	___	___
Reduced sulfur	No	No	___	___
NO_x	No	No	___	___
Hydrocarbons	No	No	___	___

If yes, describe the equipment used:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

THE FOLLOWING QUESTIONS ARE INCLUDED TO OBTAIN GAS STREAM INFORMATION WHICH COULD BE USED TO EVAULATE FEASIBILITY OF NEW DEVICES ENTERING THE MARKETPLACE.

Describe the refinery processes which feed gases to the flare.

1. Gas oil hydrotreaters, naptha hydrotreater, crude unit, steam naptha reformer (hydrogen plant), gas treating plant (H_2S recovery).

2. Same as No. 1.

3. ______________________________

4. ______________________________

Do you keep records of when the flare is on or off? Yes ☐ No ☒

If yes, who keeps these records? ____ Dedicated employee
____ Automatic recording

If no, do any other refineries owned by your company? Yes ☐ No ☒

How do you determine if the flare is on or off?

	1	2	3	4
Visual	[x]	[x]	[ ]	[ ]
Automatic	[ ]	[ ]	[ ]	[ ]

If automatic indicators are used, describe the equipment used:

1. ______
2. ______
3. ______
4. ______

Do you monitor the quantity of waste gases going to the flare? Yes [ ] No [x]

If yes, describe the equipment used:

1. ______
2. ______
3. ______
4. ______

If no, do any other refineries owned by your company? Yes [ ] No [x]

Do you monitor the composition of waste gases going to the flare? Yes [ ] No [x]

If yes, please describe the equipment used:

1. ______
2. ______
3. ______
4. ______

If no, do any other refineries owned by your company? Yes [ ] No [x]

Please estimate the potential magnitude of hydrocarbon emissions from your facility if flares were not used as a pollution control device:

1. It is currently not possible to accurately estimate the volume of gas
2. released to flares. Previous estimates have assumed that 0.19% of the average
3. crude run is lost through flaring (EPA publication AP-42).
4. ______

This information can not be accurately determined for these flares.

Estimate the following feed gas parameters:

	1	2	3	4
Flow Rate:				
Average flow rate	______	______	______	______
<u>or</u>				
Volume per episode	______	______	______	______
Frequency of episode	______	______	______	______
Composition:				
Total hydrocarbons (%)	______	______	______	______
Sulfur compounds (%)	______	______	______	______
Moisture (%)	______	______	______	______
Air (%)	______	______	______	______

THE FOLLOWING QUESTIONS ARE FOR THOSE REFINERIES THAT USE FEED GAS ACCUMULATORS TO ATTAIN FLARING CONDITIONS:

What type of vessel is used for each flare and what is the volume of that vessel?

1. ______
2. ______
3. ______
4. ______

Under what conditions does flaring occur when using feed gas accumulators?

1. ______
2. ______
3. ______
4. ______

Do you measure, either periodically or continuously, the volumes, temperatures, or pressures of the materials which are accumulated in each vessel.? If yes, please describe equipment used:

1. ______
2. ______
3. ______
4. ______

Please include a schematic, if available, of your flaring system and feed gas network. Include information on your purge gas and control/compressor system, if available.

THANK YOU FOR YOUR COOPERATION.

Return to: CH2M HILL
1500 — 114th Ave. S.E.
P.O. Box 91500
Bellevue, WA 98009-2050

CALIFORNIA AIR RESOURCES BOARD
REFINERY FLARE SURVEY

This survey is part of a study to determine the availability of feasible, cost-effective devices to continously monitor flares. Flare monitoring could include monitoring emissions from flares, monitoring gases going to the flares, or simply monitoring to determine whether the flare is on or off.

We understand that some answers will be estimates, but we feel that the refineries have the best information available to make these estimates. You are encouraged to refer to other departments within your company to obtain the most complete answers. Feel free to use extra pages to complete your answer if necessary. We appreciate your participation in this survey.

Refinery Name: Newhall Refining Co., Inc.

Mailing Address: P.O. Box 938
Newhall, CA 91322

Person to contact concerning flare operations:

Name: H. A. Seal

Title: Refinery Manager

Please answer the following questions about operational flares at your facility:

How many flares are in use at your facility? 1

Type of flare(s)?

