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ALYESKA PIPELINE SERVICE COMPANY
VALDEZ, ALASKA

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I. SUMMARY

In December 1985 the National Institute for Occupational Safety and Health received a request from the State of Alaska Department of Labor to evaluate reports of adverse health effects among former contract workers at the Alyeska Pipeline Service Company's Ballast Water Treatment facility (BWT) in Valdez, Alaska. They were concerned about potential health effects resulting from exposure to oil sludge and vapors during oil sludge removal and maintenance activities. In response to this request, NIOSH investigators conducted a medical survey March 10-12, 1986, and an environmental survey May 3-8, 1986.

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.

A ballast water tank was drained April 29-30, 1986, and the ventilation of the tank began April 30. The first entry into the tank occurred on May 3, to obtain samples of the sludge. The workers wore hip boots, Tyvek suits, and self-contained breathing apparatus (SCBA). The workers who cleaned the tank wore protective clothing that consisted of Tyvek suits, boots, rain gear, and gloves. These were taped to prevent entry of liquid through any joint. After the tank was "certified" for entry on May 6, the workers switched from SCBA to half-face chemical cartridge respirators with organic vapor cartridges.

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 0.01 ppm. These are all well below their respective evaluation criteria.

On the basis of the data collected during this evaluation, the investigators determined that workers cleaning the oil sludge from ballast water storage tank #92 were potentially exposed to benzene vapors and total hydrocarbon vapors that exceeded the evaluation criteria for these substances. Their actual exposure to the oil sludge was reduced through the use of protective clothing and showers, and to benzene and total hydrocarbon vapor through the use of respiratory protection. Alyeska maintenance workers reported self-limited symptoms, consistent with exposures to volatile organic compounds known to be present in the DAF area, when working in that area without a respirator. Former contract workers also reported symptoms consistent with unprotected exposure to substances present at the BWT, but their chronic health problems were too varied to suggest a pattern of association with exposures at the BWT. Recommendations regarding personal protective equipment and practices to reduce exposures are included in Section VIII of this report.

KEYWORDS: SIC 1311 (Crude Petroleum and Natural Gas), benzene, hydrogen sulfide, phenol, polynuclear aromatic hydrocarbons (PNA's), total hydrocarbons, toluene, xylene

II. INTRODUCTION

In December 1985 the National Institute for Occupational Safety and Health received a request from the State of Alaska Department of Labor to evaluate reports of adverse health effects among contract laborers at the Alyeska Pipeline Service Company's Ballast Water Treatment facility (BWT) in Valdez, Alaska. They were concerned about potential health effects resulting from exposure to oil sludge and vapors during oil sludge removal and maintenance activities. NIOSH investigators conducted a walk-through inspection and medical survey March 10-12, 1986, and an environmental survey May 3-8, 1986. A letter reporting the findings of the medical survey was distributed March 26, 1986, to the Alaska labor and public health agencies and to company and union representatives.

III. BACKGROUND

The Alyeska Pipeline Service Company, headquartered in Anchorage, Alaska, operates and maintains the Alaska pipeline, which transports crude oil from the North Slope, and the pipeline terminal in Valdez, Alaska. In Valdez, the crude oil is stored in above-ground tanks until it is loaded into tanker ships for delivery to refineries in the United States and foreign countries. The ships arrive in Valdez with ballast water in their holds. The ballast water, which has been mixed with the materials that were last shipped in the holds, is pumped out of the holds to the ballast water storage tanks. This ballast water is then treated in the BWT, where the oils and organic solvents are removed. The cleaned waste water is then pumped into the bay.

Routine operations at the terminal are performed by Alyeska employees. Certain maintenance procedures - tank cleaning, for example - are performed by contractors. According to the business manager for the Construction and General Laborers Union - Local 341, about 75 union members have worked at the BWT as employees of one of the contractors, performing such jobs as cleaning tanks, dissolved air floatation (DAF) cells, basins, and ponds. An estimated 40 have had more than minimal contact with sludge, and an estimated 15-20 of these had heavy exposure or health complaints.

