TECHNICAL REPORT

SAFETY ASSESSMENT OF PETROLEUM AND GAS PRODUCERS

By
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Prepared For

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Contract No. 210-77-0033

May 1979

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June 29, 1979

Mr. John A. Gerard
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
944 Chestnut Ridge Road
Morgantown, West Virginia 26505

Re: NIOSH Contract No. 210-77-0033
FMRC J. I. 4A6N8.RG

Dear Mr. Gerard:

The final changes to the technical report "Safety Assesment of Petroleum and Gas Producers", as we discussed in our telecon of 20 June 1979, have been made.

In accordance with the provisions of the referenced contract, we have enclosed five (5) copies and the reproducible master of this report for your use. Five (5) copies have also been sent to the Clearinghouse for Occupational Safety and Health and one (1) copy has been forwarded to Mr. Leo Sanders, Contracting Officer.

A small number of extra copies have been printed and are available for your convenience, if you need them.

Cordially,

L. M. Krasner

LMK:bmz

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ABSTRACT

The purpose of this work effort was to perform a comprehensive assessment of the personnel safety hazards encountered in the petroleum and gas industry. This assessment required: 1) the collection and documentation of historical accident and illness data; 2) an investigation of current regulations, standards and related research; and 3) the development of recommendations for improvement of problem areas or processes.

Federal and state government agencies as well as private safety organizations were contacted in the search for historical accident and illness data. These data included statistical data, estimated casualty figures and documented case histories of previous accidents. All data were computerized and subjected to machine manipulation to aid in analyses.

Safety regulations and standards written for the protection of the man-at-work were researched for their applicability to petroleum industry personnel. In addition, a search of on-going applied research projects was made in order to determine the existence of programs relating to the safety of petroleum and gas producers.

The collected data were analyzed and recommendations designed to ameliorate problems regarding the safety of petroleum and gas producers were made. In addition, recommendations on the collection and reporting of casualty data were also presented.

ACKNOWLEDGEMENTS

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INTRODUCTION

Since 1970, when national attention was first focused on an impending energy crisis, there has been accelerated growth and expansion in the petroleum and petrochemical industries. During the years between 1970 and 1976 the national demand for crude oil increased by 23-percent. In 1970, demand for crude oil was at 10,909,000 barrels per day (bpd)[1]. This figure rose to approximately 13,457,000 bpd by 1976. A 22-percent increase in the number of employees was also experienced during this same period. In 1970 there were approximately 461,000 employees in the oil, gas and petroleum refining industries. Of these, 294,000 were classified as production employees. By 1976 this number had risen to a total of 563,000 employees; 378,000 of whom were listed as production workers.

The bulk of the increase is attributed to expansions in U.S. drilling activity. Well completions jumped from 29,467 in 1970 to 41,455 in 1976. This, in turn, led to an increase in workers at oil and gas extraction sites from 270,000 in 1970 to approximately 360,000 in 1976, a growth of roughly 33-percent.

Petroleum refining operations experienced a somewhat slower growth rate in work force, from 154,000 employees in 1970 to 157,000 in 1976.

Together with the expansion in the petroleum industry was an expected increase in accident and injury cases. This is due possibly to the utilization of new and inexperienced personnel necessary for handling the increased exploration and processing activities.

(1) Oil and Gas Journal, Jan. 30, 1978

The objective of this study was to assess the current personnel safety hazards associated with the petroleum and petrochemical industries in this country. To accomplish this, a comprehensive survey of the types of accidents occurring in these industries was conducted. An attempt was made to determine causative factors relating to the recorded accidents.

The industries considered are those dealing with the exploration, extraction, processing, and storage of crude oil, natural gas, and liquefied natural gas. Accidents occurring in transit, either by vehicle or pipeline beyond a distribution center, were excluded from this study. Pertinent data from over 1,800 accident reports occurring between 1970 and 1977 were gathered and computerized for analysis. The analyses performed on these data were directed toward defining and evaluating the magnitude and extent of the safety problems existing in the oil and gas industries.

II

DATA COLLECTION AND MANIPULATION

2.1 EXISTING REGULATIONS AND STANDARDS

Initially an attempt was made to determine the extent of existing petroleum industry safety regulations and standards. While hard regulations aimed specifically at the petroleum industry are scarce, it was discovered that safety guidelines are currently available through several sources. The American Petroleum Institute (API), National Fire Protection Association (NFPA), Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH) are organizations in this country that issue standards and guidelines applicable to the petroleum industry. Sources outside the United States that also issue guidelines are the British Standards Institution (BSI) and the Institute of Petroleum (IP) in Great Britain.

The most comprehensive set of recommended practices issued in this country for the petroleum industry comes from API. Many of these are gleaned from existing regulations for other industries and modified to apply specifically to the petroleum industry. These guidelines are generated by members of API working in conjunction with safety experts from other organizations and petroleum industry personnel.

Specific guidelines for the handling and storage of petroleum products, together with recommended fire fighting techniques, are issued by NFPA in the form of Fire Codes. Like the API, NFPA's Fire Codes are the result of a collective effort of many individuals and organizations. Members of API, fire equipment manufacturers, private and government safety research organizations and petroleum industry personnel combine to write the applicable standards.

For the most part, safety problems in the petroleum industry tend to be of the same type as those encountered in any other industrial occupation. Thus, the standards issued by OSHA in its General Industry Safety and Health Standards(1) provide applicable safety guidelines for petroleum industry facilities.

(1) General Industry Safety and Health Standards, (29CFR1910), Occupational Safety and Health Administration, Rev. January 1976.

General safety guidelines for the petroleum industry are also provided by NIOSH in its Health and Safety Guide for Bulk Petroleum Plants.

Other sources of petroleum safety regulations and standards are the various insurance companies specializing in these types of risks. These companies issue guidelines applicable only to the areas they insure. Information regarding such guidelines is generally not available to the public.

Sources of regulations and standards outside this country include the Institute of Petroleum in Great Britain which has prepared a series of safe practice codes covering almost every aspect of the petroleum industry. One other organization, the British Standards Institution (BSI) of London has also issued safety guidelines.

Appendix A contains a listing of standards and regulations concerned with the safety of the man-at-work in the petroleum industry.

2.2 ON-GOING RESEARCH

FMRC performed a literature search of its available resources in an effort to determine the extent of on-going research into the safety problems of the petroleum industry. To assure completeness, the Smithsonian Science Information Exchange (SSIE) was commissioned by FMRC to conduct a survey of all on-going research projects contained in its data base also. The SSIE collects and indexes over 100,000 research project records annually. Its data base includes input from over 1,300 public and private research organizations covering basic and applied research in all areas of the life, physical, social, behavioral, and engineering sciences.

With the exception of several epidemiological studies, mostly directed at the determination of carcinogens, the searches by SSIE and FMRC yielded little data. Apparently there are few petroleum industry safety studies in progress at this time. A bibliography of projects of possible interest to the petroleum industry is presented in Appendix B.

One project worthy of note is currently being conducted by the Explosion and Energetics section of FMRC's Applied Research Division. This work is a joint effort by FMRC and a large petroleum company and consists of a series of explosion tests in enclosures modeled after those found on off-shore platforms. Hopefully, the end result will be a reduction of the severity of explosions occurring at these facilities by determining explosion venting requirements for process enclosures. However, all test results and information relating to the project are proprietary at this time.

2.3 INCIDENTS

2.3.1 Sources

Numerous organizations were contacted in the search for data for inclusion in this program; the following responded with population information and/or case histories:

American Petroleum Institute (API);
Bureau of Labor Statistics (BLS);
National Fire Protection Association (NFPA);
U.S. Geological Survey (USGS);
Occupational Safety and Health Administration (OSHA);
Departments of Labor from the States of California, Pennsylvania and Oklahoma;
U.S. Coast Guard (USCG); and
National Fire Prevention and Control Administration (NFPCA).

Other information was obtained from NFPA publications, Oil and Gas Journal, Factory Mutual Loss Incident data, and various publications and periodicals.

The entire incident data set consists of 1,887 incidents collected from over fifteen sources. However, the bulk of the data set was taken from the American Petroleum Institute (57%), the Occupational Safety and Health Administration (16%) and the U.S. Geological Survey (14%). Most of the recorded incidents occurred between the years 1973 to 1977, with 316 recorded for 1975, 519 for 1976, and 475 events for 1977.

2.3.2 Quality

As expected, the most detailed information came from our own Factory Mutual Loss Reports. However, these reports only include 1) those companies which are, in whole or in part, insured as organizations in the Factory Mutual System, and 2) those incidents involving large property losses. Incidents which involved many casualties but little or no property loss would not be included in the FM data base. The FM System does not insure personnel.

Other sources of fairly detailed information were API, NFPA, USGS and the state departments of labor. Recordkeeping practices for those organizations were varied, resulting in differing degrees of completeness of the data. In general, the incident reports received from all sources were sanitized to exclude names of persons, places and organizations. Some of these reports lacked specific dates for low-severity occurrences.

As a rule, data from the API consisted primarily of fire-related phenomena (fire, fire/spill, explosion) taken from that organization's annual Fire Loss Summary. The exceptions to this rule were the fatality incident data which included all fatalities reported to the API. API data prior to 1974 is only marginally complete. Much of the data in the early years of collection by the API does not contain specific dates or causal information, and usually consists of a one or two-line description of the incident. Beginning in 1974 the computerization of incidents resulted in more detailed information by this organization.

Computerized data containing incidents for the years 1971 through 1978 were obtained from the NFPA and the USGS. These data were fairly complete although they represented only narrow areas of interest. The NFPA data provided incidents of fire and explosion occurring in the petroleum industry. The USGS data consisted of fires, explosions and blowouts occurring in the offshore petroleum industry. Such incidents were generally classified as "Major" because their inclusion in the data meant that significant property damage or casualties were incurred.

Computerized data from OSHA provided casualty information. All incidents which met the OSHA criteria for reporting injuries and fatalities for the period between July, 1970 to June, 1976 were included in these data. These data should, therefore, provide a means of comparison with other data sources, particularly with API and BLS, and show the reliability of the fatality statistics. According to OSHA guidelines, an on-site investigation is warranted for any industrial accident which results in at least one fatality or five or more injuries requiring hospitalization. Therefore, all occupational fatalities in the U.S. should be included in the OSHA data.

The BLS was the major source of statistical data, although some manipulation of the data was warranted since population and casualty figures for production and nonproduction (secretaries, office workers, maintenance employees, etc.) were lumped together. The BLS began the computerization of their data during the last half of 1971. Personnel contacted expressed varying degrees of confidence in the reliability of the data for the 1971 and 1972 reports. As a result, the year 1973 was selected as the starting point for survey of this organization's data. The last year in which there was a complete report was 1975; only partial data exists for 1976.

Information concerning petroleum industry illnesses is very sketchy. With exception of the illness incidence rates provided by BLS and API, such information was not available. The best sources of industrial illness data are the State Workmen's Compensation Commissions. The task of obtaining and reviewing the reports from these agencies was judged to be impractical.

2.3.3 Manipulation

To facilitate the handling of incidents and insure the recording of all essential information, a Loss Incident Report form was drawn up. This form consisted of 22 categories of information and the provision for inclusion of remarks on the back of the form if further clarification were warranted. In most cases there was not enough information to fully complete the form, but as a rule information was sufficient to facilitate some manipulation of the data. The form was designed to allow the conversion of this information to computer codes (see Appendix C, Page 1). Various types of information in each of the categories were given alpha or numeric computer codes which would allow the complete computerization of all data. The sheet contains spaces for information such as date, location and time of incident, weather factors, Standard Industrial Classification (SIC) code, operational activity and occupancy in which the incident occurred, type of incident, cause and number of casualties, equipment involved, primary and secondary causes of the incident, responding emergency equipment, business interruption and damage costs, and the type of petroleum product involved. A copy of the coding manual outlining the method of translation of incident information into computer codes is included in Appendix C.

A Loss Incident Report form for each incident was filled out as completely as possible then forwarded to the FMRC Computer Center. These data were recorded on storage disks in the form of 125 character records with each record representing one incident. Each record consisted of 57 fields of coded information. Since data were taken from various information sources, there was a very high probability of recording an incident more than once. This was especially true for high severity incidents. It was, therefore, necessary to devise a method of partitioning the data set which would isolate duplicate entries.

Three techniques were employed to eliminate duplicate entries from the data. The first technique was employed as the incidents were being added to the data set. The second came after the data set was finalized and required the development of a separate computer program. The third technique consisted of a manual survey of all incidents classified as duplicate entries using the first two techniques.

Each record (incident) is keyed using the first eleven characters of information from the coded Loss Incident Report form. These characters consist of the file transaction code (1-2), date (3-8), state (9-10) and the incident number (11). As records were put onto disk storage, the date and state codes were checked against those records already stored to determine if an incident with identical codes were already on file. If such an incident were present, an incident number beginning with the number 1 was inserted in space 11 of the new record. As other records with identical state and date codes were added, the incident number was incremented by one up to a maximum of nine. If more than ten incidents with the same date and state codes were encountered, duplication was assumed and all were immediately printed out for inspection. Some data from the API caused some difficulties resulting in modifications to this procedure. Over 320 incidents from 1973 were recorded in which neither the month, day of the month, nor state were reported. This left the year in which the incident occurred as the only identifying key. Since more than 320 incidents occurred in 1973 (with no other keying information), no more than 10 incidents could be added to the data set because the others were identified as duplicate entries. Dummy variables for month, day of the month and state were added to these records to make each one unique.

The second method of determining duplicates was performed after the data set was finalized and involved the comparison of several fields of information on each record. Data fields containing coded information for date of incident, operational activity, occupancy, incident type, and information source were chosen for this comparison. The record of each incident in the data set was scanned and the fields containing the first four of the cited parameters were checked to see if they were identical to those of any other incident record in the data set. It was felt that it would be highly improbable that two incidents of the same type (fire, explosion, personnel injury, etc.) could occur on the same date and involve the same operational process. If the first four parameters of the two incidents were identical, then the last parameter (information source) of each record was checked. If the two incidents were reported by the same information source it was assumed that they were distinct occurrences, since each major information source screens its own data for duplicates. However, if the information sources were different, it was assumed that one of the incidents could be a duplicate and both were printed out for further evaluation.

Finally, an extensive manual survey of all incidents occurring on the same date was conducted. The coded information available on each of these incidents was examined and compared for similarities with others. Those judged to be duplicates were eliminated from the data set. This manual survey yielded less than 20 suspected duplicates in excess of those already screened by computer techniques.

After finalizing the data set, software was developed to perform the necessary analyses. This entailed the development of a COBOL computer language program consisting of over 2,000 statements. This program is capable of partitioning the data set by any one of, or a combination of, up to three data fields. For example, the number of incidents occurring in a given year can be found, or the number of incidents in a given year which were taken from a specified information source can be isolated. Even further, the number of incidents in a given year, from a specified information source as a function of operational activity can also be determined. Combinations of different data fields were used to partition the data into various configurations needed for an effective analysis. Computer runs of several partitions are presented in Appendix D. All programming was performed on the IBM 370/158 computer.

III

DATA ANALYSIS

3.1 EXTENT OF THE SAFETY PROBLEM

Data analysis began with the comparison of existing statistical data available from the Bureau of Labor Statistics (BLS) and the American Petroleum Institute (APS) in order to obtain an assessment of the extent of the problem. Unfortunately, the data from each of these two organizations are collected and presented using different guidelines, making comparison difficult.

The most complete source of statistical data on industrial injuries and illnesses is the BLS; therefore, these data were examined first. The BLS data are presented in categories defined by the Standard Industrial Classification (SIC) manual[(1)]. These data include annual employment figures plus total recordable occupational injury and illness incidence rates for lost workday cases and non-fatal cases without lost workdays. The BLS data are obtained through the use of an annual survey questionnaire (OSHA Form No. 103) sent to over 200,000 sample units throughout the United States. These sample units are selected to constitute a representative cross-section of all industries in the private sector. Completion of the questionnaire and its return to the BLS are mandatory under federal regulations[(2)].

The two most clearly applicable categories for the oil and gas industry are SIC Major Groups 13 and 29. SIC Major Group 13 covers all operations involving the extraction, production and recovering of crude oil and natural gas. This category includes exploration of well sites, drilling activites and crude oil and gas preparation up to the point at which the product leaves the producing site for refining. Major Group 29 covers all establishments primarily involved in petroleum refining, including the production and manufacture of hydrocarbon liquids (gasoline, kerosene, benzene, jet fuels, etc.), solvents, cutting and lubricating oils, and liquefied petroleum gases.

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(1) Standard Industrial Classification Manual, Office of Management and Budget, 1972.

(2) Code of Federal Regulations, Title 29, Part 1904.20-22.

Unfortunately, the BLS data provide only injury incidence data computed as an average for all workers in a given industry. Those rates include the injury experience of managers, administrators and assorted office and building employees not actively involved in production or manufacturing.

The BLS injury and illness data provide incidence rates in the form of events per 100 full-time employees. These incidence rates are computed using the formula:

$$I = \frac{N_T \times 200,000}{EH} \qquad (1)$$

Where

N_T = total number of injuries;

EH = total hours worked by employees during period, usually taken as one calendar year.

The 200,000 represents an hourly base for 100 full-time equivalent workers for one year (40 hours per week x 50 weeks per year x 100 full-time employees).

Using this method, the actual hazards experienced in certain production activities could go undetected if the nonproduction labor force associated with it were sufficiently large. To eliminate the effect of nonproduction personnel, an exercise was developed which computes injury incidence rates for production personnel only.

Essentially, this exercise is based on the assumption that the nonproduction personnel in a given industry are not exposed to any significantly different hazards than are the nonproduction workers in any other industry. In short, the safety hazards encountered by an office manager in a textile manufacturing firm would not be appreciably different than those of an office manager in a plastics factory, financial institution, or business service organization. By eliminating the injuries normally associated with such occupations, together with the percentage of the work force represented by them, a more accurate assessment of the injury experience of a given occupation could be obtained. For this exercise, the office and administrative personnel in the oil and gas industry were likened to those in the business-related category, Miscellaneous Business Services (SIC Code 73).

Those employees classified under Miscellaneous Business Services include maintenance personnel and service employees as well as office workers. This seems to represent a realistic mix of workers for nonproduction personnel in the industries under investigation. The number of injuries associated with the nonproduction and production personnel are computed using the following formula:

$$N_{NP} = \frac{I_{OFFICE} \cdot T_{NP}}{100} \tag{2}$$

where:

I_{OFFICE} = injury incidence of workers in Miscellaneous Business Services. (units of injuries per 100 employees)/year;

T_{NP} = average number of nonproduction personnel for the industry in question; and

$$N_P = N_T - N_{NP} \tag{3}$$

where:

N_P = total injuries for production personnel/year;

N_T = total injuries for industry (from BLS data)/year; and

N_{NP} = total injuries for non-production personnel/year.

The adjusted injury incidence rates can be computed using

$$I_{ADJ} = \frac{N_P \times 200{,}000}{EH_P} \tag{4}$$

where:

EH_P = hours for all production personnel = T_P (total production personnel) $\times H_{AVE}$ (average weekly hours for production personnel) x 50 (weeks per year worked).

With this technique, several industries were selected, in addition to the oil and gas industry categories, for comparison. The Chemical (SIC 28), Textile (SIC 22), Metal (SIC 33) and Lumber (SIC 24) industries were chosen as representative industrial areas whose injury incidence rates bracket those representing the petroleum industry.

The adjusted injury incidence rates are presented in Table I under columns labeled I_{adj}. As expected, the adjusted rates were significantly higher in all instances. Using the injury incidence rates of Miscellaneous Business Services non-production personnel, increases ranged from 16% in 1976 to 28% in 1972 for Major Group 13 (Oil and Gas Extraction). Major Group 29 (Petroleum Refining) yielded increases from 14% in 1973 to 27% in 1975 when these rates were adjusted. The textile industry (SIC Code 22) proved to be least affected by the adjustment, recording increases of less than 5 %. This allowed three categories, Petroleum & Refining, Chemical, and Textiles to be judged as having roughly the same hazard potential to their workers. However, the adjusted rates for the petroleum refining industry are not significantly higher than are the average injury incidence rates for the total private sector.

The figures for the oil and gas extraction industry present a slightly different picture. The injury incidence rates for this industry both before and after adjustment are higher than the averages for the total private sector.

The inference to be drawn from the BLS data is that, while safety problems do exist for both Petroleum Industry categories, the more serious of these is encountered during the exploration and extraction phases.