	1	2	3	4
Ground	☐	☐	☐	☐
Elevated	☒	☐	☐	☐

Manufacturer and model:

1. National Airoil 12" NSR-110' Self-supported, steam inducted
2.
3.
4.

Type of service:

	1	2	3	4
Continuous flow	☒	☐	☐	☐
Scheduled intermittent flow or blowdown	☐	☐	☐	☐
Emergency release	☒	☐	☐	☐

Do you monitor flare emissions for any of the following pollutants?
(Please write YES or NO in each space.)

	1	2	3	4
SO_x	No	___	___	___
Reduced sulfur	No	___	___	___
NO_x	No	___	___	___
Hydrocarbons	No	___	___	___

If yes, describe the equipment used:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

THE FOLLOWING QUESTIONS ARE INCLUDED TO OBTAIN GAS STREAM INFORMATION WHICH COULD BE USED TO EVAULATE FEASIBILITY OF NEW DEVICES ENTERING THE MARKETPLACE.

Describe the refinery processes which feed gases to the flare.

1. Pressure relief valves from crude units, Merox, HDS, Reformer, DEA, Sour Water Stripper units
2. ______________________________
3. ______________________________
4. ______________________________

Do you keep records of when the flare is on or off? Yes [X] No [ ]

If yes, who keeps these records? X Dedicated employee
___ Automatic recording

If no, do any other refineries owned by your company? Yes [ ] No [ ]

How do you determine if the flare is on or off?

	1	2	3	4
Visual	[X]	[ ]	[ ]	[ ]
Automatic	[ ]	[ ]	[ ]	[ ]

If automatic indicators are used, describe the equipment used:

1. __________
2. __________
3. __________
4. __________

Do you monitor the quantity of waste gases going to the flare? Yes [X] No [ ]

If yes, describe the equipment used:

1. Hot wire device manufactured by Fluid Components
2. __________
3. __________
4. __________

If no, do any other refineries owned by your company? Yes [ ] No [ ]

Do you monitor the composition of waste gases going to the flare? Yes [ ] No [X]

If yes, please describe the equipment used:

1. __________
2. __________
3. __________
4. __________

If no, do any other refineries owned by your company? Yes [ ] No [X]

Please estimate the potential magnitude of hydrocarbon emissions from your facility if flares were not used as a pollution control device:

1. __________
2. __________
3. __________
4. __________

Estimate the following feed gas parameters:

Flow Rate:	1	2	3	4
Average flow rate	200 SCFM			
or				
Volume per episode				
Frequency of episode				
Composition:				
Total hydrocarbons (%)	100			
Sulfur compounds (%)	0			
Moisture (%)	0			
Air (%)	0			

THE FOLLOWING QUESTIONS ARE FOR THOSE REFINERIES THAT USE FEED GAS ACCUMULATORS TO ATTAIN FLARING CONDITIONS:

What type of vessel is used for each flare and what is the volume of that vessel?

1. N.A.
2.
3.
4.

Under what conditions does flaring occur when using feed gas accumulators?

1. N.A.
2.
3.
4.

Do you measure, either periodically or continuously, the volumes, temperatures, or pressures of the materials which are accumulated in each vessel.? If yes, please describe equipment used:

1. N.A.
2.
3.
4.

Please include a schematic, if available, of your flaring system and feed gas network. Include information on your purge gas and control/compressor system, if available.

THANK YOU FOR YOUR COOPERATION.

Return to: CH2M HILL
1500 — 114th Ave. S.E.
P.O. Box 91500
Bellevue, WA 98009-2050

Chevron

Chevron U.S.A. Inc.
P.O. Box 1272, Richmond, CA 94802

Manufacturing Department
Richmond Refinery
J.K. Murray
General Manager
J.B. Krider
Manager, Operations
J.P. Gegner
Manager, Technical Services
R.M. Coulter
Manager, Maintenance
S.A. Starosciak
Manager, E.R. and Admin.
H.E. Holt
Manager, Public
and Government Affairs

July 15, 1985

California Air Resources Board
Refinery Flare Survey

Mr. Ed Powell
CH_2M Hill, Inc.
1500 - 114th Avenue, S.E.
Bellevue, WA 98004

Dear Mr. Powell:

This letter is the Chevron U.S.A. Inc. Richmond Refinery's response to Mr. D. C. Simeroth's request of June 6, 1985 for information on our Refinery's flares. The attached Table I summarizes the engineering information requested by your survey.

