U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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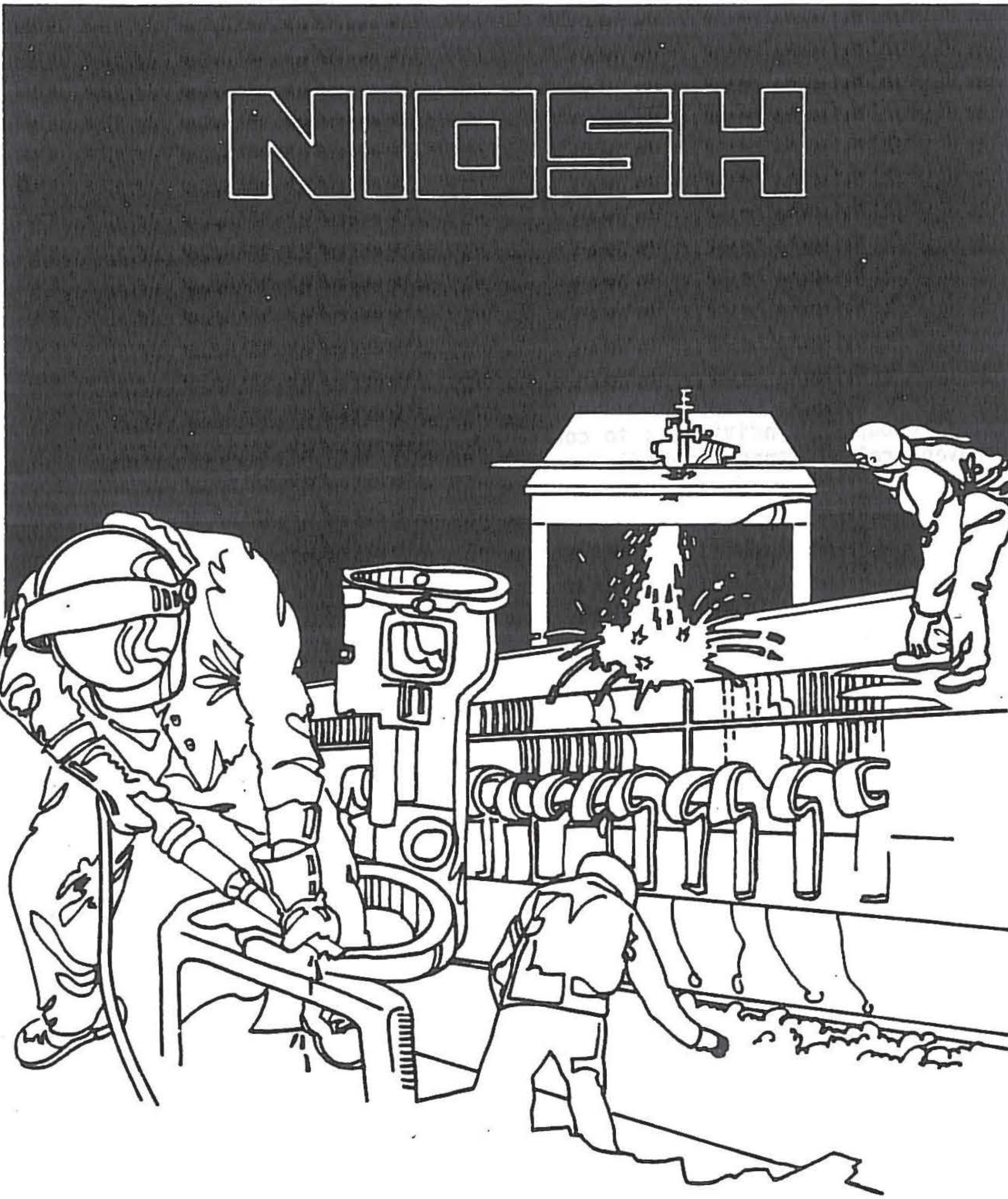

Health Hazard Evaluation Report

HETA 83-440-1537
PAPILLION CREEK WASTEWATER
TREATMENT PLANT
OMAHA, NEBRASKA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 83-440-1537
NOVEMBER 1984
PAPILLION CREEK WASTEWATER TREATMENT PLANT
OMAHA, NEBRASKA

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I. SUMMARY

On September 6, 1983, NIOSH was requested, by the City of Omaha, to evaluate working conditions at the Papillion Creek Wastewater Treatment Plant in Omaha, Nebraska. This request was prompted by the death of a worker exposed to "sewer gas" in the plant on September 3, 1983.