Periodically, the ballast water storage tanks are drained, the sludge removed, the tanks cleaned, and maintenance performed in the tank. Tank #92 was scheduled for cleaning for the spring of 1986, its first total cleaning. Tank #92 is 250' in diameter and 55' high. There are 61 pillars that support the roof. The floor of the tank is slightly domed in the center and tapers toward the outside wall. There are two large hatches (8' x 26') on the roof that are opened during the cleaning. Two copious supply air blowers are installed on the roof. Air is pumped into the tank through flexible ducting that extends near the floor of the tank. At the ground level there are three access holes. Supply air blowers are installed in two of these openings, and the third is used for personnel access. A covered shelter was constructed over the access hole and was used as a decontamination facility.

Tank #92 was drained April 29-30, 1986, and the ventilation of the tank began April 30. The first entry into the tank occurred on May 3, to obtain samples of the sludge. The workers wore hip boots, Tyvek suits, and self-contained breathing apparatus (SCBA). On May 6, a marine chemist entered the tank and took measurements to determine the vapor concentrations relative to the lower explosive limit. He also took several detector tube samples to determine the toluene concentration. He then stated that the tank was "certified" for entry.

The workers who entered the tank after it was certified for entry wore Tyvek suits, rain pants and jacket, rubber boots, rubber gloves, and half-face air purifying respirators with organic vapor cartridge. The cartridges were changed daily. The rain pants were taped around the boots, the rain jackets were taped around the pants, and the sleeves were taped over the gloves. As workers exited the tank, the oil sludge was rinsed off with a cleaning solution, and the rain gear was removed. The workers then dressed in their own clothes. At the end of the day, they showered, and all their clothing was laundered.

At the start of the cleaning there was approximately 15" of sludge around the edge, and it was several inches deep in the middle. The cleaning consisted of moving the sludge toward the outside edge of the tank with large squeegees and water.

Sludge pumps were placed in the tank to pump the sludge to an open holding tank to await further processing. Several workers spent most of their time maintaining the pumps. There were usually 4 to 6 workers in the tank at a time. A worker would be in the tank 8-10 hours per day.

IV. EVALUATION DESIGN

A. Environmental

Environmental breathing zone air samples and general area samples were collected to determine employees' exposures to the substances listed in Table 1. Samples for vapors and gases were collected in the tank prior to entry by lowering sampling equipment into the tank (7 ft above the tank floor) through the roof hatches. During the tank cleaning, personal and area samples were collected in the tank. The vapor concentrations in the tank were measured every two hours by the Alyeska Pipeline Service Company using a direct-reading HNu instrument.

B. Medical

At the time of the initial visit, the NIOSH medical officer interviewed 10 former contract workers, 7 in Anchorage and 3 in Valdez. These workers were identified by the union as having health complaints that they thought might be attributable to exposures at the BWT. The medical officer also interviewed 13 Alyeska employees present at the BWT during the site visit. These employees, selected on the basis of availability rather than previously reported health complaints, included eight maintenance employees and five others (operators and oil spill and marine technicians). One maintenance worker from a different shift, who was reported to have complaints, was also interviewed.

V. EVALUATION CRITERIA

A. Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week, for a working lifetime, without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, medications, or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criteria. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent becomes available.
The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations; 2) the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV's); 3) the U. S. Department of Labor (OSHA) occupational health standards; and 4) the American Industrial Hygiene Association's Hygiene Guide Series. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits, or ceiling values, which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

B. Specific Substances

Environmental evaluation criteria and health effects of substances of concern in this investigation are discussed in Table 2.

VI. RESULTS AND DISCUSSION

A. Environmental

Environmental air samples were collected in tank #92 several days before the workers entered to remove the oil sludge and during the first three days of sludge removal. The temperature during the period May 3-8, 1986, ranged from 38 to 49°F (Table 3). It was overcast most of the time, and there were occasional showers. Since the sun did not shine, the tank did not heat up inside. The supply air blowing into the tank also kept the inside temperature close to the outside temperature. During this time period, the two large hatches (8' x 26') on the roof were open. There were two copious blowers on the roof blowing air (volume unknown and measurement not practical) into the tank. There were also two blowers in the lower access hatches, but only one was in operation.