With respect to your other questions, we offer the following comments:

- We monitor flare activity but do not directly monitor flare emissions.
- We have included Appendix A to describe the processes which feed gases to each flare.

Attached is a schematic showing our flaring system and feed gas network.

Please contact Mr. Jay Witherspoon (415) 620-3310 with any questions or comments.

Very truly yours,

Attachments

TABLE I

ENGINEERING INFORMATION - CHEVRON U.S.A. RICHMOND REFINERY FLARES

Location	Plant	Manufacturer & Model		Elevated	Ground	Flare Gas Recovery	
						Yes	No
Richmond	3 CAT**	John Zink	STF-S-36C	X			X
Richmond	LSFO*	John Zink	STF-SA-36S	X		X	
Richmond	RLOP*	Flare Gas	FS	X		X	
Richmond	UDEX**	John Zink	S-36	X			X
Richmond	Thermal*	John Zink	SA-36S	X		X	
Richmond	N. Isomax*	Flare Gas	FSC-42	X		X	
Richmond	S. Isomax*	John Zink	S-42	X		X	
Richmond	FCC*	John Zink	SA-42	X		X	
Richmond	Alky/Poly*	Flare Gas	FS-30	X		X	
Richmond	Alkane	John Zink	(None)	X			X
Richmond	AO Plant**	John Zink	(None)	X			X

Notes:

1. All are steam injected for smokeless operation. Where steam control is not "automatic," manual remote control is provided.
2. All are "emergency or blowdown release" only.

*TV monitors, flame scan systems and pilot-flame thermocouples used to monitor flares.

**Standby flare, not in use.

APPENDIX A

FLARE	REFINERY PROCESSES WHICH FEED GASES TO FLARE
3 CAT	Shut down.
LSFO	Hydrotreating - Adds H_2 to gas oils to remove sulfur and nitrogen.
RLOP	Hydrocracking - Uses H_2 to crack gas oils into light products, denitrify and desulfurize. Hydrofinishing - Uses H_2 to remove sulfur and nitrogen.
UDEX	Shut down.
THERMAL	Rheniformers - Rearrange molecules to increase octane. Separation Processes - Separate crude oil constituents into common boiling point fractions.
N. ISOMAX	Hydrocrackers - Uses H_2 to crack gas oils into light products, denitrify and desulfurize.
S. ISOMAX	Hydrogen compressors, solvent de-asphalting.
FCC	Uses a fluidized catalyst to crack gas oils to light products.
ALKY/POLY	ALKY - Uses H_2SO_4 acid to convert butanes to alkylate which is a high octane gasoline blending component. POLY - Uses phosphoric acid to polymerize propylene to C_{12}-C_{15} which are used to make detergent.
ALKANE	Uses HF acid to convert C_{12}-C_{15} polymer to detergent raw material.
AO PLANT	Shut down.

CALIFORNIA AIR RESOURCES BOARD
REFINERY FLARE SURVEY

This survey is part of a study to determine the availability of feasible, cost-effective devices to continously monitor flares. Flare monitoring could include monitoring emissions from flares, monitoring gases going to the flares, or simply monitoring to determine whether the flare is on or off.

We understand that some answers will be estimates, but we feel that the refineries have the best information available to make these estimates. You are encouraged to refer to other departments within your company to obtain the most complete answers. Feel free to use extra pages to complete your answer if necessary. We appreciate your participation in this survey.

