Literature Review of

Oil Industry Worker Exposure

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EXECUTIVE SUMMARY

There is limited data available on the impact of oil and gas drilling and production activities on human health. It would stand to reason that the population that would most likely exhibit signs of exposure would be individuals who work in the oil and gas industry. A review of documented cases of reports of illness and disease of this population could act as a sentinel of which areas, and chemicals used in this Industry impact human health.

A search of the National Institute for Occupational Safety and Health (NIOSH) Heath Hazard Evaluation database specific to the oil and gas industry was done. A search of the Society for Petroleum Engineers *E-Library* was also conducted. In addition the NIOSH Oil and Gas Program office was contacted and information on occupational exposures occurring in oil and gas workers was requested. Results are limited to the search terms used.

The following was concluded from the information reviewed:

- Other than Silicosis, no specific chronic illness can be associated with chemical exposures in the oil and gas industry
- In a long term occupational study (27 years) of workers in the oil and gas industry there was no evidence of increasing cancer incidence or cancer mortality.
- There are various factors, including work area, viscosity of oil and season which impact exposures to oil vapors.
- Worker trainer, proper communication, and proper personal protective equipment, reduces health issues, and fatalities in workers.
- Additional studies are needed to characterize the impact of working in the oil and gas industry and worker health.

SUMMARY TABLE

Report	Issue	Conclusion
[1]S & B Engineers & Construction	Skin Problems Ethylene	No specific environmental exposure
[2]Aleyska Pipeline	Oil Sludge & Vapours	• Chronic problems to varied to suggest a pattern • Exposures are due to lack of PPE
[3]Gas Station Attendants & Operators	MTBE	No health hazard expected
[4]Exxon Valdez Oil Spill	Benzene, PNA	Inhalation risk was insignificant
[5]Exxon Service Station	MTBE	• Peak exposure occurs during refueling • Vapour recovery system may not be effective
[6]MTBE Worker Exposure	MTBE	Exposure to Benzene was very low
[7]MTBE Worker Exposure	MTBE	• Exposure to potentially hazardous levels of Benzene • Need Administrative and Engineering controls
[8]Retrospective Exposure Assessment for Benzene in the Australian Petroleum Industry	Benzene and lympho-haematopoietic cancers	• Exposure dated back to 1940 • Overall exposures to benzene in the industry were low. • Virtually all activities and jobs were below a TWA of 5 ppm.
[9]Australian Institute	Worker mortality and cancer incidence	• 19,000 past and current employees in the study. • No evidence of increasing cancer incidence or cancer mortality
[10]Low Level Benzene Exposure & Leukemia	Benzene Leukemia	Risk of leukemia **not** associated with increasing cumulative benzene exposure (Limited participants further studies needed)
[11]Oil Mist and Oil Vapor	Airborne Hydrocarbons over 5 years	• Monitoring reports from 37 facilities during drilling with oil based muds • Rig type, type of base oil, viscosity of oil, work area, mud temperature and season significantly determines exposure to oil vapors
[12]Health Issues in Oil & Gas Industry		SOPs and communication minimize and mitigate risk
[13]H2S Co-worker Fatalities	H2S	Proper training and education will help reduce fatalities.
[14]Respirable Silica	Silica	Proper PPE and Medical Evaluation suggested

SUMMARY OF DOCUMENTS REVIEWED

NIOSH assesses the impact of hazardous materials or harmful occupational conditions through a Health Hazard Evaluation (HHE). The assessment is done under the following conditions:

- Employees have an illness from an unknown cause.
- Employees are exposed to an agent or working condition that is not regulated by OSHA.
- Employees experience adverse health effects from exposure to a regulated or unregulated agent or working condition, even though the permissible exposure limit is not being exceeded.
- Medical or epidemiological investigations are needed to evaluate the hazard.
- The incidence of a particular disease or injury is higher than expected in a group of employees.
- The exposure is to a new or previously unrecognized hazard.
- The hazard seems to result from the combined effects of several agents

The summary that follows was prepared using information gathered from Health Hazards Evaluations and other Scientific Papers. In an attempt to maintain the intent of the authors, most information is verbatim from the documents.