An initial site visit was conducted on September 20, 1983; and during the week of October 17, 1983, an environmental and epidemiological investigation was conducted at the plant. Personal and area samples were collected for hydrogen sulfide (H_2S) in all areas of the plant. Personal air samples for H_2S for all workers sampled ranged from none detected to 2.2 ppm. Area air samples for H_2S ranged from none detected to 133 ppm. Instantaneous area (grab) samples ranged up to 200 ppm, which was the upper limit of the direct-reading instrument being used. NIOSH recommends a ceiling concentration not to exceed 10 ppm.

Fifty-four of the 65 workers in the plant responded to a self-administered questionnaire. Seventy-six percent of the respondents indicated they had experienced at least three of the symptoms associated with H_2S exposure. Conditions associated with long-term exposure to H_2S in the plant were reported less frequently with only 35 percent of the workers indicating some problem. Positive responses were not associated with estimated exposure levels.

A review of the hospital records and the autopsy report of the deceased worker found the pattern of his illness and death was compatible with fatal hydrogen sulfide exposure. Ventilation measurements and operating parameters at the plant were also investigated to try and establish what conditions resulted in the death of the worker. We concluded that the death was the result of: a) the nature of sewage coming into the plant (high concentration of dissolved H_2S because of flow times), b) inappropriate design of the ventilation system in the wet well area, and c) inadequate procedures for workers to follow when entering areas potentially dangerous to life and health.

Based on the information gathered during this investigation, NIOSH investigators conclude that conditions in the plant were such that levels of H_2S immediately dangerous to life and health are possible and that the City of Omaha should take steps to eliminate this possibility. Workshift area air levels of H_2S exceeded 10 ppm in several process areas. Since these levels were measured in potential worksites for employees, they also need to be corrected. Recommendations to correct these conditions are included in Section X of this report.

KEYWORDS: SIC 4952 (Sewage Workers) SIC 4950 (Sanitary Services) SIC 1623 (Heavy construction - Water, Sewer....Construction), hydrogen sulfide, wastewater, confined space, sewage, sewage treatment plant, incinerators, ash.

II. INTRODUCTION/BACKGROUND

On September 2, 1983, between 12:30 a.m. and 1:00 a.m., several employees of the City of Omaha's Papillion Creek Wastewater treatment were overcome by gases in the Parshall Flume area of the plant. At approximately 5:30 p.m. on September 3, 1983, one of the individuals involved in the incident died from acute respiratory distress syndrome associated with the exposure.

On September 6, 1983, the National Institute for Occupational Safety and Health (NIOSH) received a request for technical assistance to evaluate working conditions and to recommend improvements in the Papillion Creek Wastewater Treatment Plant to provide a safe work environment for all employees.

On September 20, 1983, a NIOSH investigator visited the Omaha Papillion Creek Wastewater Treatment plant in Bellevue, Nebraska to conduct an initial walk-through survey. During this initial site visit, information was collected concerning the circumstances surrounding the death of the worker, as well as general information on the plant and its personnel. A walk-through survey of the entire plant was conducted to determine appropriate sites for air sampling during the first follow-up survey. During the walk-through of the Parshall Flume area, the ventilation system was subjectively evaluated. The NIOSH investigator discovered that a large fan was supplying air into the area and pushing the air into the bar screen and mezzanine. It was suggested that the airflow be reversed so that air was removed from the most contaminated area. This was accomplished by reversing the fan.