Hydrogen Sulfide - The hydrogen sulfide results are shown in Table 4. The hydrogen sulfide concentrations were <0.1 ppm when no one was working in the tank. During the work when the sludge was being disturbed, the concentrations rose to 0.6 ppm. This is well below the evaluation criterion of 10 ppm, and it is unlikely that the 10 ppm ceiling value was exceeded during any portion of the work time.

Phenol - The phenol results are shown in Table 5. All concentrations were less than 0.01 ppm. The evaluation criterion for phenol is 5 ppm.

Polynuclear Aromatic Hydrocarbons - The di- and polynuclear aromatic hydrocarbon results are shown in Table 6. Only acenaphthylene, acenaphthene, fluorene, phenantrene, anthracene, and naphthalene were present in detectable concentrations. Only napthalene has an established evaluation criterion, 50 mg/cu m. The highest concentration measured was 2 mg/cu m, which is only 4% of this criterion. The PNA's found in measurable quantities in these samples are not listed by ACGIH as potential human carcinogens. Skin contact with these substances can cause irritation and may cause photodermatitis. Several workers had considerable sludge contamination on their neck and face at the end of the work shift.

Benzene - The benzene results are shown in Table 7. The benzene concentrations in the tank ranged from 4.2 to 5.9 mg/cu m with no activity in the tank, and from 6.0 to 15.4 mg/cu m while work was being conducted. All the sample results in the tank exceeded OSHA's proposed benzene standard of 1 ppm (3 mg/cu m) and the NIOSH recommended exposure limit of 0.1 ppm,[1] both of which are based on benzene's carcinogenity. Respirators are required under the OSHA proposed standard; a half-face chemical cartridge respirator with organic vapor cartridge is permitted in concentrations less than 10 ppm (30 mg/cu m). All sample concentrations were less than 30 mg/cu m, and during the sample periods all the workers in the tank wore this type of respirator. NIOSH, however, recommends the use of a pressure demand supplied air respirator with an auxiliary SCBA or pressure demand SCBA if exposure exceeds 0.1 ppm.[1]

Toluene - The toluene results are shown in Table 7. The toluene concentrations ranged from 3 to 10 ppm (12 to 38 mg/cu m). These were all less than 10% of the NIOSH recommended exposure limit of 100 ppm (375 mg/cu m).

Xylene - The xylene results are shown in Table 7. The xylene concentrations ranged from 9 to 21 ppm (39 - 90 mg/cu m). These were all less than 21% of the NIOSH recommended exposure limit of 100 ppm (435 mg/cu m).

Total Hydrocarbons (except benzene, toluene, and xylene) - These sample results are shown in Table 7. The vapor present in the tank is a complex mixture. The major compounds, identified by gas chromatography/mass spectroscopy, were mostly C6-C12 aliphatic hydrocarbons, toluene, xylene, and benzene. Some higher molecular weight (MW)-120 and MW-134 aromatics, naphthalene, and methyl naphthalene were also detected. There are no OSHA standards for most of these substances. NIOSH's recommended exposure limit for refined petroleum solvents (the best available approximation of this vapor composition) is 350 mg/cu m. The individual sample (half-shift) total hydrocarbon (excluding benzene, toluene, and xylene) concentrations ranged from 371 to 1228 mg/cu m. The full-shift TWA concentrations ranged from 426 to 863 mg/cu m. All the TWA concentrations were 1.2 to 2.5 times the evaluation criterion of 350 mg/cu m.

General Discussion - Spot measurements for total hydrocarbons were made by Alyeska Pipeline Service Company using an HNu meter. The results of the measurements are shown in Table 8 and are compared to the NIOSH charcoal tube sampling results. The HNu meter measurements were approximately 50% or less of the charcoal tube sample results. The HNu meter is used as a survey instrument to determine relative concentrations. Based on the results obtained in tank #92, a correction factor of at least two times the reading needs to be made when using this instrument.