[1]NIOSH Health Hazard Evaluation Report S & B Engineers and Constructors
An employee working at the Sweeny Oil Refinery requested that an evaluation be conducted of employees experiencing skin problems. Ethylene is the contaminant of concern.

Medical Records were reviewed for 46 employees. Private interviews and skin exams were conducted on 34 current employees, 2 former employees, and 4 subcontractors. They all worked in a variety of jobs. No single clinical pattern of skin findings and distribution could be determined.

Conclusions:

- No specific environmental exposure was found that could account for most of the cases
- Bulk sample analysis results did not identify any unexpected constituents or contaminants.
- Possible cause is multiple environmental factors, which may or may not be related
    - Exposure to renovation activities and materials used
    - The use of fire resistant clothing
    - Laundering practices
    - Exposure to spent catalyst or residual chemicals

[2]NIOSH Health Hazard Evaluation Alyeska Pipeline Service Company 1985
The Alaska Department of Labor requested that NIOSH evaluate reports of adverse health effects among former contract workers at the pipeline. They were concerned about potential health effects resulting from exposure to oil sludge and vapors during oil sludge removal and maintenance activities. A medical and environmental survey was conducted. Fourteen Alyeska employees and ten former contract workers were interviewed. Five of eight Alyeska maintenance workers reported headache, dizziness, or nausea sometimes when working around the dissolved air floatation (DAF) cells without a respirator. The symptoms typically resolved within two hours of leaving the area or putting on a respirator. The contract laborers reported acute irritative, respiratory, and other symptoms, as well as a variety of chronic respiratory, dermatologic, neurologic, and other problems.

All of the air samples collected in the tank May 3-8 for benzene vapors exceeded both the OSHA proposed standard of 1 ppm and the NIOSH recommended exposure limit of 0.1 ppm; benzene concentrations ranged from 1.4 to 2 ppm when no one was in the tank, and from 2 to 5.1 ppm while workers were in the tank. The time-weighted average concentrations collected for total hydrocarbons

ranged from 426 to 863 mg/cu m, all exceeding the criterion of 350 mg/cu m used for this evaluation. The toluene concentrations ranged from 3 to 10 ppm, xylene 9 to 21 ppm, and hydrogen sulfide <0.1 to 0.6 ppm; phenol concentrations were all less than 0.01ppm. These are all well below their respective evaluation criteria.

Conclusion

- Workers cleaning the oil sludge were potentially exposed to benzene vapors and total hydrocarbon vapors that exceeded the evaluation criteria for these chemicals.
- Actual exposure was reduced through the use of protective clothing, respiratory protection, showers,
- Former contract workers also reported symptoms consistent with unprotected exposure to substances present at the site, but their chronic health problems were too varied to suggest a pattern of association with exposures at the site
- Although measured exposures have been within current Alaska Department of Labor standards, at levels that would not be expected to produce acute symptoms, exposure concentrations averaged over the duration of the job (rather than over the full shift) have not been determined for specific maintenance jobs. The Permissible Exposure Limits (PEL) is established for the average worker, symptoms can occur when air concentrations are below the PEL in some individuals.

[3]NIOSH Health Hazard Evaluation of Service Station Attendants and Operators June 1993

The American Petroleum Institute (API) requested that NIOSH assess airborne exposures to methyl tert butyl ether, among service station attendants and operators.

Conclusions:

MTBE exposure averaged less than 1 ppm, even at service stations using 12% MTBE motor fuel blends. Based upon the available toxicity information, no health hazard would be expected from these exposures, other than the possibility of transient irritative symptoms. Benzene exposures are apparently not affected by MTBE content of motor fuels. At the service stations monitored, vapor recovery had no effect on reducing exposures to MTBE or benzene.