TABLE I
INJURY INCIDENCE COMPARISON*

Year	SIC Code	Employees (Thousands) All	Employees (Thousands) Production	Avg. Weekly Hours	Total Injuries (Thousands) All	Total Injuries (Thousands) Lost Workday	Injury Incidence Per 100 Empl. All	Injury Incidence Per 100 Empl. Lost Workday	I_{ADJ} All Injuries Per 100 Empl.[2] (Adjusted) Non-Production	I_{ADJ} All Injuries Per 100 Empl.[2] (Adjusted) Production	I_{ADJ} Lost Workday Injuries/100 Empl.[2] (Adjusted) Non Production	I_{ADJ} Lost Workday Injuries/100 Empl.[2] (Adjusted) Production
1976 Total Private Sector (Total non-government labor force)							NA	NA	4.6		1.8	
Oil & Gas Extr.	13	360	247	42.8	44.1[1]		12.8	5.9		14.9		
Pet Refining	29	203	131	40.0	15.1		7.6	3.1		9.0		
Chemical	28	1034	589	40.0	78.0		7.5	2.9		9.8		
Textiles	22	966	844	40.0	94		10.3	2.7		10.5		
Metals	33	1190	933	40.0	183		16.0	6.1		18.3		
Lumber	24	606	508	40.0	146.9		21.7	9.6		28.0		
1975 Total Private Sector (Total non-government labor force)							8.8	3.2	4.9			
Oil & Gas Extr.	13	335.7	231	42.3	45.8[1]	20.8[1]	13.8	6.1		16.6		7.6
Pet Refining	29	197.4	125	39.4	16.8	5.8	8.5	3.0		10.8		3.5
Chemical	28	1013	570	39.4	74.7	25.7	7.5	2.6		9.4		3.0
Textiles	22	902	782	39.4	82.4	20.0	10.0	2.4		9.9		2.3
Metals	33	1180	919	39.4	184.1	67.9	16.4	5.9		18.9		6.9
Lumber	24	557	464	39.4	101.8	42.8	20.7	8.5		21.3		8.96
1974 Total Private Sector (Total non-government labor force)							10.0	3.4	5.2		1.8	
Oil & Gas Extr.	13	304.5	206	42.4	35.2[1]	16.2[1]	11.8	5.4		13.8		6.6
Pet Refining	29	198.6	126	40.0	17.3	5.7	8.9	2.9		10.7		3.5
Chemical	28	1056.6	616	40.0	89.2	28	8.5	2.6		10.8		3.2
Textiles	22	988.1	875	40.0	102.8	23.5	10.8	2.5		11.1		2.4
Metals	33	1335.5	1067	40.0	250.2	87.1	19.0	6.6		22.1		7.7
Lumber	24	626.2	539	40.0	130.4	53.1	21.8	8.9		23.4		9.6
1973 Total Private Sector (Total non-government labor force)							10.6	NA	5.4		1.8	
Oil & Gas Extr.	13	274.3	182	42.5	34.4[1]	15.5[1]	12.6	5.7		15.2		7.2
Pet Refining	29	193.4	122	40.7	16.9	4.8	9.2	1.8		10.5		2.8
Chemical	28	1035.5	603	40.7	89.4	27.5	8.8	2.7		10.8		3.2
Textiles	22	1030.5	905	40.7	116.5	25.9	11.4	2.5		11.9		2.6
Metals	33	1320.9	1062	40.7	264.3	80.8	20.2	6.2		23.2		7.0
Lumber	24	639.7	551	40.7	146.0	56.2	23.6	9.1		25.2		9.7
1972 Total Private Sector (Total non-government labor force)							10.5	NA	5.5		2.2	
Oil & Gas Extr.	13	261.9	174	40.6	33.3	14.5	12.6	5.5		16.1		7.1
Pet Refining	29	189.6	117	40.7	18.0	4.6	9.7	2.5		11.8		2.5
Chemical	28	1002.2	581	40.7	91.5	26.5	9.1	2.6		11.6		2.9
Textiles	22	991.0	871	40.7	111.9	26.4	11.3	2.7		11.9		2.7
Metals	33	1234.8	984	40.7	249.7	67.7	20.4	5.5		23.6		6.2
Lumber	24	612	527	40.7	149.1	54.6	24.9	9.1		26.9		9.8

* Incidence rates computed as events per 100 full-time employees.

1) Computed from Incidence Rates.

Statistical data from the American Petroleum Institute (API) were examined next. The differences in collecting and presenting data by the API make it difficult to compare with data from BLS. Using the API system of reporting, a company could report its injury and illness statistics using several SIC codes. For example, injuries occurring while two employees were engaged in distinct work activities for the same company could be reported using two different SIC codes. The BLS system requires the use of one SIC code by a company at a given site. This is usually determined by the primary work activity at this location.

In the petroleum industry numerous contracting organizations engage in various specialty operations such as exploration, drilling, work-over/maintenance and fire fighting. Under the reporting systems utilized by API and BLS, casualties incurred by a contractor, while performing operations for a given company, would not be reported by that company, even though the incident occurred on its property. The reporting of such casualties would be the sole responsibility of the contractor. Consequently, if a contractor failed to file a report, the event would go undocumented. Since contracting firms specialize in some of the more hazardous petroleum industry operations, it is highly desirable that their injury and accident experience be fully documented. It is expected that this will have a more significant impact upon API statistical data than upon BLS data. If such firms are not API members, then these data will be lost. Theoretically, the BLS includes representation from the entire private sector, so the contribution from petroleum industry contracting organizations should be included in its data.

The API made some minor modifications in presenting its data beginning in 1973 and culminating with its 1974 Annual Summary. Data prior to 1974 are not as detailed as those presented in the years since that time. Table II presents a breakdown of pertinent statistical data available from the American Petroleum Institute. As is the case with the BLS, the API data indicate that the major problem is in extraction and not in refining.

Efforts were made to obtain petroleum industry casualty statistics from the National Safety Council (NSC). The NSC is a nongovernmental public service organization which collects and compiles safety statistics for the purpose of accident prevention. The bulk of its data comes from voluntary reports submitted by its members. However, differences in reporting and compilation

TABLE II
AMERICAN PETROLEUM INSTITUTE
INJURY AND ILLNESS DATA[1]

Year	SIC Code	Number of Employees	Average Weekly Hours	Total Injuries All	Total Injuries Lost Workday	Injury Incidence[2] All	Injury Incidence[2] Lost Workday	Total Illnesses
1976[3]		417,713	40.7	19,301	6,644	4.68	1.91	577
Exploration & Production	1311	60,866	40.8	2,591	894	4.28	1.44	62
Gas Process.	1321	7,084	41	288	75	3.98	1.1	1
Drilling	1381	2,486	40	608	210	24.47	8.77	0
Refining	2911	79,781	40.7	5,030	926	6.58	2.32	307
1975		424,904	40.8	20,673	6,132	4.9	1.74	567
Exploration & Production	1311	54,598	41.3	2,460	732	4.44	1.35	36
Gas Process.	1321	5,927	41.5	299	67	4.87	1.12	1
Drilling	1381	1,918	42.2	515	196	25.45	9.69	0
Refining	2911	81,698	40.2	5,594	912	7.2	2.25	321
1974		406,427	41	20,324	6,226	5.0	1.62	513
Exploration & Production	1311	51,430	41.5	2,418	713	4.62	1.36	48
Gas Process.	1321	5,808	42.1	311	73	5.11	1.19	1
Drilling	1381	1,506	46.8	487	179	27.66	10.2	1
Refining	2911	81,292	40.6	5,212	1,031	6.63	1.66	262

(1) Occupational injuries and illnesses recordable under OSHA record keeping requirements. Recordable cases include:

1) Occupational fatalities regardless of the length of time between injury and death, or the length of the illness; or
2) Occupational illnesses; or
3) Occupational injuries which result in one or more of the following: loss of consciousness, restriction of work or motion, transfer to another job, or medical treatment (other than first aid)

(2) Computed as $I = \frac{N_T \times 200,000}{EH}$

I = incidence rate
N_T = total number of inuuries
EH = total hours worked by employees during period, usually taken as one calendar year.

The 200,000 represents an hourly base for 100 full-time equivalent workers for one year (40 hours pr week x 50 weeks per year x 100 full-time employees).

(3) All API respondents

procedures made the comparison of its data with that from the API and BLS difficult. In addition, the NSC ceased to compile current injury incidence rates for the petroleum industry after 1973. It was slated to resume its reporting of petroleum industry accident data after a revision of its compilation procedures in 1977.

Fatality data from OSHA, API and BLS were also obtained. This was done in order to provide some indication of the degree of coverage of the petroleum industry by each of these organizations. As can be seen in Table III, significant differences do exist.

TABLE III
FATALITY STATISTICS[1]

Organization	1974	1975	1976
OSHA	69	82	95
API	70	50	41
BLS*	210	200	160

* Estimates projected from injury incidence rates and rounded to the nearest ten.

[1] Totals are the sum of deaths for major SIC groups 1300 and 2900.

3.2 REVIEW OF CASE HISTORY DATA

In order to obtain causative information on accidents and injuries in the oil and gas industry, it was necessary to collect and review case histories of previous accidents. A number of these are presented in Appendix E.

A review of such data revealed that the amount of causative information contained in an accident report varied directly with the severity of the incident. Incidents which received national media coverage contained the most detailed information.

Incidents were selected to illustrate an operation or area in which a problem seemed to exist. The incidents were grouped in one of three categories according to the general operational area in which the incident occurred:

1) Exploration and extraction - onshore, offshore;
2) Processing - petroleum, gas, petrochemicals;
3) Storage - petroleum, gas, petrochemicals.

3.2.1 Extraction Sites

The most widely recognized occurrence which is likely to produce casualties at an extraction site is the blowout. A blowout is an uncontrollable flow of fluids from a wellhead or wellbore due to the unbalanced high pressure in the reservoir. Many blowouts seem to occur during workovers, i.e., routine maintenance and repair operations performed during temporary production interruptions. One reason for the relatively high incidence of blowouts during workovers is that safety equipment is often removed during these operations. Most wells are equipped with "choke valves", whose purpose is to shut off the flow of fluid in case of a sudden increase in pressure from the reservoir. These types of devices are removed during workovers to allow equipment to move freely in the wellbore.

A blowout is a hazardous event under any circumstances but, if ignition of the petroleum or gas occurs, the results can be disastrous. Wells can burn for weeks or months before being extinguished. In these cases, the casualty list can include fire fighters as well as petroleum workers.

While blowouts are the most publicized events in oil and gas operations, the majority of accidents occurring at extraction sites, both onshore and offshore are similar to those in other activities.

Workers on site include welders, electricians, carpenters, pipe fitters, millwrights, heavy equipment operators, and laborers. Consequently, significant hazards exist apart from those associated with fires and explosions. Because of this, it is very difficult to categorize these incidents. Most injuries are not the result of a catastrophic incident. Instead they are usually the result of falls, lifting heavy objects and contact with high voltage or hot surfaces by one individual.

3.2.2 Processing Facilities

Problem areas in processing include operations involving furnaces or heated reactor vessels, pumps and piping. There are many variations in types of equipment utilized in the processing of oil, gas and petrochemicals and there are no readily identifiable problems because of the general lack of specific detail in the incident reports. The difficulty arises when the product escapes containment.

Of the types of equipment involved in accidents, furnaces and pumps are most frequently singled out as malfunctioning units. The large volume of petroleum products handled by this equipment makes any malfunction a serious one.

The number and proximity of personnel to the defective equipment are the primary factors contributing to the number of casualties.

Repairs on process and storage equipment during shutdown are significant contributors to accident and injury rates and deserve special mention. Flammable liquids and gases remain in vessels and can be ignited during repairs or maintenance operations.

3.2.3 Storage Areas

Tank farms and storage areas for large quantities of petroleum and petrochemicals represent a slightly different hazard than those encountered in other operational areas Usually, no significant numbers of personnel are assigned to these locations so that the risks to operators is reduced. However, once material has spilled or been ignited, the prime candidates for casualties are the emergency response units such as the plant emergency organization, municipal fire fighters and rescue squads. Very often, in the cases of fires and explosions, they are dealing with an unpredictable phenomenon.

Tanks may release burning liquids or vapors, or have fires surround them for hours without incident, but then, under seemingly identical circumstances, these tanks will rupture violently. There have been cases where this occurred and resulted in multiple fatalities and injuries.

3.3 ANALYSIS OF THE DATA SET

The data set was partitioned in numerous ways in order to provide for analyses. Printouts of the various partitions run for these analyses are presented in Appendix D.

The American Petroleum Institute was the largest single source of incident detail and, therefore, influenced greatly the conclusions drawn from analysis of the data. Approximately 48% of the API incidents were fire events. An additional 32% were fires with a spill mentioned somewhere in the scenario. Equipment failure was cited as the primary cause for 62% of the mishaps. Process malfunction, the second largest category, was responsible for 12% of the incidents. The API reported a total of 147 injuries and 239 fatalities (production personnel only) over the years 1973 through 1977. The totals reported by API for the entire industry (production plus non-production personnel) are, of course, significantly higher. Of the reported incidents only 7% involved an injury and only 6% resulted in a fatality. A comparison of fatalities to injuries leads to the conclusion that "serious" incidents, i.e., those involving major property damages or loss of life, are more likely to be included in API data than high-frequency but low-severity occurrences.

Data from reports by the Occupational Safety and Health Administration accounted for 16% of the incidents. The OSHA incidents were all subject to the OSHA reporting guidelines. This is reflected in the breakdown of the data. Approximately 77% of the OSHA incidents were personnel accident cases. Only 11% were fire cases. The most frequently listed cause for all incidents was "other" which accounted for 41% to the incidents. Another 16% were listed with "unknown" as the primary cause. This is not necessarily a reflection of the completeness of the OSHA reports, rather it reflects the vagueness of the automated summaries which were used in reviewing the data. The OSHA incidents covered the years from 1974 through July, 1977. There were a total of 302 incidents involving 128 injuries and 292 fatalities. As in the API data the ratio between fatalities and injuries shows that OSHA is primarily interested in the serious mishaps.

The U.S. Geological Survey (USGS) provided the offshore incidents, roughly 85% of which were fires. The primary causes of these incidents were grouped under several different categories (see Appendix C). Equipment failure and "unknown" causes each accounted for 28% of the events. Another 14% were caused by process malfunction and 12.5% were attributed to personnel error. The 263 incidents reported by the USGS involved 191 injuries and 51 fatalities. These incidents occurred between the years 1970 to 1977.

Any conclusions drawn will be somewhat biased because of a nonrepresentative data base. The bulk of the data obtained were fire incidents (See Figure 1).

A graph showing the severity of recorded incidents by operational activity (See Figure 2) provides an excellent illustration of the lack of a significant spread between injuries and fatalities for each of the operational areas. This indicates that a large percentage of the high-frequency, low-severity accidents were not included in the data base.

An inspection of the BLS injury and fatality data presented in Table I shows injury counts of 52,000 to 62,000 per year for the years 1974 through 1976 for the petroleum industry (SIC Codes 13 and 29). The fatality counts during the same period were estimated by BLS to be between 160 and 210 for the same SIC major categories (Table III). On the other hand, figures from the API (Table II) show injury counts of about 28,000 per year with fatalities averaging about 55 per year.

Certain injuries likely to occur in most other manufacturing areas are also likely to occur in the gas and oil industries. Petroleum industry casualty data should include trips/falls, strains and overexertions which are the most frequently listed causes of industrial injuries. Unfortunately, only a few of these types of injuries are included in the data base. Burns represented the single most frequently listed cause of trauma for the incidents in the collected data. However, the burns accounted for just over 5% of total injuries. Over 92% of the injuries were listed as either unknown or unspecified.

An effort was made to determine the primary fuel involved in the collected incidents. Gases (unspecified) were reported in 7% of the incidents. Finished gasoline involved approximately 5%. Oil (unspecified) was identified in

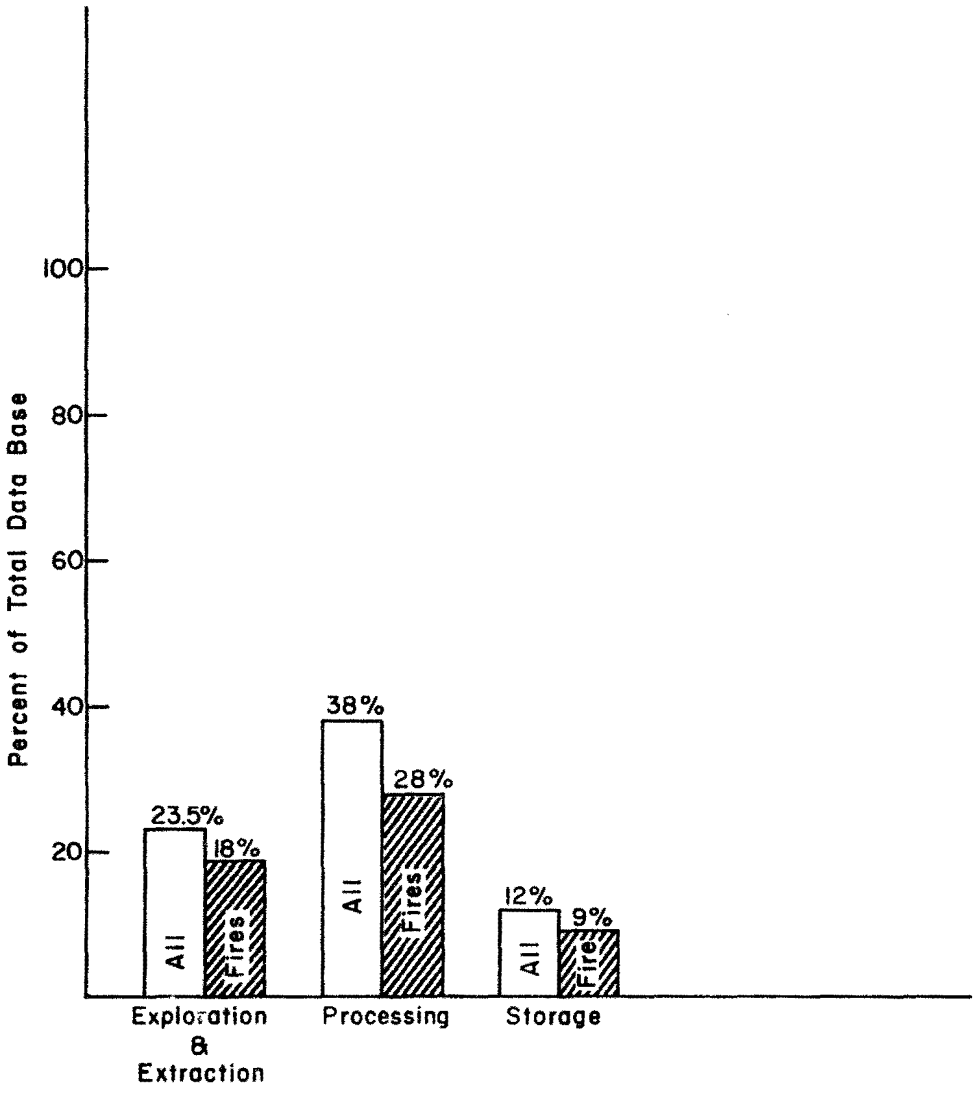

FIGURE 1 DISTRIBUTION OF INCIDENTS BY OCCUPATIONAL AREA

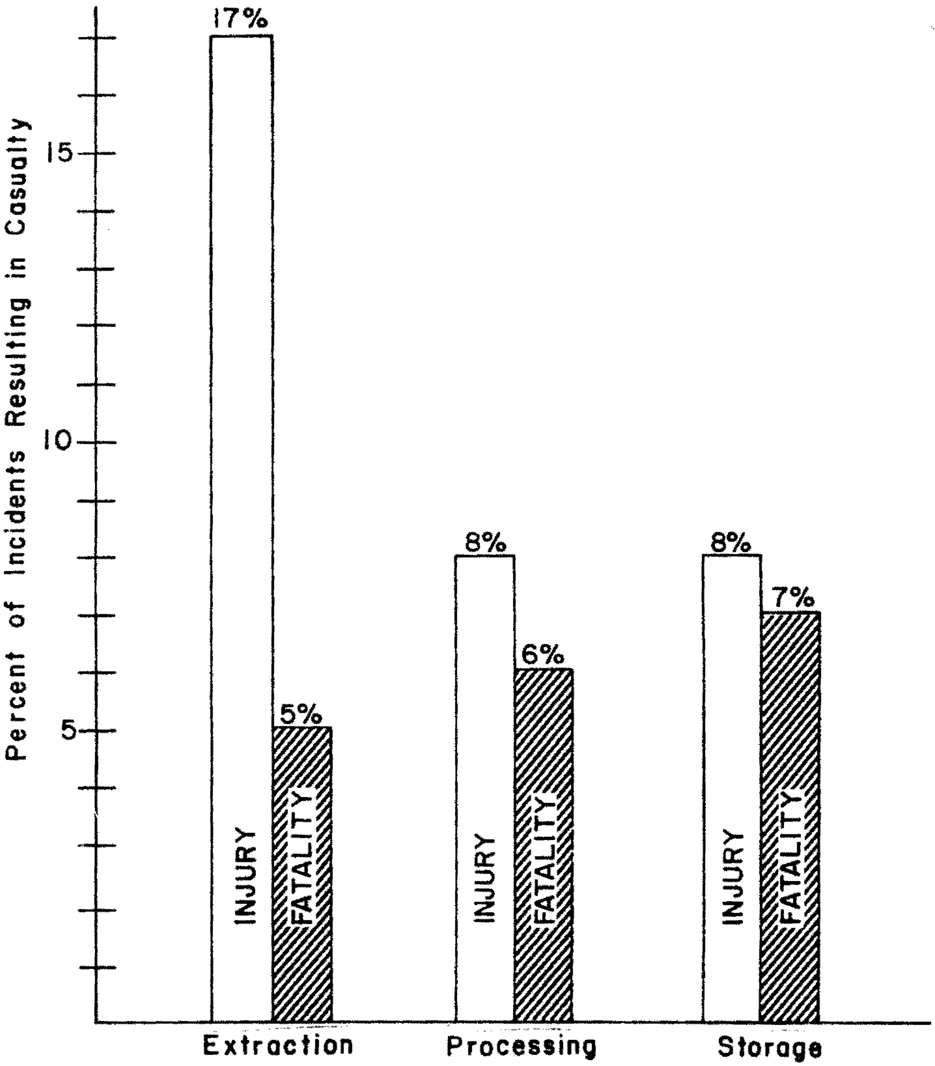

FIGURE 2 DISTRIBUTION OF CASUALTIES BY OCCUPATIONAL AREA

4% of the cases and naphtha was named in 2%. Approximately 17% of the incidents involved no petroleum product at all. The bulk of the data reported unknown or unspecified petroleum products.