The total hydrocarbon results show that when no workers were in the tank there was approximately 500 to 750 mg/cu m of vapor present. When workers entered and disturbed the surface, the concentration would rise slightly. On Wednesday, May 7, however, the concentrations in the workers' breathing zones rose to 1000-1228 mg/cu m. During warmer and sunny weather, the concentrations could be higher than those measured during this survey. Additional supply air into the tank would probably not significantly reduce these levels unless very large volumes of air were used. This would not be practical, however, since linear reductions in concentrations of air contaminants would require geometrically increasing volumes of air.

B. Medical

Five of the eight maintenance workers at the plant (and the one interviewed by phone) reported headache, dizziness, or nausea sometimes when working around the DAF cells without a respirator. These symptoms typically resolved within two hours, sometimes within minutes, after leaving the area or putting on a respirator. One worker reported symptoms lasting 1-1/2 days after performing work (not his usual job) in the DAF area. Another worker reported a rash after contact with oil in the past, but had no current problem.

There was agreement among Alyeska employees that protective clothing and respirators were readily available, whether or not specifically required for a particular job. There was also general agreement that work involving the most contact with sludge was done by contractors. Some Alyeska employees observed contract laborers using the same protective gear as Alyeska employees, but others said that this was not always the case.

The contract laborers reported acute irritative, respiratory, and other symptoms. They also reported a variety of chronic respiratory, dermatologic, neurologic, and other problems. Many reported that protective equipment was not readily available, that it was not in good condition, or that it was provided without adequate instruction in its use.

VII. CONCLUSIONS

A. Environmental

Workers cleaning the oil sludge from the ballast water storage tank #92 were potentially exposed to benzene vapors and total hydrocarbon vapors that exceeded the evaluation criteria for these substances. Their actual exposure to the oil sludge was reduced through the use of protective clothing and showers, and to benzene and total hydrocarbon vapor through the use of respiratory protection.

B. Medical

Alyeska maintenance workers reported self-limited symptoms associated with work in the DAF area without a respirator. Such symptoms are consistent with exposures to volatile organic compounds known to be present in the area. 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. Furthermore, symptoms can occur even when air concentrations of individual substances are below their OSHA permissible exposure limits, especially when there is exposure to a combination of substances.

Except for their severity, the acute symptoms reported by contract laborers were comparable to those reported by Alyeska employees and were consistent with unprotected exposure to substances present in the BWT. We could not answer the question of whether unprotected or inadequately protected exposure was as common in the past as claimed by the laborers. Even if there were heavy exposures in the past, however, the reported chronic health problems were sufficiently varied that they did not suggest a pattern of association with exposures at the BWT. (This does not rule out the possibility that there may be individual cases of health problems related to past exposures at the BWT, but evaluation of such cases on an individual basis is beyond the scope of a NIOSH investigation).

Given the lack of an identified chronic health effect characteristic of potential chemical exposures at the BWT, the relatively small group of workers with substantial exposure to sludge or other substances, the sporadic occurrence of such exposures, and potential exposures from other jobs over the years, further epidemiologic investigation of past workers for chronic health effects attributable to exposures at the BWT would not likely be productive.

VIII. RECOMMENDATIONS

1. Respiratory protection should be worn during the entire time that a tank is being cleaned. The OSHA proposed benzene standard permits the use of half-face respirators with organic vapor cartridges for exposures up to 10 ppm. If this type of respirator is used, the cartridges should be changed daily. NIOSH, however, recommends the use of a pressure demand supplied air respirator with an auxiliary SCBA or pressure demand SCBA if the NIOSH recommended exposure limit is exceeded.

2. The same level of protective clothing used during this evaluation should be used on future cleaning jobs.

3. All workers who work with the oil sludge should shower at the end of the work shift.

4. The practices of using a change room and separation of street clothes and work clothes, as was done during this evaluation, should be continued for future work.