[4]NIOSH Health Hazard Evaluation for Exxon Valdez Alaska Oil Spill May 1991

The Laborer's International Union of North America, the Alaska State Health Department, and the U.S. Coast Guard requested that NIOSH conduct a health hazard evaluation during the cleanup of more than 10 million gallons of oil spilled in Prince William Sound, Alaska. NIOSH's response focused primarily on industrial hygiene assessment of potential occupational exposures [benzene and other volatile organic compounds, oil mist, polynuclear aromatic hydrocarbons (PNA's), diesel fumes, and noise) during typical tasks performed by the majority of the 11,000 workers involved in the 1989 cleanup activities. In addition, NIOSH efforts also included evaluation of the training provided to new employees; evaluation of the adequacy, availability and decontamination of the personal protective equipment (PPE); and evaluation of the worker decontamination procedures. Also, an attempt was made to evaluate illness and injury issues. Most of the cleanup work force was made up of Alaska residents who were not expecting to engage in such work after the 1989 cleanup effort terminated.

Conclusions

- The "weathered" crude oil (WCO), was found to be essentially devoid of the lighter, more volatile, petroleum fractions; therefore, in general, there was no known appreciable health risks from inhalation of these components at the time of this evaluation.
- Benzene was detected in 12 of 33 full shift personal breathing zone samples in concentrations of up to O.3 parts per million (ppm); however, the gasoline used as a fuel in the "skiffs" (small flat-

bottomed boats) was the likely source, rather than the WCO. Three samples, two at 0.2 ppm and one at 0.3 ppm, were above the NIOSH Recommended Exposure Limit (REL) of 0.1 ppm but below the current OSHA Permissible Exposure Limit (PEL) of 1.0 ppm.

- Oil mist was not detected in any of the air samples. The limit of detection (LOD) for oil mist for this evaluation was 0.4 milligrams per cubic meter (mg/m3).
- No mutagenic activity was detected when the original crude and WCO were evaluated via. Ames mutagenicity assays. At the time of this evaluation (about 4 months after the spill), inhalation exposure to volatile components of "weathered" crude oil was insignificant for those work situations evaluated.
- Certain aspects of the health and safety program designed to minimize skin contamination with crude oil, such as decontamination procedures and the wearing of PPE, were not always effectively and consistently implemented from site to site.
- Exposures to volatile components of the crude oil at the very beginning of the cleanup operation may have been substantially different.

[5]NIOSH Health Hazard Evaluation for Exxon Service Stations 1995

A health hazard evaluation was conducted at two Exxon service stations located in the greater Newark, New Jersey area. Environmental monitoring to assess service station attendants' exposures to oxygenated gasoline that contained methyl tert–butyl ether (MtBE), which is an oxygenating compound blended with unleaded gasoline to help reduce vehicle emissions. Environmental measurements were made using two methods: (1) conventional air sampling (NIOSH Method 1615) and (2) video exposure monitoring with the use of real–time instrumentation.

Laboratory analysis of 21 personal breathing–zone (PBZ) air samples collected for total hydrocarbons (THC) as gasoline and MtBE revealed a geometric mean time–weighed average (TWA) concentration of 1.89 parts per million (ppm) (range: 0.43 – 4.43 ppm) for THC and a geometric mean TWA concentration of 0.38 ppm (range: 0.08 – 1.27 ppm) for MtBE. These concentrations for THC and MtBE were well below their most stringent exposure criteria of 300 ppm and 40 ppm, respectively. Real–time exposure monitoring results revealed a high variability of "relative" THC peak concentrations that were measured as high as 327 ppm. Video exposure monitoring demonstrated that the act of manual refueling is significantly responsible for exposures to oxygenated fuels, particularly peak exposures.

Conclusions

- Full–shift TWA sampling results indicated relatively low exposure concentrations for THC and MtBE,
- Real–time measurements for THC revealed elevated peak concentrations, as much as 130 times greater than TWA concentrations. This suggests that similar conclusions can be drawn about MtBE peak exposures.
- Estimated peak exposures may be as high as approximately 70 ppm. However, there is no human toxicity data available that suggests brief peak MtBE exposure to 70 ppm causes symptoms reported by attendants and self–service customers.
- Peak exposures to oxygenated gasoline do occur during refueling, even in the presence of Stage II Vapor Recovery Systems NIOSH investigators concluded that it is not known whether a health hazard exists due to peak THC concentrations.
- Improvement of vapor recovery system effectiveness and attendant work practices suggested in this study could be applied to refueling operations throughout the industry to reduce exposures to oxygenated gasoline.
- It is believed that vapor recovery systems may not be effective in controlling gasoline vapor emissions

[6]NIOSH Health Hazard Evaluation of Worker Exposure in Fairbanks Alaska

NIOSH was asked to evaluate workers' exposures to the gasoline components methyl *tert*-butyl ether (MtBE), benzene, toluene, and xylene. Eight facilities which include: two automobile dealerships, two auto repair shops, and four municipal agencies were included in the evaluation. Bulk samples of the various grades of fuel were collected from sites which dispensed gasoline and the liquid volume percent of benzene, toluene, xylene, and MtBE was determined.