To assist the analysis of the data set, the incidents were divided into three categories according to the operational area in which the incident took place: 1) Exploraton and Extraction, 2) Processing, and 3) Storage. A breakdown of the casualty statistics is given in Table IV.

3.3.1 Exploration and Extraction

Incidents clearly defined as having occurred during exploration activities represented less than 1/2% of the data set (8 incidents). Six of these were either a fire or an explosion. Data on this operational area comes primarily from the API. The BLS combines exploration data with its extraction category, making it impossible to separate the two.

Approximately 23% (442 incidents) of the data set were incidents occurring at extraction sites. This figure includes the operational activities separately listed as 1) Development, 2) Field Production, and 3) Extraction(1). Over 347 of these incidents were fires (See Figure 1). The most frequently listed causes were equipment failure and process malfunctions.

According to our data base, nearly 17% (75) of all extraction site incidents resulted in at least one injury. Of these incidents, offshore operations were responsible for 65 injury-causing events and only 10 were attributed to onshore extraction sites. A total of 197 injuries occurred at extraction sites. The bulk of these injuries were reported by offshore platforms with 171 cases. The remaining 16 were reported by onshore facilities. Four high-severity mishaps(2) combined for a total of 74 of the 197 injuries reported. All four of these occurred on off-shore platforms.

Just under 5% (21) of the extraction site incidents involved at least one fatality. A total of 89 fatalities were reported as occurring at extraction sites, representing slightly more than 12% of the 726 fatalities in the data base. Sixty-one of these were reported by offshore platforms. Three high-severity incidents(2) produced 42 of the documented fatalities. Off-shore platforms reported two of these high-severity incidents which claimed 32 lives.

(1) See Appendix C, page 6.
(2) Ten or more casualties.

TABLE IV
DISTRIBUTION OF INCIDENTS AND CASUALTY STATISTICS

Operational Area	Number of Incidents	Percentage[1] (%) of Data Base	High Severity Occurrences[2] Involving Injuries		High Severity Occurrences[2] Involving Fatalities	
			Incidents	Count	Incidents	Count
Exploration and Extraction	450	25%	4	74	3	42
Processing	716	38%	4	63	9	116
Storage	138	12%	3	42	1	40

[1] Incidents in which the operational area was unknown or unspecified accounted for approximately 25% (470).
[2] Ten or more casualties.

3.3.2 Processing

Nearly 38% of the incidents in the data base occurred during processing. A total of 716 incidents were recorded either during processing or during the transfer of the material to and from processing sites (excluding transportation accidents). Approximately 8% of the recorded incidents involved an injury. Four of these were high-severity mishaps accounting for a total of 63 injuries. Six percent of the recorded incidents caused at least one fatality. There were nine high-severity occurrences resulting in a total of 116 deaths. Interestingly, the injury and fatality totals were each 198. Processing accounted for over 29% of the total injuries and approximately 27% of the total fatalities.

Approximately 45% of all incidents collected for this category were classified as fires; another 28% were spills involving fires. The most frequently listed cause of the fire incidents was equipment failure (45%). Nearly 25% of those incidents which reported equipment failure named furnaces (11%) and pumps (14%) as the malfunctioning units. Piping, hoses and fittings malfunctioned in an additional 6% of the reported incidents and faulty tanks accounted for approximately 4%.

3.3.3 Storage

Slightly over 12% (138) of all incidents collected occurred in storage areas. The largest percentage were fires (62 %) and fire/spill events (14 %). The most frequently listed causes of these incidents were equipment failure (42%) and personnel error (10%). Storage tanks failed in almost 40% of the incidents. Vaporizers failed in 12% of the documented cases.

Less than 8% of the incidents occurring in storage areas involved an injury; a total of 68, of which 42 came as results of three separate high-severity incidents. Approximately 7% of the total incidents involved a fatality; 58 being reported as occurring in storage areas. Forty of these occurred in one incident. These casualty figure for storage areas represent 20% of the total injuries and 8% of the total fatalities documented in the data set.

IV

CONCLUSIONS

During the conduct of this project the major work effort was directed toward the review and collection of existing petroleum industry safety and health data. Conclusions relating to this effort are presented first.

A review of existing safety regulations and standards show that the API issues the most comprehensive set of standards and recommended practices in this country. Outside the United States, the Institute of Petroleum in Great Britain provides a fairly complete set of Safe Practice codes. Insurance companies provide guidelines to their insureds in the petroleum industry, but these are usually proprietary.

On-going research projects which undertake the study of accidents and injuries in the petroleum industry are virtually nonexistent.

The bulk of the recorded data came from the API, OSHA, and USGS. The largest percentage of these data were fire-related incidents (fire, fire/spill and explosions).

The most detailed incidents tended to be the low-frequency, high-severity occurrences. Even these were sanitized to exclude names of persons, places, and organizations. There was very little documentation of high-frequency, low-severity incidents.

Statistical data from the BLS, even when adjusted to exclude non-production personnel, and from the API show that injury incidence rates for refining (SIC 2911) are not significantly different from averages computed for the entire private sector.

At present there is no system for determining any correlation of reported petroleum industry occupational illnesses with any inherent job hazard. Even more significant is the fact that there is no one comprehensive data source from which petroleum industry injury and illness data can be secured.

Analysis of the data set revealed several trends of interest. It must be reiterated that these conclusions are drawn from a data set biased in favor of 1) low-frequency, high-severity incidents, 2) fire events, and 3) injuries, instead of a realistic mix of injuries and illnesses.

From an inspection of the data, there appears to be a significant injury problem in the area of extraction (See Figure 2). According to the collected data, 17% of the extraction site incidents result in at least one injury. Data on extraction sites available from the BLS and API also give indication of safety problems at extraction sites.

Incidents in processing areas represented the largest block of data in the set. Nearly three-quarters of these were fire-related. The most significant information obtained from the analysis of processing incidents was the identification of furnaces and pumps as potential hazards; this was substantiated by a review of case histories.

Storage areas present the least hazard to petroleum industry personnel due, in part, to minimal exposure in these areas. The most frequently listed (42% of the total) cause of incidents was equipment failure. However, the potential for major catastrophe is increased in these areas due to the high concentration of flammable and explosive products.

Causal information shows that the primary cause of all incidents was equipment failure which was responsible for over 43% of the total. Process malfunctions were the second leading cause with approximately 10% of the total. Personnel error was attributed to over 9% of the recorded incidents.

With the possible exception of the extraction area casualty figures, it is difficult to draw conclusions using the available injury and fatality data.

The differences in fatality rates shown in Figure 2 are not significant enough to indicate a trend. However, early in this program an attempt was made to correlate the number of deaths reported by each agency to that agency's degree of coverage of the petroleum industry. As can be determined from Table III, there are significant differences in the numbers of fatalities reported by OSHA, API and BLS.

Of the three organizations, only OSHA has mandatory reporting requirements. A work-related fatality must be reported to an OSHA office within 48 hours of such an occurrence. However, there have been questions regarding industry strict compliance with these regulations in the past.(1)

The API gathers its data from voluntary reports submitted by its members on a yearly basis. API provided the best causal information and claims to represent 90 to 95% of the petroleum industry. However, the injury and fatality counts given by API were consistently lower than those of other sources.

(1) "National Safety Council and BLS Procedures for Estimating Work Accident Fatalities", Statement to Senate Subcommittee on Labor, July 22, 1974.

The differences in reporting and presenting data by this organization explain the discrepancies and these are mentioned in Section III.

The fatality counts given by the BLS are significantly higher than those of the other two organizations for a given year. The fatality figures are also the result of an estimation procedure similar to the one used to determine injury incidence rates.

V

RECOMMENDATIONS

Although a credible number of incidents were documented and analyzed during the conduct of this research effort, a significant discovery was that this number represented only a small biased percentage of the total accident and injury cases. Consequently, most of the recommendations deal with the issue of acquiring the data needed for an effective analysis of the injury and illness situation in the petroleum industry. With this in mind the following recommendations are offered:

1. Analysis of the data collected for this study reveals that the mechanical problem of furnaces and pumps is significant enough to warrant further attention. In order to define the extent of hazards associated with the use of this equipment, a study of the various types of furnaces and pumps used in the petroleum and gas producing industry should be conducted. Topics to be addressed are: 1) the failure rates of furnaces and pumps versus the failure rate of other types of equipment used in oil and gas producing operations; and 2) the identification (type, manufacturer, etc.) of the malfunctioning equipment in an attempt to identify problem makes or models. At present the best available data have identified this equipment in generic terms only and no data exist which will provide a profile of operating equipment used in the petroleum and gas producing industry.
2. Since most of the historical accident data were lacking in the details necessary to determine causal factors, a reporting system which collects and updates accident cause information on, at least, an annual basis should be instituted. This is particularly applicable to the high-frequency, low-severity accidents occurring in the petroleum and gas industry.
3. At present there is very little information regarding petroleum industry illnesses. A system should be developed which will provide for the reporting and compilation of petroleum industry illness data.

4. Currently, the bulk of injury and illness data appear to be collected and presented by Standard Industrial Classification (SIC) codes or by operational area. The collection of these data within other variables should be investigated; for example, collection of injury and illness data by occupation, type of trauma, or type of incident would simplify the task of determining where the more serious problems occur.

5. The data collection system should be continued as begun in this project with the most detailed and recent data available, including the use of newspapers and journals. The task of reviewing historical accidents is complicated by the lack of detail in all but the most severe cases. Documenting recent accidents on a continuous basis would, at least, partially remedy this problem. As better reporting systems are developed and initiated, the data collection system used for this project would be capable of incorporating the new and more detailed information.

6. For particular areas of interest where more immediate answers are needed, an extensive survey should be conducted using a combination of questionnaire and on-site visits. Specific questionnaires should be sent to petroleum and gas producers, local and state agencies for the purpose of collecting new data and clarifying data already collected. Follow-up on-site visits could be used whenever warranted. During the conduct of this study, it was found that, while some organizations possessed relevant data on file, they were unable to provide this information due to the absence of the necessary manpower on their part and the time constraints imposed by the contract on ours.

APPENDIX A

EXISTING SAFETY REGULATIONS AND STANDARDS FOR THE PETROLEUM INDUSTRY

NATIONAL FIRE PROTECTION ASSOCIATION

STANDARDS

54	National Fuel Gas Code
58	Liquefied Petroleum Gases, Storage and Handling
59A	Liquefied Natural Gas, Storage and Handling
70	National Electric Code
704	The Fire Hazards of Materials
30	Flammable and Combustible Liquids Code
78	Lightning Protection Code

RECOMMENDED PRACTICES

329	Underground Leakage of Flammable and Combustible Liquids
325M	Properties of Flammable Liquids, Gases, Solids
77	Static Electricity
497	Electrical Installations in Chemical Plants

OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION

Part 1910, Title 29 of the Code of Federal Regulations

BRITISH STANDARDS INSTITUTION

CP3013: 1974, Code of Practice For Fire Precautions In Chemical Plants, July 1974.

AMERICAN PETROLEUM INSTITUTE

STANDARDS

12B	Specification for Bolten Production Tanks, 11th Edition, May 1958.
12D	Specification for Large Welded Production Tanks, 7th Edition, Aug. 1957.
12F	Specification for Small Welded Production Tanks, 6th Edition, Mar. 1968.
526	Flanged Steel Safety Relief Valves, 2nd Edition, Nov. 1969.
607	Fire Test for Soft-Seated Ball Valves, 1st Edition, Sept. 1977. (Tentative)
620	Recommended Rules for Design and Construction of Large, Welded, Low-Pressure Storage Tanks, 5th Edition, July 1973. Supplement No. 2 to 5th Edition, Dec. 1974. Replaced by 6th Edition, Aug. 4, 1977.
650	Welded Steel Tanks for Oil Storage, 5th Edition, July 1973. Supplement No. 1, 5th Edition, Oct. 1973. Supplement No. 2, 5th Edition, Aug. 1974. Replaced by 6th Edition, Aug. 4, 1977.
1104	Standard for Welding Pipe Lines and Related Facilities, 12th Edition, December 1971. (Met. Lab. has 5 copies)
2000	Venting Atmospheric and Low-Pressure Storage Tanks (Refrigerated) 2nd Edition, Dec. 1973.
2023	Guide for Safe Storage and Handling of Heated Petroleum-Derived Asphalt Products and Crude Oil Residue, March 1977.

RECOMMENDED PRACTICES

500A	Classification of Areas for Electrical Installations in Petroleum Refineries, 3rd Edition, April 1966.
510	Inspection, rating and repair of pressure vessels in petroleum refinery service, July 1975 (3rd Edition).
520	Design and Installation of Pressure-Relieving Systems in Refineries, Part I--Design, Dec. 1976. Part II--Installation, Jan. 1963.
521	Guide for Pressure Relief and Depressuring Systems, Sept. 1969.
2003	Protection Against Ignitions Arising Out of Static, Lightning, and Spray Currents, Sept. 1967.

STANDARDS

2015	Cleaning Petroleum Storage Tanks, 2nd Edition, Nov. 1976.
2021	Guides for Fighting Fires In and Around Petroleum Storage Tanks. First Draft, May 1974.
2510	Design and Construction of LP-Gas Installations at Marine and Pipeline Terminals, Natural Gas Processing Plants, Refineries, and Tank Farms, 3rd Edition, May 1970.

INSTITUTE OF PETROLEUM

PART	CODES OF SAFE PRACTICE IN THE PETROLEUM INDUSTRY
1	Electrical Safety Code
2	Marketing Safety Code
3	Refining Safety Code
4	Drilling and Production
6	Petroleum Pipelines
8	Drilling and Production in Marine Areas
9	Liquefied Petroleum Gas
10	Storage and Piped Distribution of Heating Oil

European Petroleum Organizations

Part 1: Operations	European Code of Safe Practice in the Storage and Handling of Petroleum Products

APPENDIX B

ON-GOING RESEARCH INTO INJURY AND ILLNESS PROBLEMS IN THE PETROLEUM INDUSTRY

Underscoring indicates items of special interest.

C002039 SSIE NO.: ZMA 905 1
REPORT OF CHARACTERIZATION OF ORGANIC EMISSIONS FROM PETROCHEMICAL SOURCES
INVESTIGATORS: BARNES HM
PERFORMING ORG: U.S. ENVIRON. PROTECTION AGCY.,ENVIRON. SCIENCES RES. LAB.,DURHAM,NORTH CAROLINA,27711
SPONSORING ORG: U.S. Environmental Protection Agency,Office of Research & Development,Environmental Sciences Research Lab.,Research Triangle Park,North Carolina,27711
MONITOR: Nader JS
CONTRACT/GRANT NO.:G7128-BD-14
1/76 TO 9/78 FY: 78 FUNDS: $20,000

The objective of this task is to quantitatively and qualitatively determine the gaseous organic emissions from various petrochemical sources, principally those involving chemical processing..

Initial investigations involve studies at stationary sources emitting halocarbon compounds.. The two sources examined thus far include a solvent degreaser using trichloroethylene and one using methylene chloride.. Sequential samples are collected both at the point emission sources and at downwind fenceline locations and analyzed for halocarbons using GC/MS techniques..

Currently, a preliminary report on hydrocarbon characterization data available in the literature as well as a discussion of on-going programs within EPA, was issued in 8/76.. A halocarbon emissions measurement report will be issued in 7/77..

DESCRIPTORS:
Nonresearch & Selected Topics, 2.Literature Search
Substances, 3.Trichloroethylene
Organic Compounds, 2.Aliphatic Compounds, 3.Halides, 4.Chloride, 5.Methylene Chloride
Chemical Kinetics & Mechanisms, 2.Reaction Media, 3.Gaseous
Chemical Engineering, 2.Petroleum Research, 3.Refining Processes, 4.Refining Process -other:, Petroleum Chemicals:, 2.Safety, 3.Occupational Saf
Chemistry - Specialized Fields, 2.Chemistry -major Fields, 3.Chemical Engineering
Air Pollution, 2.Sources of Air Pollution, 3.Industrial Sources, 4.Chemical Industry:, 2.Types of Pollutants, 3.Gases, 3.Organic Compounds, 3.Stack Emission - Flue Products
Applications of Materials, 2.Lubricants and Fluids, 3.Greases
Surface Cleaning, Finishing, 2.Chemical Cleaning
Chemical Processing, 2.Chemical Processing -general

0300726 SSIE NO.: GMA 3957 1
EVALUATION OF LINER MATERIALS EXPOSED TO HAZARDOUS AND TOXIC SLUDGES
INVESTIGATORS: HAXO HE; GOLUEKE CG; WHITE RM
PERFORMING ORG: MATRECON INCORPORATED,2811 ADELINE ST.,OAKLAND,CALIFORNIA,94608
SPONSORING ORG: U.S. Environmental Protection Agency,Office of Research & Development,Municipal Environmental Research Lab.,26 W. St. Clair St.,Cincinnati,Ohio,45268
MONITOR: Landreth RE
CONTRACT/GRANT NO.:68-03-2173; C618A-7005
2/75 TO 11/78 FY: 78 FUNDS: $74,000

OBJECTIVE: To determine the effective lives of twelve pond liner materials exposed to a variety of nonradioactive industrial hazardous wastes.
APPROACH: To expose specimens of liners sealed at the bottom of individual test cells to six different hazardous wastes to determine seepage through liners and changes in physical properties over twenty-four months.
CURRENT PLANS: To seal six polymeric liners and six admix and soil liners in cells for exposure to six different sludges containing hazardous waste streams., The six polymeric liners will include polyvinyl chloride, butyl rubber, chlorosulfonated polyethylene, chlorinated polyethylene, ethylene propylene rubber and neoprene., The soil and admix liner materials will include a bentonite clay seal, an emulsified asphalt seal, a soil cement, an hydraulic asphalt concrete, a compacted fine grain soil and a sixth liner to be selected., The hazardous wastes will include a strong acid, a strong base, a pesticide, an oil refinery tank bottom waste containing scale, lead wastes from gasoline tanks and a cyclic hydrocarbon sludge., Seepage through the liners will be assessed over twenty-four months and exposed liner specimens will be demounted at intervals and then physical properties determined for comparison with original properties.,

DESCRIPTORS:
Pesticides, 2.General Classifications, 3.Pesticides -nonspecific
Substances, 2.Toxic Substances, 3.Toxic Substances -nonspecific, 3.Bentonite
Soil Mechanics, 2.Soil Types, 3.Soil Cement
Organic Compounds, 2.Aliphatic Compounds, 3.Halides, 4.Chloride, 5.Chlorides -other;, 2.Poisons, Toxic Compounds, 3.Pesticides
Organic Sulfur Compounds, 2.Sulfonic Acids and Derivatives, 3.Sulfonates
Polymer Chemistry, 2.Organic Polymers, 3.Chloropolymers, 3.Polyethylene, 3.Polypropylene, 3.Polyvinyl Chloride, 3.Organic Polymer -other;, 2.Polymer Type -other
Chemical Energy Conversion, 2.Fuels, 3.Hydrocarbon Fuels, 4.Gasoline
Chemical Engineering, 2.Safety, 3.Hazardous Materials
Waste Water Treatment/Disposal, 2.Source of Wastes, 3.Industrial Wastes, 4.Chemical Manufacturing Wastes, 4.Petroleum Wastes;, 2.Sludge Treatment & Disposal, 3.Sludge Disposal, 4.Sludge Disposal -other;, 3.Sludge -other
Chemical & Physical Properties, 2.Physical & Chemical Properties, 3.Phys. & Chem. Properties -gen.
Chemistry - Specialized Fields, 2.Chemistry -related Fields, 3.Environmental Chemistry
Energy Research, 2.Energy Cross Refer., 3.Fuel Storage
Physical Properties- Materials, 2.Physical Properties -general
Applications of Materials, 2.Sealants, Seals
Miscellaneous Materials, 2.Asphalt Concrete, 2.Bituminous Materials
Elastomers, 2.Neoprene, 2.Rubber -synthetic
Elements & Inorganic Compounds, 2.Acids - Inorganic, 3.Acid -inorganic Non-specific;, 2.B Sub-group, 3.Lead, 4.Lead;, 2.Bases, 3.Bases -other

0297525 SSIE NO.: WX 696 1
OCCUPATIONAL MALIGNANCIES AMONG PETROCHEMICAL WORKERS OF ALBERTA
INVESTIGATORS: GRACE MG; FINCHAM S ; EGEDAHL R
PERFORMING ORG: W.W. CROSS CANCER INSTITUTE,BIOSTAT ANALYS & CANC REGISTRY,11560 UNIVERSITY AVE. T6G 1Z2,EDMONTON, ALBERTA,CANADA
SPONSORING ORG: Supporting Organization Not Reported,Country not reported
CONTRACT/GRANT NO.:D-IARC-78-64
0/77 TO 0/79 FY: 78 FUNDS: NA

A study is being designed to demonstrate possible relationships between occupational exposure to carcinogenic substances and cancer incidence and mortality in Alberta., Retrospective data will be collected on approximately 1,800 members of the Oil, Chemical and Atomic Workers Union, and on an unexposed control group similar in size and other characteristics. Sources of data will be union and employers records, vital statistics, the Provincial Cancer Registry and Patient Index System., Persons with occupational radiation exposure are excluded from the study.,

DESCRIPTORS:
Public Health, 2.Epidemiology of Disease, 3.Environmental Health, 4.Occupational Hazards
Cancer, 2.Carcinogenesis, 3.Environmental Carcinogenesis;, 2.Cancer Epidemiology
Test Animals, Human, 2.Homo Sapiens - Modern

C217630 SSIE NO.: CY 589
ANALYSIS, SCREENING, AND EVALUATION OF CONTROL TECHNOLOGY FOR WASTEWATER GENERATED IN SHALE OIL DEVELOPMENT
INVESTIGATORS: DAWSON GW; MERCER BW
PERFORMING ORG: BATTELLE MEMORIAL INSTITUTE, WATER & LAND RESOURCES, P.O. BOX 999, RICHLAND, WASHINGTON, 99352
SPONSORING ORG: U.S. Energy Research & Development Admin., Div. of Environmental Control Technology, Washington, District of Columbia
CONTRACT/GRANT NO.: EY-76-C-06-1830
10/76 TO 9/77 FY: 77 FUNDS: NA

The program is designed to identify the capabilities of current technology to produce environmentally acceptable discharges from shale oil development wastewaters.. Wastewaters related to shale oil development will differ significantly from those of the petroleum industry.. Should improper or inadequate treatment technology be employed, shale oil development may threaten then quality of ground and surface waters with high dissolved solids levels, oxygen demand, and toxic trace materials.. Experimental data will be generated utilizing bench and pilot-scale facilities to prepare mine and in situ retort waters for surface discharge, groundwater recharge, or land spreading.. Work will focus on wastewaters from the Wyoming and Colorado tracts..
RESULTS: A critical evaluation of wastewater treatment needs has been written identifying the areas of concern and some of the likely technologies which can be applied..