III. PLANT DESCRIPTION

The Omaha Papillion Creek Water Pollution Control Plant is located south of Bellevue, Nebraska close to the Missouri River, and was completed and became operational in August 1977. It was constructed as a secondary-type treatment facility and was designed to treat 50-70 million gallons per day (MGD). The facility consists of a raw sewage pump station, a solids processing unit, a grit and grease removal unit, primary clarifiers, sludge thickeners, digesters, trickling filters, chlorine contact basin, personnel shop and storage, and an administration and laboratory building.

The Parshall Flume, bar screen, raw sewage pump station, grit-grease aeration separation unit, solids processing unit and sludge incinerator are all located in the largest single structure on the site. Two sets of four primary clarifiers are located adjacent to the solids processing structure. Each clarifier is 115 feet in diameter and is a concrete tank with an aluminum cover. Each set of four clarifiers is controlled from an operating room in the center of the four. The two sludge thickeners are concrete tanks 65 feet in diameter. They also have aluminum covers but are only accessible from outside and have no control rooms. The sludge digester complex consists of four 75-foot diameter tanks, with a control room in the center of the cloverleaf and a gas collection room adjacent. The four trickling filters are also sited in a cloverleaf pattern but are not connected by a common control room. They are covered with an aluminum structure and are only accessible from the outside. The remaining structures on the site consist of the chlorine unit, shop and support structure, and the administration and laboratory building.

Since the facility is in a remote location, the structures on the grounds are very well sited, with plenty of room for expansion. Most of the structures are connected by underground tunnels, and all are connected on the exterior by concrete roadways. The grounds are very well kept and, in fact, are routinely irrigated with non-potable waste water from the plant.

IV. PROCESS DESCRIPTION

The treatment plant receives all sanitary and industrial wastewater in the Papillion Creek watershed portion of the Omaha metropolitan area. This services all of the City of Omaha west of 42nd Street, plus the communities of Bellevue, Offutt Air Base, and Papillion.

Raw sewage flows by gravity approximately 25 miles from the last major intercepter to the plant. This results in a transit time of approximately eight hours. The sewage flows into the plant in a 108-inch diameter pipe. Upon entrance to the plant, the wastewater flows through a Parshall Flume where the depth is monitored and recorded hourly. Wastewater samples were also collected in this area until the untimely death of a worker. Wastewater from all of the various internal operations at the plant are also discharged into this section of the plant, including the periodic discharge of highly corrosive supernatant from the sludge digesters and thickeners.

The raw sewage then passes through one of four bar screens where large solid objects are removed. This debris is carried up through the mezzanine level to the bar screen collection area. This residue is hauled to a landfill. Workers periodically enter these areas to check for lodged items and for general preventative and curative maintenance.

After passing through the bar screen, the raw sewage is collected in the wet well where it is pumped to the aeration basins. Both electric motor and engine-driven pumps fueled with natural gas (from digesters) are used to lift the raw sewage. The aeration floats the grease, which is removed by skimming, and the grit settles to the bottom. The collected material is removed either for incineration or for disposal in a landfill. The liquid sewage is then pumped to the primary clarifiers.

The raw sewage enters the clarifier tanks at the center. The clarifiers allow the solids to settle. The solids are then removed from the bottom of the concrete basin by a slowly rotating sweeping arm. The supernatant flows over a peripheral weir and is pumped to the trickling filters. The sludge is pumped to the gravity thickener to allow more solids to settle. The supernatant from the gravity thickeners is returned to the wet well area. The sludge from the thickeners, still containing only 6% solids, is pumped to either the sludge digesters or to the incinerators.

The sludge digesters further reduce the total volume of solids to be dewatered. Bacterial action in the sludge digesters produces methane gas that is processed and used to maintain the sludge at 95°F, as well as producing gas for the raw sewage pumping engines. The digesters have floating covers which serve both as variable volume gas collectors and protection against the weather. The sludge in the digesters has a residence time of approximately 45 days. Supernatant from the digesters is collected and returned to the wet well at the front end of the plant.