5. Contaminated clothing should be cleaned prior to reuse.

6. On the basis of symptoms reported by Alyeska workers, some maintenance tasks in the DAF area appear to warrant routine use of respirators. Exposures associated with the various tasks should be monitored. The need to use respirators can then be determined on the basis of the exposure data.

7. Since a respirator can increase the pulmonary, cardiac, and other physiologic stresses associated with work, workers should have periodic medical evaluations to determine their ability to wear respirators. Guidelines regarding the content and frequency of the medical evaluations, and the medical reasons for recommending restrictions on respirator use, have been published.[2,3]

IX. REFERENCES

1. National Institute for Occupational Safety and Health. Testimony of J. Donald Millar, M.D., Director, presented at the OSHA informal public hearing on the proposed rule for occupational exposure to benzene, 29 CFR 1910, docket no. 11-059C, Washington, DC, March 20, 1986.

2. Harber P. Medical evaluation for respirator use. J Occup Med 1984; 26:496-502.

3. Hodous TK. Screening prospective workers for the ability to use respirators. J Occup Med 1986;28:1074-80.

X. AUTHORISHIP AND ACKNOWLEDGEMENTS

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XI. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45336. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office, at the Cincinnati address.

Copies of this report have been sent to:

1. Alaska State Department of Labor
2. Construction and General Laborers Union–Local 341
3. Alyeska Pipeline Service Co.
4. OSHA Region X

For the purpose of informing affected employees, a copy of this report shall be posted in a prominent place accessible to the employees for a period of 30 calendar days.

Table 1
Substances Measured
Alyeska Pipeline Service Company
Valdez, Alaska

HETA 86-132
May 3-8, 1986

Substance	Collection Method	Flow Rate	NIOSH Analytical Method
Benzene	Charcoal Tube	50 cc/min	1500
Hydrogen sulfide	Long term detector tube passive dosimeters	20 cc/min	-
Phenol	0.1 NaOH in impingers	1 lpm	3502
PNA's	Teflon filter followed by XAD2 resin tube	1 lpm	5515
Total Hydrocarbons	Charcoal Tube	50 cc/min	1500
Toluene	Charcoal Tube	50 cc/min	1500
Xylene	Charcoal Tube	50 cc/min	1500

Table 2
Evaluation Criteria and Health Effects
Alyeska Pipeline Services Company
Valdez, Alaska
HETA 86-132

Substance	NIOSH or ACGIH Recommended Criteria 10-Hr TWA	State of Alaska 8-Hr TWA	Health Effects
Benzene	0.1 ppm (0.3 mg/cu m); 1 ppm ceiling (NIOSH)	10 ppm (30 mg/cu m); proposed OSHA std: 1 ppm (3 mg/cu m)	Headache, dizziness, nausea; decreased production of red and white blood cells; leukemia
Hydrogen sulfide	10 ppm ceiling (NIOSH)	20 ppm acceptable ceiling; 50 ppm maximum ceiling (10 min)	Weakness, headache; confusion, nausea vomiting, impairment of respiration
Phenol (skin)	5.2 ppm; 15.6 ppm ceiling (NIOSH)	5 ppm	Irritation of eyes, nose, and throat; weakness; muscle aches; liver and kidney damage; dermatitis; skin burns from liquid
PNA's:			
Napthalene	50 mg/cu m; 75 mg/cu m ceiling (ACGIH)	50 mg/cu m	Eye irritation; inflammation of eyes and skin with exposure to sunlight; some are carcinogenic
Acenaphthylene	None	None	
Acenaphthene	"	"	
Fluorene	"	"	
Phenanthrene	"	"	
Anthracene	"	"	
Total hydro-carbons (mainly C6-C12)	350 mg/cu m; 1800 mg/cu m ceiling (NIOSH)	OSHA standards are for individual substances	Depends on individual components; dizziness, drowsiness, headaches, and irritation of eyes, nose, and throat are typical
Toluene (skin)	375 mg/cu m (100 ppm); 750 mg/cu m ceiling (NIOSH)	750 mg/cu m (200) ppm	Dizziness, confusion, fatigue, weakness, dermatitis
Xylene	435 mg/cu m (100 ppm); 870 mg/cu m (NIOSH)	435 mg/cu m (100 ppm)	Headache; dizziness; drowsiness; incoordination; nausea; irritation of eyes, nose and throat; dermatitis