DESCRIPTORS:
Substances, 2.Toxic Substances, 3.Toxic Substances -nonspecific
Chemical Engineering, 2.Petroleum Research, 3.Shale Oil:, 2.Process Development, 3.Bench Scale
Waste Water Treatment/Disposal, 2.Source of Wastes, 3.Industrial Wastes, 4.Petroleum Wastes:, 2.Characteristics of Waste Water, 3.Biological Oxygen Demand, 3.Total Dissolved Solids:, 2.Waste Water Treatment, 3.Waste Treatment -general:, 2.Waste Water Disposal, 3.Artificial Recharge, 3.Land:, 2.Sewage System- Treatment Plant, 3.Sewage Treatment Plants, 4.Effluent Standards, 4.Pilot Plants
Chemistry - Specialized Fields, 2.Chemistry -related Fields, 3.Petroleum Chemistry
Energy Research, 2.Fossil Fuels and Sources, 3.Oil Shale:, 2.Environmental Aspects
Economic Geology, 2.Deposits - Non-metallic, 3.Oil Shale
Water Resources, 2.Environment - Locale Parameter, 3.Industries, 4.Mineral Processing Industry, 4.Mining Industry:, 2.Types of Water, 3.Groundwater, 3.Surface Water:, 2.Water Quality, 3.Pollution Sources, 4.Mining Activities:, 2.Water Supply, 3.Recharge -water, 4.Artificial Recharge
Geographic Locations, 2.North America, 3.Colorado, 3.Wyoming

0211227 SSIE NO.: ZXC 1176

STUDIES OF OCCUPATIONAL CANCER
INVESTIGATORS: DECOUFLE P ; DECOUFLE P ; BLAIR AE; THOMAS TL ; GRAUMAN DJ; MASON TJ
PERFORMING ORG: U.S. DEPT. OF HLTH. ED. & WEL., NATL. CANCER INSTITUTE, FIELD STUDIES & STATISTICS SEC, BETHESDA, MARYLAND, 20014
SPONSORING ORG: U.S. Dept. of Health Education & Welfare, Public Health Service, National Inst. of Health, National Cancer Inst., 9000 Rockville Pike, Bethesda, Maryland, 20014
CONTRACT/GRANT NO.: Z01-CP-04480-01-EEB
10/76 TO 9/77 FY: 77 FUNDS: NA

This project concerns identification of unusual patterns of cancer within specific occupational groups that may be indicative of exposure to hazards in the work environment.. Study groups are selected for a variety of reasons including 1) known or potential exposure to established or suspect carcinogenic substances, 2) prior case reports and case-control studies suggesting an unusual cancer experience for the group, 3) availability of existing sources of data for defining a population-at-risk.. Data sources include employment and death records maintained by companies, membership and death listings maintained by labor unions and professional organizations, and state licensing records.. Studies underway include cohort mortality studies of persons employed in dry cleaning establishments, men employed in different work areas of large manufacturing plant (machinists, foundry workers, welders, platers), and persons exposed to benzene and other chemicals in a single chemical production plant.. Proportionate mortality studies are being conducted for workers in the petrochemical industry and pharmaceutical and biological manufacturing, chromate painters and leather workers..
BIBLIOGRAPHIC REFERENCE: Decoufle, P., Lloyd, J.W., and Salvin, L.G.: Causes of Deaths Among Constuction Machinery Operators., J. Occup. Med. 19: 123-128, 1977..

DESCRIPTORS:
Public Health, 2.Epidemiology of Disease, 3.Environmental Health, 4.Occupational Hazards:, 3.Statistical Studies, 4.Morbidity, 4.Mortality:, 2.Preventive Medicine, 3.Case Finding
Cancer, 2.Carcinogenesis, 3.Environmental Carcinogenesis:, 2.Cancer Epidemiology
Pharmacology, 2.Drug Groups, 3.Carcinogens
Occupations, Populations, 2.Occupations - Other Specific, 3.Factory Workers
Substances, 2.Elements & Inorganic Anions, 3.Transition Metals, 4.Chromium, 5.Chromate:, 3.Benzene
Test Animals, Human, 2.Homo Sapiens - Modern

?210079 SSIE NO.: ZXC 130 8
U.S. CANCER MORTALITY SURVEY
INVESTIGATORS: MASON TJ; MASON TJ; MASON TJ; FRAUMENI JF; HOOVER RN; BLOT WJ; STEPHENSON BL; RAMSBOTTOM RI
PERFORMING ORG: U.S. DEPT. OF HLTH. ED. & WEL.,NATL. CANCER INSTITUTE,ENVIRONMENTAL STUDIES SECTION,BETHESDA,MARYLAND,200-14
SPONSORING ORG: U.S. Dept. of Health Education & Welfare,Public Health Service,National Inst. of Health,National Cancer Inst.,9000 Rockville Pike,Bethesda,Maryland,20014
CONTRACT/GRANT NO.:Z01-CP-04378-03-EEB
10/76 TO 9/77 FY: 77 FUNDS: NA

The objective of this study is to examine the cancer mortality experience in the United States relative to cancer etiology.. Special emphasis is placed upon the selection of areas in the U.S. for intensive stud .. Publications from this area of interest have facilitated the design of ongoing analytical investigations to test specific etiologic hypotheses.. Included among these are studies of lung cancer in coastal Georgia, bladder cancer in New Jersey, colon cancer in rural Nebraska, and liver cancer in southeast Texas., An analysis of cancer mortality among nonwhites revealed striking similarities in geographic patterns for cancers of the breast, colon, rectum, and esophagus.. Site-specific analyses for cancers of the esophagus, buccal cavity and pharynx, and large bowel revealed associations with ethnicity and industry.. Industry-specific studies revealed elevated nasal cancer rates in counties with large numbers employed in the furniture industry, and elevated rates for cancers of the lung, nasal cavity and sinuses, and skin in counties where the petroleum industry is most heavily concentrated.. We are continuing to expand our data sets, both of reported deaths and measures of exposure..

BIBLIOGRAPHIC REFERENCES: Mason, T.J., McKay, F.W., Hoover, R., Blot, W.J., Fraumeni, J.F., Jr.: Atlas of Cancer Mortality Among U.S., Nonwhites: 1950-1969, DHEW Publication No. (NIH) 76-1204, 1976, 142 pp.. Mason, T.J.: Comment on Reserve Mining: Statistical Evaluation of Carcinogens in the Environment., 4:13-17, 1976.

DESCRIPTORS:
Public Health, 2.Epidemiology of Disease, 3.Environmental Health, 4.Geographic Factors:, 3.Statistical Studies, 4.Mortality
Medicine/Psyc.- General Topics, 2.Etiology
Cancer, 2.Carcinogenesis, 3.Environmental Carcinogenesis:, 2.Cancer Epidemiology
Cancer - Body Sites, 2.Digestive S stem Cancer, 3.Esophageal Cancer, 3.Intestinal Cancer, 3.Liver & Biliary System Cancer, 3.Oral Cancer:, 2.Respiratory System Cancer, 3.Lung Cancer:, 2.Urogenital System Cancer, 3.Bladder Cancer
Digestive System, 2.Pharynx, 2.Esophagus, 3.Esophagus -general:, 2.Intestine, 3.Structures, 4.Large Intestine, 5.Colon, 5.Rectum, 5.Large Intestine -nonspacific:, 2.Liver, 3.Liver -general
Respiratory System, 2.Diseases and Conditions, 3.Respiratory Disease -general
Urogenital System, 2.Struct Abnorm Func Ot Than Kid, 3.Urinary Bladder, 4.Urinary Bladder -general
Biometric Parameters, 2.Sex As A Parameter, 3.Sex Comparisons & Differences
Ethnic and Social Parameters, 2.Social Class, 3.Social Class -nonspecific:, 2.Ethnic Parameters -ns.
Regional Parameters, 2.County, 2.Rural Areas
Substances, 3.Petroleum
Test Animals, Human, 2.Homo Sapiens - Modern
Social Sciences, 2.Demography, 3.Demography -other:, 2.Occupation, 3.Occupation -general
Economics, 2.Welfare Economics
Air Pollution, 2.Sources of Air Pollution, 3.Industrial Sources, 4.Industrial Sources -general
Geographic Locations, 2.North America, 3.Maine, 3.Nebraska:, 2.Regional United States, 3.New England
Elements & Inorganic Compounds, 2.Metalloids, 3.Arsenic, 4.Arsenic

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0209288 SSIE NO.: ZMA 1113
TOXICITY TO MARINE ORGANISMS OF PETROCHEMICALS & ENERGY RELATED ORGANIC SOLVENTS DERIVED FROM OFF-SHORE ACTIVITIES & OCEAN DUMPING (ABBREV)
INVESTIGATORS: RICHARDS NL; SCHIMMEL S ; TAGATZ S
PERFORMING ORG: U.S. ENVIRON. PROTECTION AGCY.,GULF BREEZE ENVIRON. RES. LAB.,GULF BREEZE,FLORIDA,32561
SPONSORING ORG: U.S. Environmental Protection Agency,Office of Research & Development,Environmental Research Lab.,Sabine Island,Gulf Breeze,Florida,32561
CONTRACT/GRANT NO.:Q625A-2-2
10/76 TO 9/77 FY: 77 FUNDS: $20,000

Offshore petroleum extraction may affect marine organisms and ecosystems in the Gulf of Mexico and other areas undergoing intensified petroleum exploitation, extraction, and transportation activities. The research objective is to assess the effects of these emissions on marine organisms and communities. Bioassays on single species and communities will be continued on selected components of drilling muds. Work will be initiated on whole drilling muds and other pollutants emitted from extraction activities such as cutting and non-mobilized petroleum hydrocarbons.,

DESCRIPTORS:
Reference Codes, 2.Marine Biology, 3.Marine Animals
Tests and Methods, 2.Other, 3.Bioassays
Substances, 3.Petroleum
Energy Research, 2.Fossil Fuels and Sources, 3.Petroleum;, 2.Environmental Aspects
Economic Geology, 2.Deposits - Non-metallic, 3.Oil - Petroleum
Water Resources, 2.Water Quality, 3.Pollution Effects, 4.Biological, 5.Biology -general;, 3.Water Quality -general
Oceanography, 2.Marine Pollution, 3.Ocean Dumping, 3.Petroleum Wastes - Spillage
Environments, 2.Environmental Factors-geologic, 3.Environmental Impact
Geographic Locations, 2.Oceans, 3.Atlantic Ocean Areas, 4.Gulf of Mexico

0208548 SSIE NO.: WX B29
HISTORICAL DATA BASE FOR ONE COMPANY IN THE PETROLEUM INDUSTRY
INVESTIGATORS: ALDERSON MR; CARTER JT; COOMBES EJ
PERFORMING ORG: INST. OF CANCER RESEARCH,DIVISION OF EPIDEMIOLOGY,CLIFTON AVE. SM2 5PX,SUTTON, ENGLAND,UNITED KINGDOM
SPONSORING ORG: Supporting Organization Not Reported,Country not reported
CONTRACT/GRANT NO.:D-IARC-77-557
10/76 TO 9/77 FY: 77 FUNDS: NA

This project will set up a comprehensive file to examine future queries about the influence of work in a particular process upon mortality from specific diseases., Specific job histories will be obtained for all individuals who have worked at two large refineries for more than one year since these refineries were established., A comprehensive job history will be abstracted and the file will accumulate at the same time data on the plants and processes at each of the refineries including designation of the major variation in the raw materials, intermediaries, and products from each process., Individuals leaving the industry will be traced and the intention is to provide death details for all individuals who have died., This file of data will be primarily used as a computer-based retrieval system to check specific queries about health-risks from various processes., The primary approach will be to relate observed mortality to expected mortality taking into account age, sex, calendar period, and location in the country.,

DESCRIPTORS:
Methodology & Instrumentation, 3.Computer Methods -general, 4.Computers in Medicine
Nonresearch & Selected Topics, 2.Information Centers & Services, 3.Archives
Public Health, 2.Epidemiology of Disease, 3.Environmental Health, 4.Occupational Hazards;, 3.Statistical Studies, 4.Morbidity;, 2.Health Status of Populations
Cancer, 2.Cancer Epidemiology
Substances, 3.Petroleum
Test Animals, Human, 2.Homo Sapiens - Modern

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0208295 SSIE NO.: WX 301 1
INSTITUTE OF PETROLEUM EPIDEMIOLOGICAL SURVEY
INVESTIGATORS: ALDERSON MR
PERFORMING ORG: INST. OF CANCER RESEARCH,DIVISION OF EPIDEMIOLOGY,CLIFTON AVE. SM2 5PX,SUTTON, ENGLAND,UNITED KINGDOM
SPONSORING ORG: Supporting Organization Not Reported,Country not reported
CONTRACT/GRANT NO.:D-IARC-77-556
10/76 TO 9/77 FY: 77 FUNDS: NA

The aim is to monitor background data in order to quantify the overall level of morbidity and mortality and examine the variation from disease in relation to broad categories of work or "environment".. Some twenty companies in the oil industry have agreed to fund an epidemiological study through the Institute of Petroleum.. Present plans are to collect data from eight refineries (three Shell, three BP, one Esso, and one Mobil); details are required about men who have been employed for at least a year from 1950 to 1975, including those who have left the industry, retired, or died.. The analysis will examine mortality rates by cause (taking age, location, and type of work into account).. Comparisons will be made between men doing different work within refineries, and with the mortality data for men in other industries in the same region as each refinery and in the country as a whole.. Such a study can quantify the general mortality (and thus indirectly the overall level of health in the industry).. Examination of material on individual diseases may identify specific issues that warrant detailed study..

DESCRIPTORS:
Public Health, 2.Epidemiology of Disease, 3.Environmental Health, 4.Occupational Hazards;, 3.Statistical Studies, 4.Morbidity, 4.Mortality
Cancer, 2.Carcinogenesis, 3.Chemical Carcinogenesis, 3.Environmental Carcinogenesis;, 2.Cancer Epidemiology
Pharmacology, 2.Drug Groups, 3.Carcinogens
Substances, 3.Petroleum
Test Animals, Human, 2.Homo Sapiens - Modern
Chemical Engineering, 2.Petroleum Research, 3.Refining Processes, 4.Refining Process -other;, 2.Safety, 3.Occupational Safety

0205498 SSIE NO.: GMA 418B
ASSESSMENT OF ENVIRONMENTAL EMISSIONS FROM OIL REFINING
INVESTIGATORS: MESICH F ; ROSEBROOK D
PERFORMING ORG: RADIAN CORPORATION,8500 SHOAL CREEK BLVD.,AUSTIN,TEXAS,78766
SPONSORING ORG: U.S. Environmental Protection Agency,Office of Research & Development,Industrial Environmental Research Lab.,Research Triangle Park,North Carolina,27711
CONTRACT/GRANT NO.:68-02-2147; F604B-5
10/76 TO 9/77 FY: 77 FUNDS: $577,600

The project objectives are to quantify emissions to the environment from petroleum refineries., The discharge concentrations are compared to estimated risk levels in the environment., Emissions data are confirmed within known limits of error by the most appropriate means available., Actual field sampling is a major part of this program., The discharge levels are compared to estimate measures of risk by extrapolation from known adverse effects levels., Interested parties in Government as well as industry are invited to participate in the program to insure the results will be of use to all parties..
Outputs will be reports of emissions data useful for standards setting, offset calculations and estimates of risk from exposure to toxic materials emitted from petroleum refineries..

DESCRIPTORS:
Air Pollution, 2.Sources of Air Pollution, 3.Industrial Sources, 4.Petroleum Industry;, 2.Detection & Measurement, 3.Air Pollution Sampling;, 2.Air Quality Standards
Water Resources, 2.Environment - Locale Parameter, 3.Industries, 4.Petroleum Industry;, 2.Techniques and Instrumentation, 3.Water Sampling;, 2.Water Quality, 3.Water Quality -general, 3.Pollution Sources, 4.Industrial Wastes, 4.Petroleum Wastes - Spillage;, 3.Water Quality Control, 4.Water Standards & Baselines
Environments, 2.Environmental Factors-geologic, 3.Environmental Impact
Techniques and Instrumentation, 2.Field Studies, 2.Sampling

APPENDIX C

CODING MANUAL

FOR

LOSS INCIDENTS REPORTS

LOSS INCIDENT REPORT

NIOSH Contract No. 210-77-0033 FM Serial No. 4A6N8.RG

FILE TRANSACTION CODE (A-Add, C-Change, D-Delete)	[1][ ] 1 2
DATE (YR MO DA)	3 4 5 6 7 8
STATE	9 10
INCIDENT NO.	11
CITY	12 15
TIME HR. : MIN.	16 17 : 18 19
WEATHER: WIND / PRECIP. / TEMP	20 / 21 / 22
INFORMATION SOURCES	23 25
ADDITIONAL SOURCES	26 28
ADDRESS (LOCATION OF INCIDENT)	
SIC	29 32
OPERATIONAL ACTIVITY	33
OCCUPANCY	34
INCIDENT TYPE	35

	OPERATING PERS.		OTHER PLANT PERS.		OTHER PERSONS		UNSPECIFIED		TOTAL	
	INJURIES	FATAL.	INJURIES	FATAL.	INJURIES	FATAL.	INJURIES	FATAL.	INJURIES	FATAL.
	36 37	38 39	40 41	42 43	44 45	46 47	48 49	50 51	52 53	54 55

	NO.	CAUSE	NO.	CAUSE	NO.	CAUSE
INJURY	56 57	58	59 60	61	62 63	64
FATALITIES	65 66	67	68 69	70	71 72	73

EQUIPMENT INVOLVED	74 76
OTHER EQUIPMENT (IF ANY)	77 79
INCIDENT CAUSE — PRIMARY	80 / 81 82
INCIDENT CAUSE — SECONDARY	83 / 84 85
EMERGENCY EQUIPMENT	86 87
OTHER EMERGENCY EQUIPMENT	88 89
OTHER EMERGENCY EQUIPMENT	90 91
BUSINESS INTERRUPTION (DAYS)	92 94
DOLLAR COST	95 96 / 97
GROUP OF PETROLEUM PRODUCTS	98
MATERIAL NO.	99 105
CAS NO.	106 114
SEE REMARKS 0 - NO 1 - YES	115
	116 117
	118 119
	120 121
	122 123
	124 125

1518 (4-78)FMRC PRINTED IN USA (OVER) NC & REMARKS SEE OVER

LOSS INCIDENT REPORT
NIOSH CONTRACT NO. 210-77-0033
FMRC Serial No. 4A6N8.RG

Data Entry No.	
1	Register Number - Hard Coded
2	File Transaction Code A - Add, C - Change; D - Delete

Date of Incident

3 - 8 This is the date on which the incident occurred. This data element is in the major (leftmost) portion of the key to the incident.

Its format is:

YY MM DD

where YY stands for year
MM " " month
DD " " day

State Code

9 - 10 This is an alphabetic code for state as given by the National Bureau of Standards (NBS) publication FIPS PUB 5-1.