Sludge from either the digesters or the thickeners is further dewatered, using vacuum filters located in the solids processing building. The dewatered sludge cake, now containing 25% solids, is pumped to two fluidized bed incinerators for burning. Ash from the incinerator is removed to a landfill.

All the remaining liquid sewage is pumped to the trickling filters. The waste is pumped to the center of the filters and distributed to the filter bed by a large rotating boom. The effluent from the trickling filters is then chlorinated before it is discharged into the Missouri River.

V. PLANT STAFFING DESCRIPTION

The plant operates 24 hours a day, seven days a week. A 24-hour day is divided into three shifts as follows:

Day Shift - 7:30 a.m.- 3:30 p.m.

Evening Shift - 3:30 p.m.-11:30 p.m.

Morning Shift - 11:30 p.m.- 7:30 a.m.

The plant requires a minimum crew of approximately eight people to operate all the processing equipment. This minimum crew usually includes a foreman, stationary engineer and six operators. This work force is maintained throughout the week, except during the five-day-a-week day shift, in which additional staff works at the plant. The additional staff includes plant management, maintenance mechanics, additional operators and laborers. Total staff on days could run as high as 30 employees during the summer months.

The plant employs approximately 70 people to cover all these shifts. A listing of the employee job categories is shown in Table I. This list is not exact and is presented only to show the nature and distribution of employees. The hourly employees in the plant are represented by the Omaha City Employee's Local #251, American Federation of State, County & Municipal Employees, AFL-CIO.

Most of the job titles are descriptive of the type of work performed by the individuals. The Operator category represents the largest number of workers in the plant. As the name implies, these individuals are responsible for the various individual operations throughout the plant. They may rotate from operation to operation on a shift-to-shift basis. Their normal work week is 40 hours, and their work shift schedule is flexible so that all shifts, including weekends, are covered. Their principal function is to monitor equipment in their assigned area and maintain logs of the operational characteristics. Duties range from collecting water samples to grinding grease. Over a period of time, each operator will have entered all areas of the plant.

The stationary engineers' main responsibilities include the operation of the fluidized bed incinerator and the sludge digester. These individual's exposures are then related to their activities in these areas.

Maintenance mechanics have the responsibility to repair machinery in all parts of the plant. They enter into all the process units when operating, shut down for simple maintenance checks, or sometimes for shift-long repairs. This group has the greatest potential for exposure to any contaminants that may be present in the various processing areas.

The Laborers category covers a wide range of jobs and skills required. During the summer months, they are involved with cutting the grass and general upkeep of the grounds. They also perform custodial functions for the plant and are available for any other activities as necessary.

The remaining categories are in the management and plant operations area; and, although these workers do not routinely enter specific plant areas, they may enter on occasion to provide supervision and support.

The 13 job categories listed in Table I can, therefore, be lumped into three categories based on the type of job they are performing and their potential for exposure to contaminants. These categories are shown in Table II and used in the analysis discussed in the Results section of this report.

VI. METHODS

A. ENVIRONMENTAL

On October 18, 19, and 20, 1983, air sampling was conducted throughout the plant. Three types of air sampling were conducted, including personal full-shift samples, area full-shift samples and direct-reading instrument grab samples. Based on information gathered during the initial site visit, the NIOSH investigators decided to focus on H_2S as the contaminant of greatest interest. Long term length-of-stain indicator tubes served as the principal sampling technique for H_2S. Area samples for H_2S were collected using the same technique, as well as the NIOSH Analytical Method #296. Method #296 uses a molecular-sieve tube, and we added a silica gel in front of the sorbent tube to remove the moisture in the air. The results from Method #296 were all non-detectable because of methodology problems and, consequently, were not usable and will not be discussed any further.

Area samples for ammonia and butyl-mercaptan were also collected in the various process areas. Long term length-of-stain indicator tubes were used for ammonia only during the day shift of the first day. There was no ammonia detected on any of the tubes, so no further samples for ammonia were collected.