Table 3
Outdoor Temperature Ranges
Alyeska Pipeline Service Company
Valdez, Alaska

HETA 86-132
May 3-8, 1986

Date	Day	Temperature Range
May 3	Saturday	39 - 43° F
May 4	Sunday	38 - 46° F
May 5	Monday	39 - 49° F
May 6	Tuesday	40 - 49° F
May 7	Wednesday	40 - 46° F
May 8	Thursday	38 - 42° F

Table 4
Hydrogen Sulfide Air Concentrations
Alyeska Pipeline Service Company
Valdez, Alaska

HETA 86-132
May 3-8, 1986

Date	Sample No.	Time (Minutes)	Hydrogen Sulfide Concentration (ppm)
May 3	50 (GA)*	280	<0.1
May 5	52 (GA)	495	<0.1
May 6	51 (GA)	360	<0.1
	53 (BZ)**	162	0.6 (Workers entered tank for first time)
May 7	54	526	0.45
	55 (BZ)	413	0.6
May 8	57 (GA)	440	0.1

*GA - General Area
**BZ - Breathing Zone

Table 5
General Area Phenol Air Concentrations
Alyeska Pipeline Service Company
Valdez, Alaska

HETA 86-132
May 3-8, 1986

Sample No.	Date	Time (Minutes)	Phenol Concentration (ppm)
30	May 3	280	<0.01
31	May 5	495	<0.01
32	May 6	500	<0.01
33	May 7	526	<0.01
34	May 8	440	<0.01

Table 6
Di- and Polynuclear Aromatic Hydrocarbon Air Concentrations
Alyeska Pipeline Service Company
Valdez, Alaska

HETA 86-132
May 3-8, 1986

Job or Location	Date	Sample Number	Time (Minutes)	Volume (Liters)	Acenaph-thylene ug/cu m	Acenaph-thene ug/cu m	Fluorene ug/cu m	Phenan-threne ug/cu m	Anthra-cene ug/cu m	Naph-thalene ug/cu m
7' above floor--approx 75' from side of tank--4 day cumulative sample	5-4 5-6 5-7 5-8	81 (filter & tube)	495 500 526 440	1961 1961 	56	20	38	3	3	372*
GA 1 day sample	5-7	86	526	526	72	19	68	2	4	1692
GA 1 day sample	5-8	82	420	420	69	17	88	2	5	2000

*Due to the sample volume, it appears that the naphthalene vapors were eluted off the tube.

NOTE: All samples were analyzed for the following: acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(e)pyrene, benzo(a)pyrene, indeno(1,2,3-cd-pyrene, dibenz(a,h)anthracene, benzo(g,h,i)perylene, and naphthalene. Only those shown above were present in concentrations above the limit of detection of 1 ug/sample.

Table 7
Benzene, Toluene, Xylene & Total Hydrocarbon Air Concentrations
Alyeska Pipeline Service Company
Valdez, Alaska