Name	Abbrev.	Name	Abbrev.	Name	Abbrev.
Alabama	AL	Kentucky	KY	North Dakota	ND
Alaska	AK	Louisiana	LA	Ohio	OH
Arizona	AZ	Maine	ME	Oklahoma	OK
Arkansas	AR	Maryland	MD	Oregon	OR
California	CA	Massachusetts	MA	Pennsylvania	PA
Colorado	CO	Michigan	MI	Rhode Island	RI
Connecticut	CT	Minnesota	MN	South Carolina	SC
Delaware	DE	Mississippi	MS	South Dakota	SD
Dist. of Col.	DC	Missouri	MO	Tennessee	TN
Florida	FL	Montana	MT	Texas	TX
Georgia	GA	Nebraska	NE	Utah	UT
Hawaii	HI	Nevada	NV	Vermont	VT
Idaho	ID	New Hampshire	NH	Virginia	VA
Illinois	IL	New Jersey	NJ	Washington	WA
Indiana	IN	New Mexico	NM	West Virginia	WV
Iowa	IA	New York	NY	Wisconsin	WI
Kansas	KS	North Carolina	NC	Wyoming	WY

Incident Sequence Number

11 — This is a one-digit numeric data element used to ensure uniqueness in the incident key. It will be zero except when more than one incident has occurred on the same date in the same state. The second incident on the same day in the same state will be coded 1. The third will be 2, ad infinitum. It is the rightmost part of the key to incident.

City Code

12 - 15 — This is a four-digit numeric code for city from the IBM Standard "Codes for Cities and Towns of 2500 or More".

Time of Day

16 -19 — This data shows the time of day when the incident occurred.

The format is:

Hours - 2 numerics representing 24-hour clock
Minutes - 2 numerics

Weather

20 — This element shows three elements of weather (wind, precipitation, temperature) in a three-digit code.

The first digit represents wind. The Codes are:

0	Not Applicable	3	21-30 mph	6	50-60 mph
1	0-10 mph	4	31-40 mph	7	61-75 mph
2	11-20 mph	5	41-50 mph	8	Hurricane
				9	Unknown

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21 — The second digit represents precipitation. Codes are:

0 Not Applicable
1 Rain
2 Fog
3 Snow
4 Hail
5 None
9 Unknown

---

22 — The third digit represents temperature range. Codes are:

0 Not Applicable
1 Below Freezing
2 32 - 75°F (0 - 23.9°C)
3 76°F - 90°F (23.9°C - 32.22°C)
4 91°F - 100°F (32.78°C - 37.78°C)
5 Over 100 (37.78°C)
9 Unknown

Information Sources

23 This is a code to reflect the source of the report. The code is hierarchical with the first character representing:

Type of Source	Code
Federal Government Agency	A
State Governmental Agency	B
Local Governmental Agency	C
International Governmental Agency	D
Private Sector-Business	E
Private Sector-Educational	F
Private Sector-News Publication	G
Personal Contact	H
Other	Z

There are three source fields available. The second and third digits are assigned to Name of Reporting Source Code which is assigned in ascending sequence from 01 to 98. The code 99 is reserved for unknown.

The codes presently assigned are:

23.24.25

A01	U.S. Dept. of Transportation	A06	U.S. Dept. of Labor
A02	U.S. Coast Guard	A07	ERDA
A03	U.S. EPA	A08	U.S. Geological Survey
A04	Office of Pipeline Safety	A09	U.S. Dept. of Commerce
A05	OSHA	A10	NFPCA (Nat'l Fire Prot. Control Admin.
B01	Mass. Dept. of Nat'l Resources	B05	Ohio EPA
B02	Maryland Water Quality Control	B06	N.J.Fisheries Com.Lab.
B03	N.J. EPA	B07	N.Y. DEC
B04	Conn. DEP	B08	Dept. of Labor
C01	Public Fire Dept.	C02	Public Police Dept.
E01	Factory Mutual	E04	Oil & Petroleum Co.
E02	Avon	E05	Insurance Company (other than FM)
E03	American Petroleum Institute		
G01	Newspaper	G04	Fire Journal
G02	NFPA Publication	G05	Fire Command
G03	Magazine Article	G06	Chemical Engineering

35 **Incident Type**

A	Fire	J	Fire & Spill	S	Toxic Fumes & Spill
B	Explosion	K	Fire & Pollution	T	Machinery Breakdown
C	Smoke	L	Explosion & Smoke	U	Unknown
D	Toxic Fumes	M	Explosion & Toxic Fumes	V	Marine Incident
E	Spill	N	Explosion & Spill	W	Multiple (See Remarks)
F	Pollution	O	Other	X	Well Blow-out
G	Fire & Explosion	P	Explosion & Pollution	Y	Collision
H	Fire & Smoke	Q	Smoke & Toxic Fumes	Z	Employee Accident
I	Fire & Toxic Fumes	R	Toxic Fumes & Pollution		

---

36 - 51 **Injuries/Fatalities of Operations Personnel Other Plant Personnel, Other Persons & Unspecified Persons**

These two data elements are numeric in representation. The number is entered directly; i.e., if 20 others were injured or killed, a 20 is entered in the element field. The single digit numbers are entered with a zero preceding them, e.g., eight is 08. The number of injuries/fatalities is entered for Operating Personnel, other Plant Personnel, Other Persons, and for Unspecified Persons.

Note: Reports that indicate injuries and/or fatalities but do not specify the number should be coded 99. Since 99 can also indicate a definite number of injuries or fatalities in excess of 98, a note of clarification in "Remarks" is necessary.

---

52 - 53 **Total Injuries**

Enter the sum of the injuries listed in boxes 36, 37 ; 40, 41 ; 44, 45 ; 48, 49

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54 - 55 **Total Fatalities**

Enter the sum of the fatalities listed in boxes 38, 39 ; 42,43 ; 46,47 ; 50,51

SIC - Standard Industrial Code

29-30-31-32	13 00		Major Group - Crude Petroleum and Natural Gas
		1311	Crude Petroleum and Natural Gas
		1321	Natural Gas Liquids
		1381	Drilling Oil and Gas Wells
		1382	Oil and Gas Field Exploration Service
		1389	Oil and Gas Field Services, Not Elsewhere Classified
	29 00		Major Group - Petroleum Refining and Related Industries
		2911	Petroleum Refining
		2951	Paving Mixtures and Blocks
		2952	Asphalt Felts and Coatings
		2992	Lubricating Oils and Greases
		2999	Products of Petroleum and Coal, Not Elsewhere Classified

Operational Activity

33	1. Exploration	4. Transfer	7. Extraction
	2. Development	5. Plant Processing	8. Other
	3. Field Production	6. Storage	9. Unknown

34

Occupancy

A	Extraction Site (on shore)	H	Engine house	O	Other
B	Off-shore platform	I	Dog house	P	Pumping Station
C	Chemical Plant	J	Petro refin/nat gas	Q	
D	Refinery	K	Processing Mfg. Area	R	Research Facility
E	Light Hydrocarbon Processing Plant	L	Loading Facility	S	Storage (Incls. Bulk Plant)
F	By-Products Processing Plant	M	Pipeline	T	Terminal
G	Gas Processing Plant	N	Transport (Overland/Marine)	U	Unknown
				V	Compressor Station

56 - 57 **Number of injuries/Fatalities**

(59 - 60) (62 - 63) (65 - 66) (68 - 69) (71 - 72)	The number of injuries and/or fatalities for each type of trauma. The code is the actual number involved; i.e., 8 persons would be coded 08; 23 persons would be coded 23, 99 or more persons would be coded 99. The code 99 also indicates that an unspecified number of casualties involving a specified trauma was reported. Clarification of the 99 code in "Remarks" is necessary.

---

58 (61) (64) (67) (70) (73)	A one alpha-digit is used to identify the type of trauma responsible for the casualty related to the number of persons involved. Note: There can be more than one trauma causing casualties for each incident.

A	Amputation, Paralysis, Loss of Body Function or member	L	Person. Health, Heart Strain, etc.
B	Bruises and Contusions	M	Crushing Injury
C	Cuts, Lacerations & Punctures	N	Asphyxiation
D	Occupational Diseases	O	Other Injury
E	Eye Injuries n.e.c.	P	Concussion
F	Fracture	Q	Multiple Injuries
G	Injury by Extreme Temp.	R	Reported as Explosion
H	Strains, Sprains, Dislocation, Hernias	S	Chemical Burns
I	Inhalation or Absorption	T	Heat Burns
J	Electrical Shock	U	Not Reported or Unknown

74-75-76
(77-78-79)

Three numeric digit code to indicate the type of equipment involved in the incident, if any. Add code numbers for other equipment alphabetically.

000 No Equip. Involved
010 Absorber
013 Aeration Facility
015 Agitator
020 Aircraft
021 Air Cond. Unit
023 Alkylation Unit
030 Alumina Tower
035 Armature
040 Autoclave
046 Backhoe
047 Bag
048 Battery
049 Bay (Service Sta.)
050 Boat or Ship
055 Bottle
061 Blower
064 Board Road
065 Bottoms Lines
070 Boiler/ Pressure Vessels
075 Boxes (Control)
079 Burner
080 Building
083 Butadiene Unit
090 Cables
093 Canopy
100 Carburetor
107 Catalyst
110 Centrifuge
118 Charger
120 Chiller
130 Christmas Tree
138 Clinker
140 CO_2 Still
142 Coaleseer
146 Coil Outlet
147 Coil
148 Coker
150 Column
160 Communications Equipment
169 Compactor
170 Compressor
175 Cone Roots on Tanks
178 Container
180 Converter
182 Conveyor
190 Condenser
194 Controls
198 Control Panel
200 Cooler
201 Cooling Pan
203 Cooking Lines
205 Cover
210 Cracker
220 Crane or Derrick
225 Crystalizer
227 Cylinder
230 Debutanizer
240 Decking
250 Deethanizer
260 Degasser
268 Dehydrator Unit
270 Deisobutanizer
273 Delayed Cooking Unit
280 Demethanizer
281 Demister Pots
287 Disconnecting Switch
289 Disposal Tank (salt water)
290 Depropanizer
291 Dip Tank
292 Dewaxing Unit
293 Diverter Inner Sleeve
294 Drain Line
295 Drain Plug
296 Distribution System
297 Drain Valve
298 Drain Systems
300 Drill
301 Drip Pan
310 Drilling Rig & Equip.
315 Drum
317 Dryer
318 Dumpster
319 Duct
320 Electric Cable
322 Electrical Equipment
330 Elevator
337 Emergency Equipment
340 Engine
341 Energized Conductor
342 Engine Exhaust
350 Evaporizer
360 Exchanger
362 Exhaust Manifold
363 Exhaust Stack
365 Extruder
366 Fan Shaft
367 Fan Stack
368 Fat Fryer
370 Field Equip. & Mach'y.
372 Filling Valve
380 Filter
381 Filter Pot
382 Feeder
383 Feed Hopper
384 Fire Pump Driver
385 Fire Water System
386 Firewall
387 Firebox
388 Flare Drain
389 Flame Arrestor
390 Flasher
391 Flare Vent Fan Unit
392 Flare Header Line
399 Flume
400 Fluid Reformer
401 Flare Stacks
402 Floating Roof
405 Fluid Cat. Unit
406 Flume (use 399)
410 Forecolumn
420 Fractionator
424 Fuel Line
429 Fuel System
430 Furnace
436 Gasifier
437 Gas Unit
438 Gasket
439 Guy Wire
440 Generator
441 Gas Pipe Line
442 Gauge
443 Gun Barrel
444 Guard House
445 Hatch Cover Plate
447 Hangar
449 Header
450 Heater
453 Heat Shield
455 Heater Treater
457 Heat Tape
458 Heater Treater
460 Hoisting Gear

EQUIPMENT INVOLVED (Cont'd)

462	Hot Box
470	Hydrogenator
477	Hydrocracker
478	Hydraulic Line
479	Hydroformer Unit
489	Hydrotreater
481	Hydrofiner
486	Ignition System
487	Inspection Plate
490	Instrumentation
495	Industrial Vehicle
499	Jack Bolt
500	Insulation
501	Jack Screw
502	Light Fixture
503	Junction Box
504	Luct Unit
505	Lina Log Pig
509	Loading Deck
510	Loading Rack
511	Loadline of Crane
520	Laboratory Equip.
522	Ladder
524	Lubricator
525	Level Control
530	Machine Shop Equip.
531	Master Panel
533	Marine Equipment
538	Meter Equipment
539	Material Handling Equip. Loader
540	Methanator
542	Meter House
548	Mill
550	Mixer or Agitator
560	Mobile Vehicle
561	Moving Equip.
569	Mud Line
570	Motor
571	Naptha Rerun Unit
572	Overboard Line
573	Office Equip.
574	Overflow Line
576	Oxidizer
580	Piping, Hoses, Nozzles, Fittings
585	Pit Pilot Light
586	Plastic Cans
587	Platform
590	Polymer Fish Tower
599	Pole
600	Polymerization Vessel
606	Portable Pumping Unit
608	Power Line
610	Precooler
619	Precipitator
620	Prefractionator
622	Preheater
624	Pressure Regulator
625	Presaturator
626	Pressure Line
627	Production Equip.
628	Propane Stove
629	Pulverizer
630	Pump
631	Pump Station
632	Pump Bank
634	Pump Packing
640	Oil Field Treater
645	Rags
646	Radio
647	R. R. Tank Car
648	R. R. Equipment
650	Reactor
652	Reabsorber
655	Reboiler
660	Refiner
670	Reformer
671	Reformer Line
680	Refrigerator
700	Regenerator
707	Relief Valve
710	Riser
714	Roof of Tank
715	Sealing Roller
720	Safety Facility/Equip.
722	Scaffold
730	Scrubber
735	Service Sta. Equip.
738	Sewer
740	Seal, Packing, Stuffing Box
741	Shaft
743	Sign
744	Sight Glass
750	Separator and Purifier
754	Slop Oil System
755	Space Heater
756	Spilling Chain
758	Selenoid Switch
760	Splitter
770	Spray Equip.
780	Stabilizer
781	Starter Bendix
782	Stack
785	Starter Panel
786	Start Upline
790	Still
792	Steam Line
794	Steam Regulator
795	Steam Cleaning Unit
796	Steam Ejector
797	Storage Drum
798	Storage Tank
799	Steam Generator
800	Stripper
801	Strainer
807	Submergible Equip.
810	Surge Tank
811	Sump
812	Sump Vent
815	Supply Line
817	Suppressors
820	Switchgear
821	Switch Box
830	Tank
832	Thermal Relief System
834	Thief Hatch
840	Tools-Handheld
841	Tool Box
850	Tower
860	Transfer System
861	Transfer Line
870	Transformer
872	Trash Bin
879	Treater Pot
880	Treater
881	Treater House
882	Tube (Flange)
890	Turbine
899	Vacuum Bottle
900	Valve & Actuator
901	Valve Body Plug
902	Vlave Line
905	Valve Packing
910	Vaporizer
912	Adhesive Vault
915	Vent
916	Vent Line
918	Vessels
919	Vending Machine
920	Vent Stack
921	Vent System
927	Voltage Line
930	Wash Box
933	Washing Wells
940	Waste Disposal System
941	Waste Recovery Unit
945	Water Injection
950	Welding & Cutting Equip.
955	Well
956	Well Equipment
958	Window
960	Work-over Rig & Equip.
990	Other
999	Unknown

80
(83)

INCIDENT CAUSE

The first digit represents the procedural cause of the incident which resulted in casualty (casualties).

1. Equipment Failure
2. Process Malfunction
3. Transfer System, Failure Malfunction
4. Natural Phenomonon
5. Management or Personnel Fault
6. Vandalism or Sabotage
7. Mobile Equip. Accident
8. Other
9. Reported "Unknown"
0. None Reported

81-82
(84-85)

DESCRIPTION OF INCIDENT CAUSE

00 None Reported (No further breakdown)
01 Corrosion
02 Metal Fatigue
03 Inadequate Design
04 Defective Fabrication and/or Installation
05 Overload
06 Over or Under Pressure
07 Faulty Safeguard
08 Inadequate Safeguards
09 Welding Defect
10 Gas Accumulation
11 Dropped
12 Struck by Mobile Equip.
13 Struck by other object
14 Power Failure
15 Power Surge
16 Short Circuit
17 Blow-out
18 Inadequate, Lack of, Failure of Controls or Instruments
19 Malfunction or Impairment of Equipment
21 Unwanted Reaction
22 Spontaneous Combustion
23 Foreign Substance in Process
24 Improper Process Temperatures
25 Utility Failure - Electric Power
26 Utility Failure - Steam
27 Utility Failure - Air
28 Utility Failure - Cooling Water
29 Utility Failure - Inert Gas
30 Rupture, Puncture
31 Pump Failure
32 Loose Fitting(s)
33 Structural Failure of Equip.
34 Faulty Valve
35 Container Overfill
36 Spill
37 Normal Operation
38 Auto ignition
39 Corona Discharge
40 Vibration
41 Wind, Hurricane, Tornado
42 Lightning
43 Flood
44 Rain
45 Snow
46 Hail
47 Earthquake
48 Ambient Temperature
50 Negligence, Carelessness
51 Slips and Falls
52 Faulty Maintenance
53 Lack of Emergency Planning
54 Lack of Information
55 Housekeeping
56 Failure to Follow Proper Procedures
58 Human Error
59 Equip. Left Unattended
61 Vandalism
62 Sabotage
67 Upset condition
70 Collision
71 Failure of Control System
72 Helicopter Accident
73 Fixed Wing Aircraft Accident
74 Marine (Boat, Ship, Barge, etc.) Accident
75 Movement when loading or Unloading
77 Overturn
79 Collision and Overturn
80 Erosion
81 Inadequate Spacing
82 Inadequate Drainage
83 Improper Waste Disposal
85 Code Violation
86 Sparks or Hot Surfaces
87 Widespread Flammables at Time of Ignition
88 Inadequate Emergency Training or Equipment
90 Electrical
92 Inaccessable Location
93 Delayed Discovery
94 Prime Mover Failure
96 Personal Health Condition
98 Other
99 Unknown

Emergency Equipment

This element of data describes equipment utilized during after-incident operations. There are three fields for equipment.

The code is a two-digit hierarchical code. The first digit has the following values:

86	0 None		
(88)	1 Construction Equipment		
(90)	2 Firefighting Equipment		
	3 Personnel Safety Equip.	8	Multiple Types of Equip.
	4 Cleanup Contractor's	9.	Equipment Unknown

The second digit represents a breakdown of the first digit categories as follows:

	10	Construction Equip. General	12	Cranes or Hoisting Equip.
	11	Earth Moving Equip.	18	Other or Multiple Types of Construction Equipment
	13	Jacks, Braces, Wedges, etc.		
86-87	20	Fire Fighting Equip. General	24	Portable Extinguishers
(88-89)	21	Chemical, Foam, CO_2,etc.	28	Other or Multiple Types of Fire Fighting Equip.
(90-91)	22	Pumpers		
	23	Ladder		
	30	Personnel Safety Equip.	34	Masks & Prot. Clothing
	31	Ambulances		
	32	Protective Clothing	38	Multiple Types of Other Types
	33	Masks		
	40	Cleanup Equip. (Gen'l)	43	Chemical
	41	Dikes, Barriers, Containment	48	Multiple or Other
	42	Recovery, Equip. - Skimmers, etc.		
	80	Other or Multiple Types	83	Constr. & Cleaning Equip.
	81	Constr. & Fire Equip.	84	Fire & Safety Equip.
	82	Constr. & Safety	85	Fire & Cleanup Equip.
			86	Safety & Cleanup Equip.
	90	Equipment Unknown		

92-94 **Business Interruption**

No. of days the facility was off-line

Examples:		
	1 day	001
	22 days	022
	403 days	403

Cost of Damage

95-96 Cost of Product Loss, Damage and Cleanup is a data representation in two parts of the cost involved, two significant figures and an exponent. The total cost is rounded up to two significant digits if the third is 5 or more.

The two elements are coded the same using exponent as follows:

	Range of Number	Significant Representation	Exponent
Exponent 97	0-99	01-99	0
	100-990	10-99	1
	1,000-9,900	10-99	2
	10,000-99,000	10-99	3
	100,000-990,000	10-99	4
	1,000,000-9,900,000	10-99	5

To code a cost of 27500, round up to 28,000 then code:

95-96-97 2 8 3

Significant Digits Exponent

A single digit significance should be preceded by a zero.

Group of Petroleum Products

Alpha Digit Representing the Group of Petroleum Products Involved.

A	Natural Gas	N	Naptha
B	Crude Oil	O	Other
C	Gas Condensate	P	Petrochemical Feedstock
D	Diesel Oil	Q	Coke
E	Light Heating Oil	R	Residual Fuel Oils
F	Gas Oil	S	Still Gas
G	Finished Gasoline	T	Asphalt
H	Heavy Fuel Oils	U	Unknown
I	Liquified Gas	V	Reported as Oil
J	Jet Fuel	W	Waxes
K	Kerosene	X	None-Not Applicable
L	Lubricant	Y	Multiple Materials
M	Methane	Z	Reported as Gas

99-105	**Material Number**	

This code represents the material used in the "Registry of Toxic Effects of Chemical Substances" - Dept. of HEW Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, dated June 1976.

This code has two alphabetic characters followed by five numeric digits. When in ascending sort, the material names are arranged alphabetically.

106-114 — **Chemical Abstracts Registry Number**

This is a number assigned to this compound so that it may be uniquely identified. This number will also permit this incident file to be tied in with other Material Files such as OHM-TADS.

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115 — **See Remarks**

Notifier to alert the reader to any further information included under "Remarks" for which there is no code in the incident file.

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116 thru 125 — Extra spaces for expansion of the Incident Data Base.

Remarks — If additional pertinent information and/or narrative is required, it should be recorded under "Remarks" on the reverse side of the Incident data sheet and will be retrieved manually.