Samples for butylmercaptan (butanethiol) were collected during most of the shifts sampled over the three-day time period. A method developed by Knarr and Rappaport[1] was used. The results reported by the lab for these samples were all non-detectable, so they were not included as data to be discussed in this report.

A direct reading instrument for H_2S (Ecolyzer 6000 Hipster) became our constant companion during the entire survey because of the reported H_2S levels in some of the areas and the nature of H_2S. As we entered each area of the plant, readings were taken for our own personal safety; and those that were recorded are reported in the results section of this report.

Interviews with plant management personnel and workers were used to gain information relative to plant operational conditions on the night of the death of the worker and on a day-to-day basis. Personal observations were also used to establish specific work activities for each job category, as well as other operational parameters of the plant.

B. EPIDEMIOLOGICAL

Information on symptoms experienced by Papillion plant workers was gathered by a self-administered questionnaire. Fifty-four of the 65 workers on the plant roster completed the questionnaire. All job classifications were represented by at least one questionnaire.

The questionnaire had three major sections. The first section gathered demographic information such as worker age, time at the Papillion Creek plant, and total time in the wastewater treatment industry. The second section gathered the frequencies for a list of symptoms reported to be associated with hydrogen sulfide. The purpose of this section was to reveal any acute effects of hydrogen sulfide exposure. The time period that the questionnaire specified for reporting the presence of symptoms was the previous 2 weeks. This list of recent symptoms included irritant symptoms such as nose and throat irritation, neurologic symptoms such as numbness and tingling of the hands and feet, and symptoms of systemic illness such as nausea, vomiting, and fatigue. The third section asked about a number of conditions which have been reported following very high level exposure to hydrogen sulfide. The time period for reporting the occurrence of subacute/chronic conditions was the entire period since employment at the Papillion wastewater treatment plant. The purpose of this section was to reveal any high-level exposures that had occurred in the past and had caused more serious medical conditions. Conditions on this part of the questionnaire included cardiac arrhythmias, pulmonary edema, decreased fertility, etc. Other parts of the questionnaire asked about previous exposures to neurotoxic agents, smoking, and alcohol consumption.

VII. EVALUATION 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 a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with 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 criterion. 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 become 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), and 3) the U.S. Department of Labor (OSHA) occupational health standards. 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 solely 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 only 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.

Hydrogen sulfide gas is a rapidly acting systemic poison which causes respiratory paralysis with consequent asphyxia at high concentrations. It irritates the eyes and respiratory tract at low concentrations. Inhalation of high concentrations of hydrogen sulfide, 1000 to 2000 ppm, may cause coma after a single breath and may be rapidly fatal; convulsions may also occur. Exposure to concentrations of hydrogen sulfide above 50 ppm for one hour may produce acute conjunctivitis with pain, lacrimation, and photophobia; in severe form this may progress to keratoconjunctivitis and vesiculation of the corneal epithelium. In low concentrations, hydrogen sulfide may cause headache, fatigue, irritability, insomnia, and gastrointestinal disturbances; in somewhat higher concentrations, it affects the central nervous system, causing excitement and dizziness. Prolonged exposure to 250 ppm of hydrogen sulfide may cause pulmonary edema. Prolonged exposure to concentrations of hydrogen sulfide as low as 50 ppm may cause rhinitis, pharyngitis, bronchitis, and pneumonitis. Repeated exposure to hydrogen sulfide results in increased susceptibility, so that eye irritation, cough, and systemic effects may result from concentrations previously tolerated without any effect. Rapid olfactory fatigue can occur at high concentrations.