HETA 86-132
May 3-8, 1986

Sample Location	Date	Time	Sample No.	Sample Time (Minutes)	Sample Volume (Liters)	Benzene mg/m^3	Toluene mg/m^3	Xylene mg/m^3	Total Hydro-carbons except Benzene, Toluene, & Xylene mg/m^3	TWA	Total Hydro-carbons mg/m^3	TWA
GA in tank	5-3	3:20-5:00p	C-1	100	4.25	<9	21.6	66.4	647	558	735	635
GA in tank	5-3	5:00-8:00p	C-3	180	10.19	5.9	16.0	49.9	508		580	
GA in temporary access shed	5-3	3:08-8:08	C-2	300	17.23	<2	<2	<2	<11		<17	
GA in tank	5-5	7:50-11:55a	C-4	245	14.25	4.9	16.4	51.6	434	502	507	581
GA in tank	5-5	11:55a-4:05p	C-5	250	14.09	5.8	19.4	58.6	569		653	
GA in tank	5-6	9:04-3:04	C-7	360	15.62	4.5	15.0	59	461	426	540	488
GA in tank	5-6	3:04-7:51p	C-9	225	16.51	4.2	12.5	38.8	371		427	
BZ - Worker #1 in tank	5-6	5:13p-7:49p	C-6	156	9.44	6.4	15.8	44.1	462	530	528	605
BZ - Worker #2 in tank	5-6	5:13p-8:00p	C-5	167	9.37	7.5	20.6	55.6	594		678	
GA in tank	5-7	9:14a-12:34p	C-11	200	13.84	7.2	17.3	44.7	539	676	608	760
GA in tank	5-7	2:08-6:00p	C-15	232	15.85	10.0	25.2	63.1	794		892	

Table 7 - Continued

Sample Location	Date	Time	Sample No.	Sample Time (Minutes)	Sample Volume (Liters)	Benzene mg/m^3	Toluene mg/m^3	Xylene mg/m^3	Total Hydro-carbons except Benzene, Toluene, & Xylene mg/m^3	TWA	Total Hydro-carbons mg/m^3	TWA
BZ - Worker #1 in tank	5-7	9:06-12:25	C-13	259	11.63	8.9	22.1	58.7	702		792	
BZ - Worker #1 in tank	5-7	Did not return to tank in the afternoon.										
BZ - Worker #2	5-7	9:15-12:25	C-14	250	13.96	7.2	17.6	51.8	576	798	653	900
BZ - Worker #2	5-7	2:00-6:28p	C-12	268	12.96	11.7	29.2	84.1	1006		1131	
BZ - Worker #3 in tank	5-7	9:09-12:25	C-10	256	13.37	6.0	15.2	37.6	480	863	539	965
BZ - Worker #3	5-7	2:00-6:28p	C-16	268	12.96	15.4	37.8	90.3	1228		1372	
GA in tank	5-8	8:25-12:10	C-17	225	13.58	6.6	17.0	45.9	557	620	627	703
GA in tank	5-8	2:20-5:55p	C-25	215	12.60	9.3	20.2	52.9	685		767	
BZ - Worker #1 in tank	5-8	8:15-11:55	C-18	220	12.48	7.9	19.4	55.0	654	669	736	754
BZ - Worker #1 in tank	5-8	2:10-6:10	C-24	240	12.00	9.5	19.5	58.7	682		770	
BZ - Worker #2 in tank	5-8	8:19-11:55	C-20	216	12.40	6.8	18.1	55.9	583	678	664	763
BZ - Worker #2 in tank	5-8	2:10-6:15	C-21	245	14.14	10.4	22.0	56.9	762		851	

Table 8
General Area Total Hydrocarbon Air Concentrations
Using a Direct Reading HNu Instrument Compared with
Corresponding Charcoal Tube Sample Results
Alyeska Pipeline Service Company
Valdez, Alaska

HETA 86-132
May 3-8, 1986

Date	Time	Hnu Measurements: Total Hydrocarbon Concentration, ppm*	Corresponding HNu Measurements: Total Hydrocarbon Concentration, mg/cu m (approx)**	Charcoal Tube Total Hydrocarbon Concentrations, mg/cu m
May 3	pm	25 - 50	125 - 250	635
May 4	pm	25 - 50	125 - 250	None
May 6	pm	25 - 50	125 - 250	540
	pm	40 - 50	200 - 250	427
May 7	9:30pm	40	200	
	12:30pm	70 - 100	350 - 500	608
	1:45pm	65 - 70	330 - 350	
	6:15pm	65 - 75	330 - 375	892
May 8	7:00am	50 - 55	250 - 270	627
	10:00am	60 - 70	300 - 350	
	1:00pm	60	300	767
	4:30pm	50 - 70	250 - 350	

*The reading varied throughout the tank; hence, a range is given.
**Due to the complex mixture, a conversion of 1 ppm to 5 mg/cu m was used.
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