APPENDIX D

NIOSH COMPUTER PRINTOUTS

The computer sheets presented in this appendix show how the data were partitioned for analysis. For an example refer to the first page of the printout. The first line at the top of this page describes the primary partitioning variable. For this particular computer run, the data were partitioned by Occupancy Class, and this page contains all on-shore extraction site incidents. The second line gives the number of on-shore extraction site incidents included in the entire data set and the corresponding percentage. In this case, there were 200 such incidents representing 10.7 percent of the data set. The definitions of secondary variable sets of "x" and "y" are given on the third and fourth lines. For this run, the x-variable set represents the years in which the incidents occurred. It is a 13-element set which includes the years 1967 through 1978 plus "00" for unknown or unspecified year. The y-variable set represents total injuries; these are actual numbers of injuries. However, this set contains only totals for which there are corresponding incidents. For example, if no incident occurred in which there were nine injuries, then 9 would not be a part of this set. The elements of variable sets "x" and "y" are used to construct a grid. There are provisions for three sets of numbers in each slot in the grid. The number in the upper right corner represents the actual number of incidents possessing the corresponding x and y variables. The number located at the left center represents the percentage of the total incidents having the common variable x_i (an element of the set "x") represented by the uppermost number. Similarly, the number set in the lower right represents the percentage of the total incidents having the common variable y_i (an element of the set "y").

Using these guidelines, the following information can be extracted from the table. In 1976 there were a total of 49 incidents occurring at on-shore extraction sites. This represented 24.5 percent of the total incidents occurring at these sites. Forty-four of these (90%) resulted in no injury. The total number of incidents occurring at on-shore extraction sites which resulted in no injury was 190. This constituted 95 percent of the total on-shore extraction site incidents. Twenty-three percent of these no-injury incidents occurred in 1976.

DISTRIBUTION [illegible] OCCUPANCY / IN-SHORE EXTRACTION SITE INCIDENTS
200 INCIDENTS INCLUDED, 10.7[illegible] % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL INJURIES

Y \ X	67	68	69	70	71	72	73	74	75	76	77	78	79	TOTAL	%
0				2 / 1 / 99		1 / 1 / 99	67 / 35 / 99	3 / 2 / 99	1 / 1 / 50	44 / 23 / 90	72 / 38 / 97			190	95.000
1					1 / 20 / 50		1 / 20 / 1			2 / 40 / 4	1 / 20 / 1			5	2.500
2									1 / 25 / 50	2 / 50 / 4	1 / 25 / 1			4	2.000
3										1 / [illegible] / 2				1	.500
TOTAL				2	1	1	68	3	2	49	74				
%				1.0	.5	.5	34.0	1.5	1.0	24.5	37.0				

DISTRIBUTION FOR OCCUPANCY / OFF-SHORE PLATFORM INCIDENTS
242 INCIDENTS INCLUDED, 12.962 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL INJURIES

Each cell: count / column % / row %

Y \ X	67	68	69	70	71	72	73	74	75	76	77	78	100	TOTAL	%
00				5 / 2 / 56	12 / 7 / 80	21 / 12 / 76	22 / 12 / 81	25 / 14 / 76	40 / 23 / 75	34 / 19 / 71	19 / 10 / 50			177	73.140
01						4 / 13 / 15	2 / 6 / 7	3 / 9 / 9	5 / 23 / 17	4 / 25 / 17	6 / 17 / 20			32	13.223
02					2 / 13 / 13	1 / 7 / 4	1 / 7 / 4	3 / 20 / 9	4 / 27 / 8	3 / 20 / 6	1 / 7 / 2			15	6.198
03				2 / 25 / 22		1 / 13 / 4	1 / 13 / 4	1 / 13 / 3			3 / 38 / 10			8	3.306
04										1 / 50 / 2	1 / 50 / 3			2	.826
05							1 / 99 / 4							1	.413
06					1 / 33 / 7			1 / 33 / 3			1 / 33 / 3			3	1.240
10										1 / 99 / 2				1	.413

[illegible] C-DATA ACQ. DEPT.-PSYC-CH 10+CA PAGE 3

	167	168	169	170	171	172	173	174	175	176	177	178	[illegible]		TOTAL	
13				1 99 1											1	.413
14										1 99 2					1	.413
27				1 99 1											1	.413
TOTAL				9	15	27	27	33	53	43	30					
[illegible]				3.7	6.2	11.2	11.2	13.6	21.9	17.5	12.4					

67

[illegible]-[illegible] DEPT.-FACE-[illegible] PAGE [illegible]

DISTRIBUTION FOR OCCUPANCY / CHEMICAL PLANT INCIDENTS
79 INCIDENTS INCLUDED. [illegible] % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL INJURIES

	67	68	69	70	71	72	73	74	75	76	77	78	80	TOTAL	%
[illegible]					1	1	9	3	12	21	2[illegible]		1	70	88.608
					1	1	13	5	17	[illegible]	3[illegible]		1		
					50	99	99	67	92	91	[illegible]		99		
1										1	3			4	5.063
										1[illegible]	75				
										5	41				
12									1		1			2	2.532
									50		50				
									8		4				
14					1									1	1.266
					2[illegible]										
					50										
[illegible]								1		1				2	2.532
								50		50					
								33		5					
TOTAL					2	1	9	3	13	22	23		1		
%					2.5	1.3	11.4	3.8	16.5	27.8	29.[illegible]		1.3		

DISTRIBUTION FOR OCCUPANCY / [illegible] ACCIDENTS
488 INCIDENTS INCLUDED, 2[illegible].138 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL INJURIES

	67	68	69	70	71	72	73	74	75	76	77	78	[illegible]	TOTAL	%
00				2 27		2 67	92 13 99	14 3 33	76 17 88	136 30 46	141 31 93		3 1 99	456	93.443
01								1 3 5	5 39 6	2 15 1	5 38 3			13	2.664
02									2 22 2	3 33 2	4 44 3			9	1.844
03									1 33 1	1 33 1	1 33 1			3	.615
04						1 50 33			1 50 1					2	.410
05												1 [illegible] 99		1	.205
06								1 99 6						1	.205
07											1 99 1			1	.205

69

	167	168	169	170	171	172	173	174	175	176	177	178	180	TOTAL	%
15				1 99 33										1	.205
17									1 99 11					1	.205
TOTAL				3		2	42	13	86	142	152	1	3		
				.6		.4	12.4	3.4	17.5	29.1	31.1	.2	.6		

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DISTRIBUTION FOR OCCUPANCY / LIGHT HYDROCARBON PROC PLNT INCIDENTS
0 INCIDENTS INCLUDED, 0.000 % OF ALL INCIDENTS

DISTRIBUTION FOR OCCUPANCY / BY PRODUCTS PROCESS PLANT INCIDENTS
0 INCIDENTS INCLUDED, 0.000 % OF ALL INCIDENTS

[illegible] / GAS PROCESSING PLANT INCIDENTS
53 INCIDENTS INCLUDED, [illegible] OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL INJURIES

	67	68	69	70	71	72	73	74	75	76	77	78	80	TOTAL	%
0			1 2 99			1 [illegible] 99	6 13 99		17 35 99	16 35 76	9 20 82		1 2 99	46	36.792
1										4 [illegible] 19				4	7.547
2										1 [illegible] 5				1	1.887
4											1 99 9			1	1.887
5											1 99 9			1	1.887
TOTAL			1			1	6		12	21	11		1		
%			1.9			1.9	11.3		22.6	39.6	20.8		1.9		

DISTRIBUTION PER OCCUPANCY / ENGINE HOUSE INCIDENTS
1 INCIDENTS INCLUDED. 0.054 % OF ALL INCIDENTS

X = Y ... INCIDENTS
Y = TOTAL INJURIES

	167	168	169	170	171	172	173	174	175	176	177	178	[illegible]	TOTAL	%
[illegible]										1 99 99				1	100.000
TOTAL										1					
										99.9					

72

DISTRIBUTION FOR OCCUPANCY / DOG HOUSE INCIDENTS
1 INCIDENTS INCLUDED, 0.05+ % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL INJURIES

	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77	'78	'??	TOTAL	%
3											1 99 99			1	100.000
TOTAL											1				
%											99.3				

DISTRIBUTION FOR OCCURRENCY / [illegible] [illegible]/NAT GAS INCIDENTS
/ INCIDENTS INCLUDED, 0.1[illegible] % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL [illegible]

	67	68	69	70	71	72	73	74	75	76	77	78	[illegible]		TOTAL	%
[illegible]							1 50 99			1 50 99					2	66.667
[illegible]						1 [illegible] [illegible]									1	33.333
TOTAL						1	1			1						
%						3[illegible].3	33.3			33.[illegible]						

DISTRIBUTION FOR OCCUPANCY / [illegible] INCIDENTS
80 INCIDENTS INCLUDED, [illegible] OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL INJURIES

	167	168	169	170	171	172	173	174	175	176	177	178	180	TOTAL	%
00	1 1 99	1 1 99	1 1 99	1 1 99	5 4 75	7 10 86	10 14 91	6 9 99	9 13 82	21 30 78	4 6 99		5 7 99	69	86.250
01						1 50 1[illegible]				1 50 4				2	2.500
02					1 25 25				1 25 9	2 50 7				4	5.000
03										1 99 4				1	1.250
04							1 99 9							1	1.250
05									1 99 9					1	1.250
14										1 99 4				1	1.250
17										1 99 4				1	1.250

	167	168	169	170	171	172	173	174	175	176	177	178	[illegible]	TOTAL
TOTAL	1	1	1	1	4	8	11	5	11	27	4		5	
%	1.3	1.3	1.3	1.3	5.0	10.0	13.8	7.5	13.8	33.8	5.0		6.3	

DISTRIBUTION FOR OCCUPANCY / LOADING FACILITY INCIDENTS
13 INCIDENTS INCLUDED. 0.096 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL INJURIES

	67	68	69	70	71	72	73	74	75	76	77	78	00	TOTAL	%
[illegible]	2 15 99			2 15 97	1 8 99		2 15 99	1 8 99	2 15 99	3 23 99				13	100.000
TOTAL	2			2	1		2	1	2	3					
[illegible]	15.4			15.4	7.7		15.4	7.7	15.4	23.1					

77

DISTRIBUTION FOR OCCUPANCY / PIPELINE INCIDENTS
26 INCIDENTS INCLUDED, 4.575 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL INJURIES

	67	68	69	70	71	72	73	74	75	76	77	78	[illegible]	TOTAL	%
[illegible]							7 29 99	1 4 99	1 - 97	6 25 99	9 38 82			24	92.308
[illegible]											2 99 18			2	7.692
TOTAL							7	1	1	6	11				
%							26.9	3.8	3.8	23.1	42.3				

DISTRIBUTION FOR OCCUPANCY / TRANSPORT OVER-LAND/MARINE INCIDENTS
16 INCIDENTS INCLUDED, 0.657 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL INJURIES

	67	68	69	70	71	72	73	74	75	76	77	78	00	TOTAL	%
[illegible]							8 50 93			1 6 99	7 44 99			16	100.000
TOTAL							8			1	7				
%							50.0			6.2	43.8				

DISTRIBUTION FOR OCCUPANCY / OTHER INCIDENTS
19 INCIDENTS INCLUDED, 1.018 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL INJURIES

	67	68	69	70	71	72	73	74	75	76	77	78	[illegible]	TOTAL	%
00		1 5 99			2 11 99	1 5 99	6 32 99	1 5 99	3 16 99	3 16 99	2 11 99			19	100.000
TOTAL		1			2	1	6	1	3	3	2				
%		5.3			10.5	5.3	31.6	5.3	15.8	15.8	10.5				

80

DISTRIBUTION FOR OCCUPANCY / PUMPING STATION INCIDENTS
93 INCIDENTS INCLUDED, +.98% OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL INJURIES

Y \ X	67	68	69	70	71	72	73	74	75	76	77	78	79	TOTAL	%
00	1 / 1 / 99	1 / 1 / 99	3 / 4 / 99			1 / 1 / 99	1 / 1 / 99	1 / 1 / 99	3 / 4 / 99	26 / 31 / 84	47 / 56 / 92			84	90.323
01										3 / 60 / 10	2 / 40 / 4			5	5.376
02										1 / 33 / 3	2 / 67 / 4			3	3.226
07										1 / 100 / 3				1	1.075
TOTAL	1	1	3			1	1	1	3	31	51				
%	1.1	1.1	3.2			1.1	1.1	1.1	3.2	33.3	54.8				

DISTRIBUTION FOR OCCUPANCY / INCIDENTS
1 INCIDENTS INCLUDED, 0.054 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL INJURIES

	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77	'78	'00	TOTAL	%
00										1 99 99				1	100.000
TOTAL										1					
%										99.9					

DISTRIBUTION FOR OCCUPANCY / RESEARCH FACILITY INCIDENTS
2 INCIDENTS INCLUDED, 0.207 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL INJURIES

	67	68	69	70	71	72	73	74	75	76	77	78	[illegible]	TOTAL	%
0			1 50 99	1 50 99										2	100.000
TOTAL			1	1											
%			50.0	50.0											

83

DISTRIBUTION FOR OCCUPANCY / STORAGE INCIDENTS
128 INCIDENTS INCLUDED, 7.692 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL INJURIES

Each cell shows: count / code / code

	67	68	69	70	71	72	73	74	75	76	77	78	[illegible]	TOTAL	%
00	1 / 1 / 99		5 / 4 / 99	4 / 3 / 20	6 / 5 / 56	5 / 4 / 99	26 / 20 / 99	6 / 5 / 75	21 / 17 / 61	30 / 24 / 94	22 / 17 / 92		1 / 1 / 99	127	92.029
01				1 / 25 / 20	1 / 25 / 14				1 / 22 / 4		1 / 25 / 4			4	2.899
03								1 / 99 / 13						1	.725
05											1 / 44 / 4			1	.725
06										1 / 99 / 3				1	.725
08										1 / 99 / 3				1	.725
09									1 / 50 / 4			1 / 50 / 99		2	1.449
24								1 / 99 / 13						1	.725

84

	167	168	169	170	171	172	173	174	175	176	177	178	180	TOTAL	%
TOTAL	1		5	5	7	5	26	8	23	32	24	1	1		
%	.7		3.6	3.6	5.1	3.6	18.8	5.8	16.7	23.2	17.4	.7	.7		

85

DISTRIBUTION FOR OCCUPANCY / TERMINAL INCIDENTS
13 INCIDENTS INCLUDED, 0.595 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL INJURIES

	167	168	169	170	171	172	173	174	175	176	177	178	190	TOTAL	%
0							1 / 10 / 99		1 / 10 / 99	8 / 80 / 80				10	76.923
1								1 / 50 / 99		1 / 50 / 10				2	15.385
4										1 / 99 / 10				1	7.692
TOTAL							1	1	1	10					
%							7.7	7.7	7.7	76.9					

DISTRIBUTION FOR OCCUPANCY / [illegible] INCIDENTS
183 INCIDENTS INCLUDED, 9.802 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL INJURIES

	67	68	69	70	71	72	73	74	75	76	77	78	80	TOTAL	%
00	1 1 99	1 1 99	1 1 99	4 2 67	5 3 99	1 1 50	5 3 99	24 15 89	28 17 88	47 29 82	44 27 96			161	87.978
1								2 11 7	4 22 13	10 56 18	2 11 4			18	9.836
2				1 50 17				1 50 4						2	1.093
3				1 50 17		1 50 50								2	1.093
TOTAL	1	1	1	6	5	2	5	27	32	57	46				
%	.5	.5	.5	3.3	2.7	1.1	2.7	14.8	17.5	31.1	25.1				

DISTRIBUTION FOR OCCUPANCY / COMPRESSOR STATION INCIDENTS
2 INCIDENTS INCLUDED, 0.107 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL INJURIES

	67	68	69	70	71	72	73	74	75	76	77	78	00	TOTAL	%
0							1 50 99	1 50 99						2	100.000
TOTAL							1	1							
%							50.0	50.0							

DISTRIBUTION FOR OCCUPANCY / UNSPECIFIED INCIDENTS
213 INCIDENTS INCLUDED, 11.302 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL INJURIES

	67	68	69	70	71	72	73	74	75	76	77	78	79	TOTAL	%
00	1 1 93						3 2 93	26 15 70	59 35 90	54 32 96	25 15 76			168	79.621
01								7 29 13	6 25 8	5 21 8	6 25 13			24	11.374
02									3 100 4					3	1.422
03								1 14 3	4 57 5	2 29 3				7	3.316
04								2 67 3			1 33 3			3	1.422
05								1 25 3	1 25 1	1 25 2	1 25 3			4	1.896
09									1 99 1					1	.474
15										1 99 2				1	.474

	167	168	169	170	171	172	173	174	175	176	177	178	[illegible]	TOTAL	%
TOTAL	2						3	37	7[illegible]	[illegible]	[illegible]				
%	.5						1.[illegible]	17.5	3[illegible].1	2[illegible].9	1[illegible]				

90

DISTRIBUTION FOR OCCUPANCY / IN-SHORE EXTRACTION SITE INCIDENTS
200 INCIDENTS INCLUDED, 13.712 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL FATALITIES

	67	68	69	70	71	72	73	74	75	76	77	78	100	TOTAL	%
00				2 / 1 / 99			68 / 35 / 99		2 / 1 / 99	47 / 25 / 96	71 / 37 / 96			190	95.000
01					1 / 25 / 33	1 / 25 / 99		2 / 50 / 67						4	2.000
02								1 / 99 / 33						1	.500
03										1 / 99 / 2				1	.500
04											2 / 99 / 3			2	1.000
05										1 / 99 / 2				1	.500
10											1 / 99 / 1			1	.500
TOTAL				2	1	1	68	3	2	49	74				
%				1.0	.5	.5	34.0	1.5	1.0	24.5	37.0				

91

DISTRIBUTION FOR OCCURANCY / [illegible] FATALITIES INCIDENTS
242 INCIDENTS INCLUDED, 12.[illegible] % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL FATALITIES

Y	67	68	69	70	71	72	73	74	75	76	77	78	79	TOTAL	%
0				6 3 67	15 6 94	27 12 99	26 11 96	31 13 94	50 22 96	48 21 97	28 12 93			231	95.455
1								2 67 6	1 33 2					3	1.240
2							1 50 4				1 50 3			2	.826
3									1 100 2					1	.413
4				1 100 11										1	.413
6									1 100 2					1	.413
7				1 100 11										1	.413
13				1 100 11										1	.413

	167	168	169	170	171	172	173	174	175	176	177	178	180		TOTAL	%
[illegible]											[illegible]	[illegible]			[illegible]	[illegible]
TOTAL					9	[illegible]	27	27	33	53	48	29				
%					3.7	6.2	11.2	11.2	13.6	21.9	[illegible]	[illegible]				

DISTRIBUTION FOR OCCUPANCY / CHEMICAL PLANT INCIDENTS
79 INCIDENTS INCLUDED, 4.251 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL FATALITIES

	67	68	69	70	71	72	73	74	75	76	77	78	79	TOTAL	%
0					2 / 3 / 99	1 / 1 / 99	9 / 12 / 99	2 / 3 / 67	10 / 13 / 77	22 / 29 / 99	28 / 37 / 99		1 / 1 / 99	75	94.937
1								1 / 99 / 33						1	1.266
2									3 / 99 / 23					3	3.797
TOTAL					2	1	9	3	13	22	28		1		
%					2.5	1.3	11.4	3.8	16.5	27.8	35.4		1.3		

DISTRIBUTION FOR OCCUPANCY / FREQUENCY INCIDENTS
488 INCIDENTS INCLUDED, 26.133 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL FATALITIES

	67	68	69	70	71	72	73	74	75	76	77	78	79	TOTAL	%
0				2 67		2 67	32 1[illegible] 99	11 2 69	63 10 97	135 29 95	1+0 31 92	1 99	3 1 99	459	94.057
1						1 6 33		5 42 31	2 17 2	1 [illegible] 1	3 25 2			12	2.454
2										4 80 3	1 20 1			5	1.025
3										1 99 1				1	.205
4											1 99 1			1	.205
5				1 50 33							1 50 1			2	.410
5											1 99 1			1	.205
6									1 50 1		1 50 1			2	.410

	167	168	169	170	171	172	173	174	175	176	177	178	180	TOTAL	%
10											1 99 1			1	.205
11											1 99 1			1	.205
12											1 99 1			1	.205
13										1 59 1	1 50 1			2	.410
TOTAL				3		5	82	16	96	142	152	1	3		
				.6		.6	16.3	3.5	17.6	29.1	31.1	.2	.6		

DISTRIBUTION FOR OCCUPANCY / LIGHT HYDROCRBN PROC PLNT INCIDENTS
0 INCIDENTS INCLUDED, 0.000 % OF ALL INCIDENTS

DISTRIBUTION FOR OCCUPANCY 7 GAS PROCESSING PLANT INCIDENTS
53 INCIDENTS INCLUDED, 2.63% OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL FATALITIES

	67	68	69	70	71	72	73	74	75	76	77	78	80	TOTAL	%
0			1 2 99			1 2 99	6 12 99		12 24 99	20 40 95	9 18 82		1 2 99	50	94.340
13											1 100 9			1	1.887
14											1 100 9			1	1.887
15										1 100 5				1	1.887
TOTAL			1			1	6		12	21	11		1		
%			1.9			1.9	11.3		22.6	39.6	20.8		1.9		