Hydrogen sulfide [2,3] is a nearly ubiquitous, odoriferous, and acutely acting toxic substance. It has the following chemical and physical properties:

Molecular weight:	34.08
Molecular formula:	H_2S
Boiling point: (760mm Hg)	-60^oC (-76^oF)
Specific gravity: (Water = 1)	Liquid = 1.54
Vapor density: (Air = 1 at 15^oC (59^oF))	1.189
Melting point:	-82.4^oC (-116^oF)
Vapor pressure: (25^oC (77^o F))	20 atm
Solubility in water: (g/100g water at 20^oC)	2.9

H_2S is a colorless gas at room temperature and has a characteristic rotten egg odor. Although it has a rather low odor threshold (0.13 ppm), it can cause olfactory fatigue in 2 to 15 minutes at 100 ppm.

The American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) [4] for H_2S recommends a time weighted average (TWA) value of 10 ppm. They also recommend a short-term exposure limit (STEL) not to exceed 15 ppm for any 15-minute sampling period. The Occupational Safety and Health Administration's (OSHA) standard (29 CFR 1910.1000 - Table Z-2) [5] states that the acceptable ceiling concentration is 20 ppm. This standard also allows a one-time 10-minute exposure not to exceed 50 ppm during a work shift.

The National Institute for Occupational Safety and Health [6] recommends a ceiling concentration not to exceed 10 ppm, in a 10-minute sample during a 10-hour work shift. They also recommend that an area should be evacuated if the concentration of H_2S exceeds 50 ppm. The NIOSH/OSHA Pocket Guide to Chemical Hazards [7] recommends an immediately dangerous to life and health (IDLH) value of 300 ppm.

VIII. RESULTS

A. Environmental

The long-term length-of-stain indicator tube results for H_2S personal samples are shown in Table III. These samples were collected during five shifts over the three-day sampling period. Three day shifts, one evening shift and one morning shift were sampled. With the exception of samples collected on five mechanics during the day shift on October 18, 1983, the majority of the rest of the samples were collected on operators. The 40 valid samples collected ranged from none detected (n.d.) to 2.2 ppm. Twenty-four of the samples were n.d. The detection limit for these samples is a function of both the ability to read the tube and the volume sampled. Any stain on a tube was read as at least 1 microliter (ul) of H_2S. The air volumes sampled ranged from 1.7 liters to over 9 liters, with most in the 6-7 liters range. These numbers result in a lower detection limit of approximately 0.2 ppm. Therefore, it is possible to assume that each n.d. value is somewhere between zero and 0.2 ppm. Consequently, for purposes of averaging and using then.d. data in summaries, a value of 0.1 ppm was used for all n.d. values. The validity of the assumption is also supported by the fact that H_2S is present in most areas of the plant based on the area samples and that every worker has the potential duty during every shift to enter these areas.

The long-term length-of-stain indicator tube results for H_2S area samples are shown in Table IV. These samples were also collected during five shifts over the three-day sampling period. Three day shifts, one evening shift and one morning shift were sampled in the principal operating areas of the plant. These areas included the bar screen area, grease and grit area, clarifier, thickener, digester and trickling filter. A process-by-process summary of these results is shown in Table V. The bar screen area showed levels of 4.0, 6.4, 25., 47., and 56. ppm over five shifts during the three-day sampling period. The grease and grit area showed levels of n.d., 0.3, 0.5, and 5.7 ppm, over four shifts during two days. Because of the variability in the data from these two areas, calculation of averages is not a good descriptor and were not used. In the bar screen area, the main supply fan was either off or on during several of the sampling periods, which caused the variance in the final results. Activities in the grease and grit area also vary from shift to shift. The vacuum filters and grease grinders are only run on certain days, and these tasks probably influence the air levels of H_2S.

The remaining process areas operate in nearly the same manner on a day-to-day, shift-to-shift basis, and the consistency of the results obtained confirms this observation. The air level inside the clarifiers averaged 6.8 ppm H_2S over all the shifts sampled. In the thickeners, the average H_2S level was 15.2 ppm. The trickling filter average was 7.8 ppm, and the gas collection room showed the lowest level of 0.15 ppm.

The results of the direct reading instrument instantaneous samples for H_2S are shown in Table VI. Most of these samples were taken in the wet well-bar screen area during the time we were investigating circumstances that might have existed during the night the worker died. The remaining samples were collected as a precaution before entry into the areas being sampled.