Refinery Name CHEVRON USA INC., RICHMOND REFINERY

Mailing Address P.O. BOX 1272
RICHMOND, CA. 94802

Person to contact concerning flare operations:

Name: P.S. WILLIAMS (415) 620-2183

Title: ASSISTANT SUPERINTENDENT

Please answer the following questions about operational flares at your facility:

How many flares are in use at your facility? 8

* Type of flare(s)? SEE TABLE I

	1	2	3	4
Ground	☐	☐	☐	☐
Elevated	☐	☐	☐	☐

* Manufacturer and model: SEE TABLE I

1.
2.
3.
4.

* Type of service:

	1	2	3	4	... 8
Continuous flow	☐	☐	☐	☐	☐
Scheduled intermittent flow or blowdown	☒	☒	☒	☒	... ☒
Emergency release	☒	☒	☒	☒	... ☒

* SEE TABLE I - ATTACHED.

Do you monitor flare emissions for any of the following pollutants?
(Please write YES or NO in each space.)

	1	2	3	4 . . . 8
SO_x	NO →	→	→	→
Reduced sulfur	NO →	→	→	→
NO_x	NO →	→	→	→
Hydrocarbons	NO →	→	→	→

If yes, describe the equipment used:

1. ______

2. ______

3. ______

4. ______

THE FOLLOWING QUESTIONS ARE INCLUDED TO OBTAIN GAS STREAM INFORMATION WHICH COULD BE USED TO EVAULATE FEASIBILITY OF NEW DEVICES ENTERING THE MARKETPLACE.

** Describe the refinery processes which feed gases to the flare. SEE APENDIX A

1. ______

2. ______

3. ______

4. ______

Do you keep records of when the flare is on or off? Yes ☐ No ☒

If yes, who keeps these records? ______ Dedicated employee
______ Automatic recording

If no, do any other refineries owned by your company? Yes ☒ *** No ☐

** SEE APPENDIX A - ATTACHED
*** EL SEGUNDO REFINERY

How do you determine if the flare is on or off?

	1	2	3	4	. . .	8
Visual	☒	☒	☒	☒		☒
Automatic	☐	☐	☐	☐		

If automatic indicators are used, describe the equipment used:

1. ______
2. ______
3. ______
4. ______

Do you monitor the quantity of waste gases going to the flare? Yes ☐ No ☒

If yes, describe the equipment used:

1. ______
2. ______
3. ______
4. ______

If no, do any other refineries owned by your company? Yes ☐ No ☒

Do you monitor the composition of waste gases going to the flare? Yes ☒ No ☐

If yes, please describe the equipment used:

1. CHROMATOGRAPHIC ANALYSIS once per week
2. " " " "
3. " " " "
4. " " " "
:
8. " " " "

If no, do any other refineries owned by your company? Yes ☐ No ☐

Please estimate the potential magnitude of hydrocarbon emissions from your facility if flares were not used as a pollution control device:

1. CANNOT BE ACCURATELY ESTIMATED.
2. " "
3. " "
4. " "
:
8. " "

Estimate the following feed gas parameters:

Flow Rate:	1	2	3	4	. . . 8
Average flow rate	UNKNOWN				
or					
Volume per episode	UNKNOWN				
Frequency of episode	UNKNOWN				

Composition: EXTREMELY VARIABLE - CANNOT SUPPLY A REPRESENTIVE COMPOSITION

Total hydrocarbons (%)				
Sulfur compounds (%)				
Moisture (%)				
Air (%)				

THE FOLLOWING QUESTIONS ARE FOR THOSE REFINERIES THAT USE FEED GAS ACCUMULATORS TO ATTAIN FLARING CONDITIONS: N/A

What type of vessel is used for each flare and what is the volume of that vessel?

1. ______
2. ______
3. ______
4. ______

Under what conditions does flaring occur when using feed gas accumulators?

1. ______
2. ______
3. ______
4. ______

Do you measure, either periodically or continuously, the volumes, temperatures, or pressures of the materials which are accumulated in each vessel.? If yes, please describe equipment used:

1. ______
2. ______
3. ______
4. ______

**** Please include a schematic, if available, of your flaring system and feed gas network. Include information on your purge gas and control/compressor system, if available. - ATTACHED

THANK YOU FOR YOUR COOPERATION.