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DISTRIBUTION FOR OCCUPANCY / ENGINE HOUSE INCIDENTS
1 INCIDENTS INCLUDED, 0.03 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL FATALITIES

	67	68	69	70	71	72	73	74	75	76	77	78	79		TOTAL	%
99										1 99 99					1	100.000
TOTAL										1						
-										99.9						

DISTRIBUTION FOR OCCUPANCY / DOG HOUSE INCIDENTS
1 INCIDENTS INCLUDED. 0.05% OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL FATALITIES

	67	68	69	70	71	72	73	74	75	76	77	78	[illegible]	TOTAL	%
[illegible]											1 99 92			1	100.000
TOTAL											1				
%											99.9				

DISTRIBUTION FOR OCCUPANCY / PETRO PRSTN/NAT GAS INCIDENTS
. 3 INCIDENTS INCLUDED, 0.161 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL FATALITIES

	67	68	69	70	71	72	73	74	75	76	77	78	79	TOTAL	%
					1 33 99		1 33 99			1 33 99				3	100.000
TOTAL					1		1			1					
%					33.3		33.3			33.3					

DISTRIBUTION FOR OCCUPANCY / PROCESSING MFG AREA INCIDENTS
80 INCIDENTS INCLUDED, 4.85 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL FATALITIES

	67	68	69	70	71	72	73	74	75	76	77	78	[illegible]	TOTAL	%
0	1	1	1	1	4	7	10	5	9	25	4		4	72	90.000
	1	1	1	1	6	10	14	7	13	35	6		6		
	99	99	99	99	99	88	91	83	82	93	99		80		
1						1			2	2				5	6.250
						20			40	40					
						13			18	7					
3							1	1						2	2.500
							50	50							
							9	17							
15													1	1	1.250
													99		
													20		
TOTAL	1	1	1	1	4	8	11	6	11	27	4		5		
%	1.3	1.3	1.3	1.3	5.0	10.0	13.8	7.5	13.8	33.8	5.0		6.3		

DISTRIBUTION FOR OCCUPANCY / LANDING FACILITY INCIDENTS
13 INCIDENTS INCLUDED, 0.59? % OF ALL INCIDENTS

X = MEAN OF INCIDENTS
Y = TOTAL FATALITIES

	67	68	69	70	71	72	73	74	75	76	77	78	[illegible]	TOTAL	%
[illegible]	2 13 [illegible]			1 5? 50	1 9? [illegible]		2 13 99		2 15? [illegible]	3 27 99?				11	84.615
1								1 99 99						1	7.692
[illegible]				1 99? 50										1	7.692
TOTAL	2			2	1		2	1	2	3					
%	15.4			15.4	7.7		15.4	7.7	15.4	23.1					

DISTRIBUTION FOR OCCUPANCY / RIP LINE INCIDENTS
26 INCIDENTS INCLUDED, 1.593 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL FATALITIES

	167	168	169	170	171	172	173	174	175	176	177	178	19[illegible]	TOTAL	%
[illegible]							7 35 99		1 5 99	6 30 99	6 30 55			20	76.923
1								1 50 99			1 50 9			2	7.692
2											1 99 9			1	3.846
9											1 99 9			1	3.846
11											1 99 9			1	3.846
12											1 99 9			1	3.846
TOTAL							7	1	1	6	11				
%							26.9	3.8	3.8	23.1	42.3				

DISTRIBUTION FOR OCCUPANCY / TRANSPORT OVERLAND/MARINE INCIDENTS
16 INCIDENTS INCLUDED, 0.957 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL FATALITIES

	67	68	69	70	71	72	73	74	75	76	77	78	80	TOTAL	%
00							7 47 88			1 7 99	7 47 99			15	93.750
02							1 99 13							1	6.250
TOTAL							8			1	7				
%							50.0			6.3	43.8				

DISTRIBUTION FOR OCCUPANCY / OTHER INCIDENTS
19 INCIDENTS INCLUDED, 1.019 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL FATALITIES

	67	68	69	70	71	72	73	74	75	76	77	78	79		TOTAL	%
0		1			2	1	6		3	3	2				18	94.737
		6			11	6	33		17	17	11					
		99			99	99	99		99	99	99					
1								1							1	5.263
								99								
								99								
TOTAL		1			2	1	6	1	3	3	2					
%		5.3			10.5	5.3	31.6	5.3	15.8	15.8	10.5					

DISTRIBUTION FOR OCCUPANCY / PUMPING STATION INCIDENTS
93 INCIDENTS INCLUDED, 4.961 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL FATALITIES

	67	68	69	70	71	72	73	74	75	76	77	78	99	TOTAL	%
[illegible]	1 1 99	1 1 99	3 3 99			1 1 99	1 1 99	1 1 99	3 3 99	31 34 99	49 54 96			91	97.849
[illegible]											1 99 2			1	1.075
[illegible]											1 99 2			1	1.075
TOTAL	1	1	3			1	1	1	3	31	51				
%	1.1	1.1	3.2			1.1	1.1	1.1	3.2	33.3	54.8				

DISTRIBUTION FOR OCCUPANCY / INCIDENTS
1 INCIDENTS INCLUDED, 0.054 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL FATALITIES

	167	168	169	170	171	172	173	174	175	176	177	178	[illegible]	TOTAL	%
[illegible]										1				1	100.000
										99					
										99					
TOTAL										1					
%										[illegible]					

DISTRIBUTION FOR OCCURANCY / RESEARCH FACILITY INCIDENTS
2 INCIDENTS INCLUDED, 0.107 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL FATALITIES

	67	68	69	70	71	72	73	74	75	76	77	78	[illegible]	TOTAL	%
20			1 50 93	1 50 59										2	100.000
TOTAL			1	1											
%			50.0	50.0											

DISTRIBUTION FOR OCCUPANCY / STORAGE INCIDENTS
138 INCIDENTS INCLUDED, 7.37% OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL FATALITIES

	67	68	69	70	71	72	73	74	75	76	77	78	79		TOTAL	%
0	1 1 [illegible]		5 4 99	5 4 97	7 5 99	5 4 99	23 13 89	8 6 99	22 17 96	29 22 91	23 13 96		1 1 99		129	93.476
1							2 50 9		1 25 4	1 25 3					4	2.899
2										1 50 3	1 50 4				2	1.449
3										1 99 3					1	.725
7												1 99 99			1	.725
4							1 99 4								1	.725
TOTAL	1		5	5	7	5	26	8	23	32	24	1	1			
%	.7		3.6	3.6	5.1	3.6	18.8	5.8	16.7	23.2	17.4	.7	.7			

DISTRIBUTION FOR OCCUPANCY / TERMINAL INCIDENTS
13 INCIDENTS INCLUDED, 0.596 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL FATALITIES

	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77	'78	'0?	TOTAL	%
0							1 9 33	1 9 33	1 9 99	8 73 80				11	84.615
1										1 99 10				1	7.692
2										1 9 10				1	7.692
TOTAL							1	1	1	10					
%							7.7	7.7	7.7	76.9					

DISTRIBUTION FOR OCCUPANCY / UNKNOWN INCIDENTS
193 INCIDENTS INCLUDED, 9.802 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL FATALITIES

	67	68	69	70	71	72	73	74	75	76	77	78	80	TOTAL	%
0	1 1 [illegible]	1 [illegible] [illegible]	1 1 99	4 6 67	5 7 99	1 1 50	5 7 99	2 3 7	7 10 22	19 26 33	28 38 57			72	39.344
1				1 1 17		1 1 50		22 22 81	24 24 75	33 33 53	20 20 43			101	55.191
2								2 40 7		3 60 5				5	2.732
3								1 99 4						1	.546
4									1 99 3					1	.546
5										1 99 2				1	.546
6										1 99 2				1	.546
9				1 99 17										1	.546

	167	168	169	170	171	172	173	174	175	176	177	178	100	TOTAL	%
TOTAL	1	1	1	6	5	2	5	27	32	57	46				
%	.5	.5	.5	3.3	2.7	1.1	2.7	14.8	17.5	31.1	25.1				

DISTRIBUTION FOR OCCUPANCY / COMPRESSOR STATION INCIDENTS
2 INCIDENTS INCLUDED, 0.107 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL FATALITIES

	67	68	69	70	71	72	73	74	75	76	77	78	00	TOTAL	%
0							1 99 99							1	50.000
1								1 99 99						1	50.000
TOTAL							1	1							
%							50.0	50.0							

DISTRIBUTION FOR OCCUPANCY / UNSPECIFIED INCIDENTS
211 INCIDENTS INCLUDED, 11.302 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = TOTAL FATALITIES

	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77	'78	'00	TOTAL	%
0	1 2 50							3 6 [illegible]	5 10 14	19 37 26	14 27 22	[illegible] [illegible] 24		51	24.171
1								24 16 65	52 36 70	[illegible] [illegible] 75	24 [illegible] 73			146	69.194
2								6 50 16	2 17 3	3 25 5	1 8 3			12	5.687
3								1 50 3	1 50 1					2	.948
TOTAL	1						3	37	74	63	33				
%	.5						1.4	17.5	35.1	29.9	15.6				

DISTRIBUTION FOR OCCUPANCY / ON-SHORE EXTRACTION SITE INCIDENTS
200 INCIDENTS INCLUDED, 10.712 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = INFORMATION SOURCE

	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77	'78	[illegible]	TOTAL	%
[illegible]				2						3	1			6	3.000
				33						50	17				
				99						6	1				
[illegible]					1	1								2	1.000
					50	50									
					49	94									
[illegible]							63	3	2	46	73			192	96.000
							35	2	1	24	38				
							99	99	99	94	99				
TOTAL				3	1	1	63	3	2	49	74				
%				1.0	.5	.5	3[illegible].0	1.5	1.0	24.5	37.0				

DISTRIBUTION FOR OCCURRENCE / OFF-SHORE PLATFORM INCIDENTS
242 INCIDENTS INCLUDED, 12.[illegible] % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = INFORMATION SOURCE

	167	168	169	170	171	172	173	174	175	176	177	178	[illegible]	TOTAL	%
[illegible]					[illegible]	15	27	27	[illegible]	[illegible]	[illegible]	[illegible]		218	90.083
[illegible]										10	[illegible]	[illegible]		24	9.091
[illegible]					1							1		2	.826
[illegible]					9	13	27	27	33	53	[illegible]	29			
%					3.7	[illegible]	11.2	11.2	13.6	21.9	[illegible]	12.[illegible]			

[illegible]

[illegible] INCIDENTS

X = YEAR OF INCIDENTS
Y = INFORMATION SOURCE

	67	68	69	70	71	72	73	74	75	76	77	78	79	TOTAL	%
[illegible]						1 50		[illegible] 33						2	2.532
[illegible]							4 [illegible] [illegible]	1 [illegible] 33	12 [illegible] 92	27 [illegible] [illegible]	22 [illegible] [illegible]			65	83.544
[illegible]											[illegible] [illegible] 21			6	7.595
[illegible]								1 [illegible] 33						1	1.266
[illegible]									1 [illegible] 8					1	1.266
[illegible]					2 67 [illegible]								1 33 [illegible]	3	3.797
TOTAL					2	1	[illegible]	5	13	22	24		1		
%					2.54	1.3	11.4	3.[illegible]	1[illegible].5	2[illegible].8	30.4		1.3		

DISTRIBUTION FOR OCCUPANCY   7 REFINERY   INCIDENTS
487 INCIDENTS INCLUDED, 26.085 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = INFORMATION SOURCE

	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77	'78	'80	TOTAL	%
ACR										1 / 99 / 1				1	.205
[illegible]						4 / / 33	42 / 12.7 / 93	15 / 3 / 94	31 / 127 / 94	140 / 130 / 99	150 / 32 / 99		3 / 1 / 99	472	96.920
[illegible]				1 / 99 / 50										1	.205
301									1 / 50 / 1			1 / 50 / 99		2	.411
304				1 / 33 / 50		1 / 33 / 33					1 / 33 / 1			3	.616
305											1 / 99 / 1			1	.205
[illegible]						1 / 20 / 33		1 / 20 / 3	2 / 40 / 2	1 / 20 / 1				5	1.027
									2 / 99 / 2					2	.411

	167	168	169	170	171	172	173	174	175	176	177	178	100	TOTAL	%
TOTAL				2		3	82	16	86	142	152	1	3		
%				.4		.6	15.8	3.3	17.7	29.2	31.2	.2	.6		

DISTRIBUTION FOR OCCUPANCY / LIGHT HYDROCARBN PROC PLNT INCIDENTS
0 INCIDENTS INCLUDED, 0.000 % OF ALL INCIDENTS

DISTRIBUTION FOR OCCUPANCY / BY PRODUCTS PROCESS PLANT INCIDENTS
0 INCIDENTS INCLUDED, 0.000 % OF ALL INCIDENTS

DISTRIBUTION FOR [illegible] / [illegible] PROCESSING PLANT INCIDENTS
[illegible] INCIDENTS INCLUDED, 2.[illegible] % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = INFORMATION SOURCE

	167	168	169	170	171	172	173	174	175	176	177	178	179	TOTAL	%
[illegible]						1 / 50 / [illegible]			1 / 50 / 8					2	3.774
1			1 / 25 / [illegible]				1 / 25 / 17				1 / 25 / [illegible]		1 / 25 / [illegible]	4	7.547
[illegible]							[illegible] / 11 / [illegible]		11 / 24 / 92	2[illegible] / [illegible] / 95	10 / 22 / 91			46	86.792
[illegible]										1 / [illegible] / 5				1	1.887
TOTAL			1			1	6		12	21	11		1		
%			1.9			1.9	11.3		22.6	39.6	20.8		1.9		

DISTRIBUTION FOR OCCUPANCY / ENGINE HOUSE INCIDENTS
1 INCIDENTS INCLUDED, 0.054 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = INFORMATION SOURCE

	67	68	69	70	71	72	73	74	75	76	77	78	[illegible]	TOTAL	%
303											1 [illegible] [illegible]			1	100.000
TOTAL											1				
%											[illegible].9				

[illegible] INCIDENTS
[illegible] INCIDENTS

X = YEAR OF INCIDENTS
Y = [illegible]

	167	168	169	170	171	172	173	174	175	176	177	178	179	TOTAL	%
[illegible]											1 [illegible]			1	100.000
TOTAL											1				
											[illegible]				

DISTRIBUTION FOR OCCUPANCY / PETRO REFIN/NAT GAS INCIDENTS
3 INCIDENTS INCLUDED, 0.161 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = INFORMATION SOURCE

	167	168	169	170	171	172	173	174	175	176	177	178	100	TOTAL	%
F03							1 50 33			1 50 33				2	66.667
002						1 100 33								1	33.333
TOTAL						1	1			1					
%						33.3	33.3			33.3					

[illegible]

[illegible] PAGE [illegible]

DISTRIBUTION OF [illegible] FREQUENCY % [illegible] PROCESSING AREA INCIDENTS
78 INCIDENTS INCLUDED, 4.176 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = INFORMATION SOURCE

	67	68	69	70	71	72	73	74	75	76	77	78	79	TOTAL	%
[illegible]										1 50 4	1 50 25			2	2.564
[illegible]	1 6 [illegible]	1 6 [illegible]	1 6 [illegible]	1 6 [illegible]	2 13 50		1 6 9		2 13 20	5 31 19	2 13 50			16	20.513
[illegible]							3 23 27		1 8 10	8 62 31	1 8 25			13	16.667
[illegible]										1 100 4				1	1.282
[illegible]					2 5 50	8 18 99	7 16 64	6 14 99	5 11 50	11 25 42			5 11 99	44	56.410
									2 99 20					2	2.564
TOTAL	1	1	1	1	4	8	11	6	10	26	4		5		
%	1.3	1.3	1.3	1.3	5.1	10.3	14.1	7.7	12.8	33.3	5.1		6.4		

DISTRIBUTION FOR OCCUPANCY / CARRIER FACILITY INCIDENTS
13 INCIDENTS INCLUDED, 0.696 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = INFORMATION SOURCE

	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77	'78	'99	TOTAL	%
001	2 40 99			1 20 50	1 20 99				1 20 50					5	38.462
003							2 29 99	1 14 99	1 14 50	3 43 99				7	53.846
004				1 39 50										1	7.692
TOTAL	2			2	1		2	1	2	3					
%	15.4			15.4	7.7		15.4	7.7	15.4	23.1					

DISTRIBUTION FOR OCCUPANCY / PIPELINE INCIDENTS
26 INCIDENTS REPORTED, 1.39% OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = [illegible]

	167	168	169	170	171	172	173	174	175	176	177	178	179	TOTAL	%
[illegible]							7	1	1	5	11			25	96.15
										1				1	3.85
TOTAL							7	1	1	6	11				
%							26.9	3.8	3.8	23.1	42.3				

DISTRIBUTION BY ... / TRANSPORT OVERLAND/MARINE INCIDENTS
16 INCIDENTS INCLUDED, 0.667 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = INFORMATION SOURCE

	67	68	69	70	71	72	73	74	75	76	77	78	80?	TOTAL	%
NTA							8 50 99			1 6 99	7 44 99			15	100.000
TOTAL							8			1	7				
%							50.0			6.3	43.8				

DISTRIBUTION FOR OCCUPANCY / OTHER INCIDENTS
19 INCIDENTS INCLUDED, 1.018 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = INFORMATION SOURCE

	67	68	69	70	71	72	73	74	75	76	77	78	79	TOTAL	%
[illegible]					1 / 20 / 50	1 / 20 / 99	1 / 20 / 17		1 / 20 / 33	1 / 20 / 33				5	26.316
[illegible]			1 / 33 / 99		1 / 33 / 50					1 / 33 / 33				3	15.789
[illegible]							5 / 45 / 83	1 / 9 / 99	2 / 18 / 67	1 / 9 / 33	2 / 18 / 99			11	57.895
TOTAL			1		2	1	6	1	3	3	2				
%			5.3		10.5	5.3	31.6	5.3	15.8	15.8	10.5				

DISTRIBUTION FOR OCCUPANCY / PUMPING STATION INCIDENTS
93 INCIDENTS INCLUDED, 4.98% OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = INFORMATION SOURCE

	67	68	69	70	71	72	73	74	75	76	77	78	[illegible]	TOTAL	%
[illegible]3											1 [illegible] 2			1	1.075
[illegible]1	1 4 [illegible]	1 [illegible] [illegible]	3 25 [illegible]			1 8 [illegible]	1 [illegible] [illegible]	1 3 [illegible]		2 17 [illegible]	2 17 4			12	12.90[illegible]
[illegible]3									3 4 [illegible]9	24 3[illegible] 9[illegible]	[illegible]8 50 94			80	6[illegible].02[illegible]
TOTAL	1	1	3			1	1	1	3	31	51				
%	1.1	1.1	3.2			[illegible]	[illegible].1	1.1	[illegible].2	33.3	54.9				

DISTRIBUTION AND FREQUENCY / INCIDENTS
1 INCIDENTS INCLUDED, 0.054 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = INFORMATION SOURCE

	67	68	69	70	71	72	73	74	75	76	77	78	[illegible]	TOTAL	%
503										1 [illegible] 99				1	100.000
TOTAL										1					
%										99.9					

DISTRIBUTION FOR OCCUPANCY / RESEARCH FACILITY INCIDENTS
2 INCIDENTS INCLUDED, 0.107 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = INFORMATION SOURCE

	67	68	69	70	71	72	73	74	75	76	77	78	80	TOTAL	%
PPL			1 50 99	1 50 59										2	100.000
TOTAL			1	1											
%			50.0	50.0											

DISTRIBUTION BY OCCUPANCY / STORAGE INCIDENTS
138 INCIDENTS INCLUDED, 7.392 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = INFORMATION SOURCE

	67	68	69	70	71	72	73	74	75	76	77	78	80	TOTAL	%
805										1 / 99 / 3				1	.725
501								2 / 11 / 25	8 / 44 / 35	7 / 39 / 22	1 / 6 / 4			18	13.043
501	1 / 2 / 99		5 / 10 / 39	4 / 8 / 80	5 / 10 / 71	5 / 10 / 99	3 / 6 / 12	2 / 4 / 25	9 / 18 / 39	4 / 8 / 13	11 / 22 / 46		1 / 2 / 99	50	36.232
503							21 / 40 / 81		5 / 10 / 22	15 / 29 / 47	11 / 21 / 46			52	37.681
505							1 / 99 / 4							1	.725
602					1 / 33 / 14					2 / 67 / 6				3	2.174
604				1 / 11 / 20	1 / 11 / 14		1 / 11 / 4	3 / 33 / 33		2 / 22 / 6	1 / 11 / 4			9	6.522
605												1 / 99 / 99		1	.725

	167	168	169	17?	171	172	173	174	175	176	177	178	180	TOTAL
								1	1	1				3
								33	33	33				2.17
								13	4	3				
TOTAL	1		5	5	7	5	25	6	23	32	24	1	1	
%	.7		3.6	3.6	5.1	3.6	13.9	5.3	16.7	23.2	17.4	.7	.7	

[illegible]

X = YEAR OF INCIDENTS
Y = [illegible]

	167	168	169	170	171	172	173	174	175	176	177	178	[illegible]	TOTAL	%
[illegible]							1 8 100	1 8 100	1 8 100	9 75 90				12	92.3[illegible]
[illegible]										1 100 10				1	7.5[illegible]
TOTAL							1	1	1	10					
							7.7	7.7	7.7	76.9					

DISTRIBUTION FOR OCCUPANCY / [illegible] INCIDENTS
[illegible] INCIDENTS INCLUDED, 9.746 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = [illegible]