B. Epidemiological

The results are presented using the symptom groups and condition lists as described under the methods section. Tables VII and VIII describe the experience of the entire group of respondents. Then, the respondents are divided into three exposure groups, based on our observation of their job duties (Table II). Finally, the symptom and condition lists are described for each assigned exposure group.

Table VII describes the symptom frequencies for all 54 respondents for the two-week period from October 3 through October 17. The symptoms are listed in decreasing order of frequency, based on the percentage of all workers who experienced the symptom at least once. As might be expected from an irritant compound, the symptoms of coughing, nose irritation, and eye irritation head the list. Other symptoms, such as diarrhea, headaches and nausea are reported at a high prevalence. Symptom frequencies show that most workers who reported the irritative symptoms experienced the specific symptom six times or less during the preceding two weeks.

Table VIII lists the frequencies for the subacute/chronic conditions experienced by the participants any time since working at the Papillion plant. Personality change, loss of appetite, and loss of libido head the list. Cardiac arrhythmias and pulmonary edema, both conditions commonly reported after high level hydrogen sulfide exposure, were reported by fewer workers. Informal questioning of the workers reporting arrhythmias and pulmonary edema revealed that the immediate cause of these problems was probably underlying cardiac disease, and not chemical exposures.

In order to help determine whether symptoms were more frequent in workers with higher exposures, we classified workers into exposure groups based on their job titles (Table II).

Table IX lists the percentages of the respondents in each exposure category who experienced the symptom at least once during the previous two weeks. This percentage is called the symptom prevalence. If the exposure classification is accurate and if the symptoms are caused by the exposure, one would expect workers with higher exposure to have higher prevalence of symptoms. As shown in Table IX, there is no clear pattern of decreasing symptom prevalence across decreasing exposure categories. In fact, the intermittent exposure group had higher prevalences than the other two exposure groups.

Table X lists the percentages of the respondents in each exposure category who experienced the condition listed, divided into exposure categories. For the four most frequent subacute/chronic conditions, the intermittent exposure group again was most affected (Table X).

Overall, the responses indicate that forty-one (76%) of the 54 respondents reported that they had experienced three or more symptoms of hydrogen sulfide toxicity during the two week period prior to the medical survey. Two additional concerns were volunteered by workers during the survey. One worker expressed concern about pesticide usage around the plant, and another worker reported nose and throat irritation when cleaning out ash from the sewage sludge incinerator. This worker reported intermittent exposure to sewage sludge ash when the incinerators were shut down for maintenance. Workers would then enter the incinerator and shovel out the residual ash. This process did not occur during our survey.

IX. DISCUSSION

The information gathered and the results obtained during this investigation appear to focus on two problem areas at the plant. However, both are the result of the presence of H_2S in the plant air. There are two types of health hazard present: one is associated with high level acute exposures to H_2S and the other to low level, chronic H_2S exposures. Each will be discussed separately in this section of the report.

A. HIGH ACUTE EXPOSURES

The exact circumstances surrounding the exposures that resulted in the untimely death of a worker the following day will never be precisely known. The first contributing factor is the nature of the sewage coming into the plant. As previously mentioned, the average flow time to the plant is approximately 8 hours in over 25 miles of sewer pipe. At all times, but especially in times of low flow and warmer water temperatures, the sewage becomes anaerobic which facilitates the growth of H_2S producing bacteria. The presence of

H_2S has been a recurring problem at this plant. During the last stages of construction at this plant, another worker lost his life while working in the main sewer coming into the plant. Sewer gas was listed as the probable cause. High levels of H_2S in the sewage has also been a problem for residences along the sewer line and corrective action was taken by the city by sealing up some of the manhole covers with tar.