Air monitoring was performed on mechanics (technicians), service advisors, and other workers potentially exposed to gasoline and exhaust emissions during their workday. Thirty-seven personal-breathing-zone samples were collected and analyzed for benzene, toluene, xylene, and MtBE. The bulk analyses revealed that the MtBE content of the fuels ranged from 13 to 17% and the benzene content was slightly higher than 1%. Personal-breathing-zone samples for toluene and xylene ranged from less than 0.03 to 0.65 parts per million (ppm), and less than 0.02 to 0.32 ppm, respectively. These levels are well below the pertinent occupational health exposure criteria. MtBE exposure levels ranged from less than 0.03 to 12.04 ppm; levels well below the American Industrial Hygiene Association (AIHA) Workplace Environmental Exposure Limit (WEEL) of 100 ppm. The benzene concentrations ranged from less than 0.004 to 0.427 ppm. Two samples exceeded the NIOSH Recommended Exposure Limit (REL) of 0.1 ppm.

Conclusions:

The environmental data gathered during this investigation indicate that employees were exposed to potentially hazardous concentrations of benzene. In an effort to reduce workers' exposures, recommendations such as administrative and engineering controls are recommended.

[7]NIOSH Health Hazard Evaluation of Worker Exposure in Stamford Connecticut

NIOSH was asked to evaluate workers' exposures to the gasoline components methyl *tert*-butyl ether (MtBE), benzene, toluene, and xylene. Site visits were made to eight facilities (two automobile dealerships, two auto repair shops, and four municipal agencies) from April 5-8, 1993.

Conclusions

The environmental data gathered during this investigation indicate that employees were exposed to potentially hazardous concentrations of benzene. In an effort to reduce workers' exposures, recommendations such as administrative and engineering controls were made.

[8]Retrospective Exposure Assessment for Benzene in the Australian Petroleum Industry

An excess of lympho-haematopoietic cancers were identified in workers in the Australian Petroleum Industry. This cancer is strongly associated with benzene exposure

- Job histories were compiled for each subject from interviews and company records
- Site visits and telephone interviews were used to identify the task included in each job title
- Details about task were also collected
- Exposure dated back to 1940
- Used recent benzene exposure monitoring data to calculated exposure dose
- Past exposures were estimated from the base estimates by means of an exposure algorithm.
- Cumulative estimates of benzene in ppm-years.

Conclusion

Overall exposures to benzene in the industry were low
Virtually all activities and jobs were below a TWA of 5 ppm.
Exposures at terminals were generally higher than at refineries.
Exposures in upstream areas were extremely low

Estimates of cumulative estimates to benzene ranged from .005-50.9 ppm-years
Exposure data tended to be associated with the more exposed job. (reformer, crude distillation unit operators and driver loading)

[9]Australian Institute of Petroleum Health Watch 13th Report

This study was designed to monitor the health of petroleum industry employees has been ongoing for 27 years. There are 19,000 past and current employees in the study. 95% of employees approached to join the study have. Detailed analysis of job types, workplace practices, lifestyle influences, illnesses and causes of death are collected. This study provides insights into influences of occupation and worker lifestyle on worker health.

- Main output is mortality and cancer incidence
- Detailed job and health questionnaire
    - Job tasks
    - Lifestyle factors (smoking, alcohol, health status)
    - Employee included after serving 5 years in industry or after completing a survey interview whichever is later
    - Employee remains in study for life.