Cells show: count / row % / column %

	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77	'78	'79	TOTAL	%
[illegible]						1 / 1 / 50		25 / 24 / 93	26 / 25 / 81	35 / 33 / 63	19 / 18 / 41			105	56.243
[illegible]				2 / 40 / 33	1 / 20 / 20					1 / 20 / 2	1 / 20 / 2			5	2.747
[illegible]	1 / + / 99	1 / 4 / 33	1 / 4 / 99	5 / 13 / 50	4 / 17 / 80	1 / + / 50	4 / 17 / 80	2 / 9 / 7	4 / 17 / 13	1 / + / 2	1 / 4 / 2			23	12.637
[illegible]							1 / 2 / 20		1 / 2 / 3	17 / 39 / 30	25 / 57 / 54			44	24.176
[illegible]										1 / 99 / 2				1	.549
[illegible]					1 / 99 / 17									1	.549
									1 / 50 / 3	1 / 50 / 2				2	1.099
TOTAL	1	1	1	6	5	2	5	27	32	56	46				
%	.5	.5	.5	3.3	2.7	1.1	2.7	14.3	17.6	30.3	25.3				

DISTRIBUTION FOR OCCUPANCY   / COMPRESSOR STATION   INCIDENTS
2 INCIDENTS INCLUDED, 0.107 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = INFORMATION SOURCE

	67	68	69	70	71	72	73	74	75	76	77	78	79	TOTAL	%
503							1 50 99	1 50 99						2	100.000
TOTAL							1	1							
%							50.0	50.0							

DISTRIBUTION FOR OCCURANCY / [illegible] INCIDENTS
210 INCIDENTS INCLUDED, 11.244 % OF ALL INCIDENTS

X = YEAR OF INCIDENTS
Y = INFORMATION SOURCE

	67	68	69	70	71	72	73	74	75	76	77	78	80	TOTAL	%
[illegible]								35 / 13 / 95	70 / 37 / 96	57 / 30 / 90	29 / 15 / 88			191	90.952
[illegible]		1 / 50 / 64						1 / 50 / 3						2	.952
[illegible]							3 / 30 / 99		1 / 10 / 1	2 / 20 / 3	4 / 40 / 12			10	4.762
[illegible]									1 / 49 / 1					1	.476
								1 / 17 / 3	1 / 17 / 1	4 / 67 / 6				6	2.857
TOTAL		1					3	37	73	63	33				
%		.5					1.4	17.6	34.8	30.0	15.7				

Y-AXIS CODES FOR INFORMATION SOURCE

A03 US EPA

A05 OSHA

A08 US GEOLOGICAL SURVEY

B03 DEPARTMENT OF LABOR

C01 PUBLIC FIRE DEPT

E01 FACTORY MUTUAL

E03 AMERICAN PETROLEUM INST

E04 OIL COMPANY

E05 INSURANCE COMPANY

E06

G01 NEWSPAPER

G02 NFPA PUBLICATION

G03 MAGAZINE ARTICLES

G04 FIRE JOURNAL

G05 FIRE COMMAND

G06 CHEMICAL ENGINEERING

UNSPECIFIED

END OF REPORT

APPENDIX E

CASE HISTORIES

Contained in this appendix are case histories of incidents which are intended to show problem areas in the categories of 1) Exploration and extraction, 2) Processing, and 3) Storage. All are actual incidents which occurred in the United States in the years 1970 to 1977 inclusive. Data were selected from the American Petroleum Institute, Factory Mutual Loss Data Reports, and the U.S. Geological Survey, the Coast Guard, Oil and Gas Journal, NFPA Publications and various periodicals. Incidents were chosen to illustrate high-severity and high-frequency, usually low-severity, occurrences. Low-severity mishaps are generally less detailed than high-severity accidents. This becomes apparent in the case histories presented. Incidents were chosen to illustrate an operation or area in which a problem seems to exist. While casualties were not incurred in every one of the incidents presented, the hazard potential certainly was present.

EXTRACTION SITES

The following incidents occurred at extraction sites:

1. November 13, 1970. Offshore platform on the outer continental shelf in the Gulf of Mexico. An explosion in a glycol reboiler on the platform killed three men and injured 13 others. (Humble Oil Refining Co., West Delta Block No. 73. Accidents Connected with Federal Oil and Gas Oper. on the Outer Cont. Shelf. U.S. Geological Survey, July 1977.)

2. December 1, 1970. Offshore platform. Gulf of Mexico. A blowout and gas explosion occurred on this platform during wireline work on well. Four men were killed and 27 were injured. The well burned for 4-1/2 months. (Shell Oil Co., So. Timbalur Blk 26. Accidents Connected with Federal Oil and Gas Operations on the Outer Cont. Shelf. July 1977.)

3. December 7, 1973. Offshore platform, Gulf of Mexico. Oil leaking from a flange on a wet oil line was ignited by welding operations nearby. Two men were killed and five were injured in the resulting fire. (Atlantic-Richfield So. Pass Blk No. 60. Accidents Connected with Federal Oil and Gas Operations on the Outer Cont. Shelf. U. S. Geological Survey, July 1977.)

4. July 27, 1976. The crew of a drilling contractor was putting in a well when they hit a gas pocket approximately 61 m (200 ft) down. The gas ignited and flashed in the wellbore. The drilling rig caught fire, injuring one member of the crew. (San Juan, New Mexico. Kirby Exploration Company. U.S. Geological Survey Case. Contractor was Coleman Brothers Drilling Co.)

5. May 16, 1977. A drilling crew had set a liner and was continuing operations when a pocket of gas was circulated to the surface. Ignition of the gas occurred. Six men received first, second, and third degree burns. (Fremont County, Wyoming, U.S. Geological Survey case. Taken from computerized record of events.)

6. October 25, 1977. A blowout during a workover operation killed three members of a drilling crew. The accident occurred during remedial work on an oil well. Workmen had perforated a new interval and oil was in the hole when they

started to run tubing with a packer. The first joint of pipe was being run into the hole with a nubbing unit when the blowout of oil and gas occurred. (Navy's Elk Hills Field near Bakersfield, California. Employees of Hydraulic Workover, Inc. Oil and Gas J. October 31, 1977, p. 82.)

Less publicized incidents are those involving minimal property losses and few casualties. Consider the following:

1. 1973. Two employees of a California oil well drilling contractor were electrocuted when the crane they were operating contacted an overhead 16 KV line. The mechanic and driller, part of a five-man crew, were guiding a storage tank into position using the rig. The three remaining members of the crew were also injured in this mishap. (California Work Injuries, Dec. 1974, p. 16 Div. of Labor Statistics and Research.)

2. 1973. An oil field roustabout was securing a temporary steam line to be used for oil field thermal recovery. The line ran from a steam valve header to the well head. The line had been warmed up and steam had been in the pipe for approximately 15 min. About 12.2 m (40 ft) from where the roustabout was driving a hold-down stake into the ground, the line suddenly ruptured and the pipe struck the worker's head, killing him. Steam pressure in the line at the time of the accident was estimated to 1379 to 2068 kPa (200 to 300 psi). The wall thickness in the ruptured section had been reduced due to internal wear. The tube had been previously used for oil well tubing. (California Work Injuries. Dec. 1974, p. 15.)

3. 1973. Site of a California natural gas well. A driller was preparing a derrick for drilling. He was on the derrick floor when a steel deck plate gave way and dropped him 5.5 m (18 ft) to the ground. He died of injuries received in the fall. The steel floor plate was a removable section, but was too long to fit properly. One end was resting at an angle on a supporting member of the structure. Apparently the plate slipped when he stepped on it. (California Work Injuries. Dec. 1974, p. 11.)

4. 1974. Accident occurred while a crew was moving a 10 cm (4 in.) rubber hose from drilling rig to a work boat. The crew was picking up the hose from the mudroom with a crane sling hooked to a rope on the end of the hose. The rope sling broke when the employee cut the line that was securng the hose to the outside railing. When the hose fell away from the railing, the slack in the hose either knocked or pulled the employee over the railing. He fell approximately 12 m (40 ft) striking cables, which held the boat to the rig, before he struck water. He died from injuries received in the fall. (Review of Fatal Injuries in the Petroleum Industry for 1974. American Petroleum Industry, May 1975, p. 3.)

5. May, 1976. A gas explosion occurred on the lower deck of this offshore platform. An infrequently operated gas compressor which was used to send excess gas to shore was being placed into service. Gas leaks were detected in the first stage suction flanges. A violent explosion occurred in the adjacent boiler room while the compressor operator and a maintenance man were shutting down the system by closing a suction valve.

Several weeks prior to the incident, several sets of flanges on the compressor were loosened to drain water. These were not retightened before the unit was placed into service. Gas leaked from the flanges as soon as the gas line was opened. This gas accumulated in the adjacent boiler room where it was eventually ignited.

One man was killed and two others injured in the resulting explosion.

6. July 8, 1977. Trans-Alaska pipeline. A maintenance crew was working in a pump room where they removed an oil strainer from a pump. The crew failed to inform the control room that the strainer had been removed. Personnel in the control room restarted the pump and oil under 1620 kPa (235 psi) spurted from the open strainer in a solid stream. It sprayed the entire area before ignition occurred. The pump house exploded killing one and injuring five others.

7. October 8, 1974. A production crew was preparing a heater treater for crude oil. The cleanout plate had been removed and vapors from the tank were sucked into the intake of a running truck. An explosion occurred before

preventative measures could be taken. Two men were severely burned and a third received minor burns. Four 1000-barrel tanks, two 2000-barrel tanks and three heater treaters were consumed by the fire. (Chevron USA, Inc Duchesne, Utah).

PROCESSING

Examples of the types of events occurring at processing facilities are as follows:

1. January, 1973. A 7.6 m^3 (2,000 gal) Pfaudler vessel had been prepared for the atmospheric distillation of hexane. Shortly after the introduction of steam to the vessel the operator noticed fumes issuing from the area around the manhole cover. He attempted to remedy the situation by tightening the manhole cover. A shift foreman came upon the scene and, after assessing the situation, ordered the evacuation of all personnel in the immediate vicinity of the vessel. The steam to the unit was shut off and cooling water was turned on. All personnel left the area and doors to this area were closed. A short time later an explosion occurred.

Piping and piping racks were broken causing the release of hydrocarbons which subsequently ignited. (Case History No. 1898. Manufacturing Chemists Assoc. Vol. 4, 1975, p. 91. Case Histories of Accidents in the Chemical Industry Vol. 4, 1975.)

2. November 29, 1974. This incident occurred in the Isoprene Synthesis Section of a major petrochemical plant. Three employees were in the process of switching from one furnace to another when an expansion joint in the suction line of a pump ruptured. All three employees were deluged with hot, toxic quench liquor. One employee was overcome and could not escape the area. He received fatal injuries. The hydrocarbon process stream, which came from the ruptured line after the quench liquor, created a vapor cloud which ignited, resulting in an explosion and fire. The explosion caused the rupture of piping and process lines in the area, providing more fuel for the fire.

Shutdown procedures were initiated and carried out. Another employee received fatal injuries when he attempted to rescue the employee downed initially by the rupture of the process line.

The Plant Emergency Organization responded, but was virtually ineffective due to the number and magnitudes of the fires started in the area. Approximately 15 min after the first vapor cloud explosion, a second major explosion took place when a 75.8 m^3 (20,000 gal) isoprene storage tank ruptured.

Approximately 1.5 hr later, a 3.7 m (12 ft) diameter by 3.6 m x 61 m (200 ft) distillation column also failed, adding thousands of gallons of hydrocarbons to the fire.

Inadequate water supplies and the failure of an electric pump circuit hampered fire fighting efforts. (Fire Journal, Sept. 1975, pp. 99-100.)

3. June, 1975. A furnace charge pump malfunctioned and lost suction. Consequently, the oil in the heater tubes began to overheat. The pump was repaired and flow re-established but a weakened tube overpressured and ruptured. The oil spilled into the firebox and ignited. A rapidly-developing fire caused significant damage before it could be extinguished. There were no personnel casualties. (API Fire Loss Summary.)

4. October, 1975. In this natural gas processing plant a leak developed in the inlet gas line to a furnace. The unit was shut down to make repairs utilizing the normal procedure. However, a tube in the shroud section ruptured spraying hot oil over fire tube. Ignition occurred and the resultant fire damaged the heater, heater instrumentation, piping, insulation and auxiliary equipment. (API Fire Loss Summary.)

5. January 3, 1976. A destructive runaway reaction occurred in this petrochemical plant resulting in an explosion and fire.

The explosive reaction took place during normal operation of a large batch hydrogenation reactor used in the production of 3,4-dichloroaniline. The process involves the hydrogenation of 3,4-dichloronitrobenzene (DCNB) under pressure in an agitated autoclave.

The autoclave was first charged with DCNB and a catalyst as a part of the normal procedure. Then the unit was purged with nitrogen to remove air and later purged with hydrogen. The operator applied steam to the autoclave jacket and set the temperature needed for the reaction. After the vessel had been in operation for a short while, the operator noticed that the hydrogenation reaction was proceeding slower than normal. It was then that he observed that the vessel temperature was set at the low end of the allowable range. In an effort to accelerate the reaction to its normal rate, he raised the set point temperature by 10°C. Shortly after doing this he left to attend to other duties and about 3 min after his departure the incident occurred. The manway cover was blown off and the autoclave was displaced from the support and driven into the floor below. A flash fire followed. Five persons were injured in the blast and ensuing fire. Large fragments of structural concrete were propelled outward to distances up to 100 ft. There were extensive damages to the building and equipment. (E.I. duPont de Nemours and Company, Inc. Deepwater, N.J.; Report by Tong, N. R. et al. 3,4-Dichloroaniline Autoclave Incident.)

6. June 19, 1976. On the day of the accident the plant had been shut down for maintenance work on a vacuum tower heater. The fire tubes of this unit were in the process of being steamed to atmosphere when the #2 tube suddenly unplugged releasing coke, hot oil and steam. Two operators in the vicinity of the release were sprayed with hot oil. The oil vapor flashed when they contacted the flame from a nearby gas burner. Both men were engulfed in fire and received fatal burns. (API Data. Review of Fatal Injuries in the Petroleum Industry for 1976. May 1977, p. 3.)

7. July, 1976. This incident occurred in a petrochemical plant. The furnace involved experienced a burner failure, activating an alarm. The operator responded and attempted to relight the burner with a gas torch. However, he failed to notice that other burners were also out and that a significant amount of natural gas had accumulated in the firebox. The explosion occurred when the torch flame entered the firebox. The operator and another one of the plant personnel were injured. (API Fire Loss Summary.)

The problem of accidents occurring during plant shutdown for maintenance operations has not been investigated enough. Consider the following:

1. June 19, 1970. During repair operations, employees were removing copper tubing from a condensing unit with a high temperature flame torch. In an adjacent area, workmen were steam cleaning equipment when they caused the release of flammable vapors during their operations. This flammable vapor cloud entered the area in which the torch was being used where it ignited and exploded. The ensuing fire caused the five deaths of (four employees and one fire fighter) and fifteen injuries.

Damages were estimated at $3,000,000. Factors contributing to the extent of damage include the loss of electrical power (for fire pumps) due to the rapid flame spread. (Amalie Oil Co., Sugar Creek, Penn. Fire Journal.)

2. February 10, 1973. This incident involved an explosion and fire in a liquid-free liquefied natural gas tank which was undergoing repairs. Approximately 28 months before the incident, instrument reading gave indication of a leak in the liner of this tank. At that time it presented no significant hazard since the exterior shell of this tank was not damaged. Sixteen months later this unit was placed out of service for repairs and modifications. Safety controls were carried out which included the purging of the tank with nitrogen and the complete ventilation of the unit. Two months later a crew entered the tank and bean repair. A large rip was discovered in the liner at the bottom of the tank along with several small punctures. Repairs to the liner had begun when a fire flashed in the tank creating a pressure wave which lifted the tank's concrete roof from the walls, then dropped it back into the tank. The fire spread with such speed and intensity that it was impossible for any of the men in the tank to escape. As a result 40 men perished.

Apparently residual gases trapped between the tank's inner liner and shell contacted an ignition source from the maintenance crew inside the tank. (Fire Journal, May 1974, Vol. 68, No. 3, pp 71-72.)

3. February, 1976. A maintenance crew at a refinery were in the process of cleaning an empty floating roof crude tank with a hydrocarbon solvent when a flash fire occurred. Vapors from the hydrocarbon cleaning solution came into contact with an unknown ignition source and provided an ignition for remnants of crude oil in the tank. Two members of the crew were killed and eight others received injuries. (API Fire Loss Summary.)

4. May, 1976. A 20 cm (8 in.) relief valve line ruptured on a butadiene unit releasing a large quantity of butadiene-butene mixture. A vapor cloud formed and was ignited by process vessels in the area. An explosion and fire followed with the mixture coming from the relief valve behaving like a torch. Adjacent structures, process vessels and instrumentation received considerable damage. (API, Fire Loss Summary.)

5. August 12, 1976. A refinery maintenance crew, subcontracted by the refinery, was in the process of performing routine maintenance and repairs on a 63 m (207 ft) tall benzine unit when an explosion and flash fire occurred. Twelve men were killed and two others injured in the mishap. Ten of the fatalities were employees of the subcontractor; the remaining two were refinery workers. (Tenneco Oil Co., Chalmette, La. Chemical Engineering, August 76, p. 49.)

STORAGE AREAS

Incidents occurring in storage areas have an extremely high potential for disaster. Consider the following cases:

1. August 17, 1975. This incident involved a fixed roof storage tank which had recently been fitted with an internal floating roof. Steel legs welded to the floating roof prevented it from falling below a certain minimum height.

Just prior to the incident the liquid in the tank had been drawn down below the minimum level needed to support the floating roof. As a result, it rested on its steel legs and, in addition, its relief vent opened to ventilate the flammable vapors between liquid surface and the roof.

On the day of the mishap a tanker moved into position and began pumping a mixture of crude oil and 5-percent naphtha into the tank. The flow rate of petroleum was not monitored, so there was no indication of how much was being added to the tank. The flammable vapors in the space between the floating roof and the liquid surface were being forced through the roof's vent into the space between the fixed and floating roofs during the pumping operations.

As the tank filled, the hydrocarbon vapors trapped between the two roofs were forced out of overflow vents. These vapors flashed when they contacted high-temperature, high-pressure steam lines in a nearby boiler house. An explosion occurred between the two roofs forcing the floating roof down into the liquid. The oil overflowed and ignited. This explosion took place approximately 6 hr after the filling operations had commenced.

Fire fighters from the refinery, as well as those from nearby towns, responded and attempted to control the fire. During the fire-fighting operations, leaking hydrocarbons accumulated on the surface of the water and foam that had gathered in the area. Sixteen hours after the initial explosion this layer of flammable liquid flashed, catching all personnel in the area unaware. Six fire fighters caught in the flare-up or trapped during subsequent rescue operations received fatal injuries. Two others were evacuated from the fire ground and later succumbed. (Gulf Oil Co., South Philadelphia, Pa. Fire Command, January, 1976, p. 21.)

2. June 22, 1976. This incident occurred in the storage area of a butane plant in Angelton, Texas. It is believed that a flexible coupling on a 5 cm (2 in.) line failed, resulting in the release of butane. Shortly thereafter this butane ignited and the flame from this line was impinging on a 63 m^3 (18,000 gal), approximately 70 percent full, two 15 m^3 (4,000 gal) tanks and one 23 m^3 (6,000 gal) tank.

The area was cleared of all employees and personnel as fire-fighting agencies decided not to risk men and equipment fighting an unpredictable fire. Operations to cool adjacent tanks to prevent their rupture were affected.

Fortunately, no injuries or fatalities were incurred. This can be directly attributed to the assessment of the risk by the fire-fighting agencies and the subsequent decision not to fight the fire. (Fire Command. (Angelton Butane Co.) Fire Command, June 1976, p. 24.)

3. December, 1976. An employee was attempting to transfer gasoline between two tanks. The failure of an electrical device designed to detect closed valves in the transfer piping arrangement allowed the pump to work against a closed valve. Eventually, the piping ruptured and there was a backflow of product. The liquid flashed and the employee was caught in the fire area. He received fatal second and third degree burns over 60-percent of his lower body. (API Data Review of Fatal Injuries in the Petroleum Industry for 1976. May, 1977.)

4. September 24, 1977. An electrical storm is credited with having initiated this fire in the storage area of a large refinery. The entire area was experiencing torrential rains and thunderstorm activity in the early morning hours. The incident began at approximaely 2:15 a.m. when a single bolt of lightning contacted a 58 m (190 ft) storage tank containing No. 2 diesel fuel. Since the tank was not filled to capacity, the ignition of flammable vapors above the surface of the liquid resulted in an explosion. The force of the blast removed the cone roof covering the tank and it was reported that shock waves were felt 16.1 km (10 miles) away. A section of the roof from this tank struck and ruptured an adjacent 33.5 m (110 ft) diameter tank containing unleaded gasoline.

Flames from the fire were reported to be hundreds of feet high with heavy black smoke hampering fire-fighting operations. It took approximately 44 hr to effect extinguishment. Damages included lost product and three storage tanks and loss was estimated at $8,000,000. Effective fire-fighting techniques prevented a much larger loss since efforts to cool adjacent tanks, to prevent this involvement were successful. (Fire Command, February 1978, Vol. 45, No. 2, pp 21-23)