Return to: CH2M HILL
1500 — 114th Ave. S.E.
P.O. Box 91500
Bellevue, WA 98009-2050

*** - ATTACHED

CALIFORNIA AIR RESOURCES BOARD
REFINERY FLARE SURVEY

This survey is part of a study to determine the availability of feasible, cost-effective devices to continously monitor flares. Flare monitoring could include monitoring emissions from flares, monitoring gases going to the flares, or simply monitoring to determine whether the flare is on or off.

We understand that some answers will be estimates, but we feel that the refineries have the best information available to make these estimates. You are encouraged to refer to other departments within your company to obtain the most complete answers. Feel free to use extra pages to complete your answer if necessary. We appreciate your participation in this survey.

Refinery Name: Macmillan Ring Free Oil Co., Inc.

Mailing Address: 2020 Walnut Ave
Signal Hill, CA 90806

Person to contact concerning flare operations:

Name: Ted Christensen

Title: Ref Mgr

Please answer the following questions about operational flares at your facility:

How many flares are in use at your facility? 0

Type of flare(s)?

	1	2	3	4
Ground	☐	☐	☐	☐
Elevated	☐	☐	☐	☐

Manufacturer and model:

1. ______
2. ______
3. ______
4. ______

Type of service:

	1	2	3	4
Continuous flow	☐	☐	☐	☐
Scheduled intermittent flow or blowdown	☐	☐	☐	☐
Emergency release	☐	☐	☐	☐

Do you monitor flare emissions for any of the following pollutants?
(Please write YES or NO in each space.)

	1	2	3	4
SO_x	___	___	___	___
Reduced sulfur	___	___	___	___
NO_x	___	___	___	___
Hydrocarbons	___	___	___	___

If yes, describe the equipment used:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

THE FOLLOWING QUESTIONS ARE INCLUDED TO OBTAIN GAS STREAM INFORMATION WHICH COULD BE USED TO EVAULATE FEASIBILITY OF NEW DEVICES ENTERING THE MARKETPLACE.

Describe the refinery processes which feed gases to the flare.

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

Do you keep records of when the flare is on or off? Yes ☐ No ☐

If yes, who keeps these records? ____ Dedicated employee
____ Automatic recording

If no, do any other refineries owned by your company? Yes ☐ No ☐

How do you determine if the flare is on or off?

	1	2	3	4
Visual	☐	☐	☐	☐
Automatic	☐	☐	☐	☐

If automatic indicators are used, describe the equipment used:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Do you monitor the quantity of waste gases going to the flare? Yes ☐ No ☐

If yes, describe the equipment used:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

If no, do any other refineries owned by your company? Yes ☐ No ☐

Do you monitor the composition of waste gases going to the flare? Yes ☐ No ☐

If yes, please describe the equipment used:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

If no, do any other refineries owned by your company? Yes ☐ No ☐

Please estimate the potential magnitude of hydrocarbon emissions from your facility if flares were not used as a pollution control device:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Estimate the following feed gas parameters:

Flow Rate:	1	2	3	4
Average flow rate	______	______	______	______
or				
Volume per episode	______	______	______	______
Frequency of episode	______	______	______	______

Composition:				
Total hydrocarbons (%)	______	______	______	______
Sulfur compounds (%)	______	______	______	______
Moisture (%)	______	______	______	______
Air (%)	______	______	______	______

THE FOLLOWING QUESTIONS ARE FOR THOSE REFINERIES THAT USE FEED GAS ACCUMULATORS TO ATTAIN FLARING CONDITIONS:

What type of vessel is used for each flare and what is the volume of that vessel?

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Under what conditions does flaring occur when using feed gas accumulators?

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Do you measure, either periodically or continuously, the volumes, temperatures, or pressures of the materials which are accumulated in each vessel.? If yes, please describe equipment used:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Please include a schematic, if available, of your flaring system and feed gas network. Include information on your purge gas and control/compressor system, if available.

THANK YOU FOR YOUR COOPERATION.

Return to: CH2M HILL
1500 — 114th Ave. S.E.
P.O. Box 91500
Bellevue, WA 98009-2050