Summary Results

- 16623 men and 1275 women are included in the analysis
- The age adjusted death rate in men and women is significantly less than the general Australian population
- Smoking related diseases such as; lung cancer incidence and mortality, incidence of cancer of the lip, oral cavity and pharynx, ischaemic heart disease mortality and chronic obstructive pulmonary disease mortality are lower in Health Watch members than in the general population
- Mesothelioma and Melanoma have been and still are occurring at significantly higher rates in petroleum workers than in the general population. The mesothelioma is likely to be associated with asbestos exposure in refineries before the 1970's. A causal association with any exposure in the workplace and Melanoma is unlikely as the rate does not increase with increasing duration of employment, time since first employement, or period of first employment.
- The chance of getting most types of cancer is similar for women working in this industry as for the general Australian female population
- Analysis of the kidney cancer cases in the whole study population were suggestive of an association between hydrocarbon exposure and cancer of the kidney. Further study is needed with more refined exposure assessment.
- There is no evidence of increasing cancer incidence or increasing cancer mortality in men with any of the following:
    - Increased duration of employment
    - Increased time since first employment
    - Time periods of first employment

[10]The Relationship Between Low-Level Benzene Exposure and Leukemia in Canadian Petroleum Distribution Workers.

The study was conducted to assess chronic exposure to low levels of Benzene (2 ppm for 40 years). Fourteen petroleum distribution workers were a part of the study. Average exposure concentration ranged from .01 – 6.2 ppm.

Conclusion

The risk of leukemia was not associated with increasing cumulative benzene exposure. Study suggests that risk under about 50 ppm- years are either small or nonexistent. (Note risk is based on relatively few workers.) This study was consistent with other data in that it was unable to demonstrate a relationship between leukemia and chronic low level benzene exposure. The power of the study is limited, thus further study on benzene exposure at low level concentrations needs to be studied.

[11]Exposure to Oil Mist and Oil Vapour During Offshore Drilling in Norway 1979-2004

The purpose of this study was to describe exposure to airborne hydrocarbon contaminant over a 5 year period to workers during drilling with oil based muds. Qualitative and quantitative data was gathered during visits to oil, and drilling companies, chemical suppliers, and other contractors. Monitoring reports from 37 drilling facilities were gathered and analyzed.

Conclusions

Rig type, type of base oil, viscosity of the base oil, work area, mud temperature, and season significantly determined exposure to oil vapor. The levels of hydrocarbon air contaminants increased as mud temperature increases and will reach high concentration as compared to Norwegian Occupational Exposure Limit. Exposures to oil mist and oil vapor declined over time in the mud-handling areas for drilling facilities. Note possible contribution from other hydrocarbon sources were not considered. PAHs were not evaluated.

[12]Occupational and Public Health Issues in the Oil and Gas Industry

Emerging Trends and Needs for Emphasis

This papers attempts to address the need of all risks involved in oil and gas operations be identified and managed wisely. It discusses the responsibility of the employer to operate in a safe and responsible manner. The authors suggest that a quality worker health management does not have to be expensive or require a lot of consulting staff. The document contains a listing of the phase of oil and gas operation with the impact to employee health and community health.

Conclusion

Occupational exposure to oil and gas operation pose a risk of exposure to hazardous chemicals and physical agents for much longer hours and at much greater concentrations than the general public. Standard operating procedures and quality communication of these procedures minimize and mitigate the risk to the employee.

[13]Co-Worker Fatalities from Hydrogen Sulfide

This paper discusses the need for education of workers of the signs and symptoms of chemical exposure to prevent fatalities. Industries that have reported fatalities resulting from H2S exposure include the oil and gas industry.

Conclusions

Toxicity is predominantly in new workers. Proper training and education on the warning signs of chemical toxicity can help to reduce worker fatalities.

[14]Health Effects of Occupational Exposure to Respirable Crystalline Silica

In 1991 NIOSH estimated that at least 1.7 million U.S. workers are potentially exposed to respirable crystalline silica. More specific to the oil and gas industry, 408,175 workers are potentially exposed.

NIOSH recommends:

- Substituting less hazardous materials for crystalline silica when feasible,
- Using appropriate respiratory protection when source controls cannot keep exposures below the Recommended Exposure Limit (REL) and
- Making medical examinations available to exposed workers.

Conclusions

There is a significant risk of chronic silicosis for workers exposed to respirable crystalline silica over a working lifetime. Appropriate personal protective equipment should be used.

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