The second contributing factor to the death is the ventilation system in the mezzanine, bar screen and wet well area. There are two entrances down to the mezzanine level. One is an open stairwell to the raw sewage pump room. The other access is through a normally closed door from the solids loading area down a set of stairs to the mezzanine level. The mezzanine area is a "T" shaped room. The cross part of the "T" is 18' by 78' and contains the two stairways, shafts that pass from the motor room above to the raw sewage pumps below, the screw controls for the sliding doors to the wet well and the air supply and exhaust outlets. The leg of the "T" is 28' by 38' and contains the penetrations for the four bar screen conveyors and the access hatch (3' X 3') to the catwalk and Parshall Flume below. The worker who died was on the catwalk collecting a routine hourly sewage sample.

In-plant wastes are also returned to the inflowing sewage stream at this location in the plant. This waste, at times, contains supernatant from the digesters and thickeners, both of which have the potential to contain high levels of H_2S. The manner in which it is delivered by the Kennison nozzle, in a turbulent, free falling stream, may enhance H_2S removal from the liquid stream. There is an outside air supply opening over the Parshall Flume.

The ventilation system in this area was designed to keep the entire area under positive pressure apparently for odor control outside the plant . The supply air fan for the Parshall Flume is located above ground outside the building and supplies non-conditioned air into the area at a rate of 12000 cfm. Another supply fan is located on the roof and supplies 3000 cfm of air into the mezzanine area. An exhaust duct is also located on the mezzanine level and removes air at a rate of 5000 cfm. This air is ducted to an air scrubber before discharge to the outside. The air being moved by these devices was checked during the survey and found to be 12,560 cfm, 3,125 cfm and 7,056 cfm. Consequently, the excess air being supplied to the area has the potential to carry contaminants to other parts of the plant. To illustrate air flow patterns, a smoke bomb was set off on the catwalk, and smoke came right up through the hatch into the mezzanine area. Also, when the door from the solids loading area to the mezzanine stairwell was opened, one always got a blast of air in one's face.

With the plant operating in the normal mode as described above, air levels of H_2S were measured on the mezzanine level, starting at around 8:00 a.m., throughout the day. These values, along with the plant flow, were as follows:

Time	H_2S Conc. ppm	Plant Flow mgd
8:00	35	29
11:00	45	30
13:00	75	51
15:00	125	53
*17:30	7	50
**23:45	200	45

*Fan reversed
**Fan off

Although the air concentration of H_2S in the mezzanine area may not be linearly related to plant flow, we think there definitely is an association. At approximately 4:30 p.m. on this day, we recommended that the supply fan to the Parshall Flume be reversed so that it was exhausting air from the area. By 5:30 p.m., the air concentration of H_2S in the mezzaine area was down to 7 ppm.

However, when we returned that same evening to sample the morning shift, we found an air level of over 200 ppm of H_2S when the door from the solids loading area to the mezzanine stairway was opened. We did not attempt to enter the area and later discovered that the supply fan to the Parshall Flume was not operating. There had been a short power outage before we arrived at the plant that evening, and the operator had failed to restart the fan. Any or all of these conditions might have existed on the evening of the worker's death. Given a level of 200 ppm at the doorway to the mezzanine level we would estimate that the level of H_2S in the Parshall Flume area was in the 1000 - 2000 ppm range. This level is considerably above the NIOSH IDLH value of 300 ppm.

The third factor that contributed to the death of the worker was the absence of formal procedures that would allow safe entry into areas containing gases that may be immediately dangerous to life and health. Workers have been collecting wastewater samples from the catwalk in the Parshall Flume every hour on the hour for several years without incident. A remote sewage sampling pump was installed in the plant during construction but has not been used because of operational difficulties. The dynamic conditions under which the plant operates and the unpredictable nature of H_2S will always present a potential for the same hazardous condition that existed on the evening of the death, unless carefully written and enforced procedures are implemented.

A final aspect of our medical investigation was the review of the medical records and autopsy report of the deceased worker. In the opinion of our medical investigator, the clinical presentation and pathologic findings are consistent with fatal hydrogen sulfide exposure.

B. CHRONIC LOW EXPOSURES

Even before doing any sampling, there is evidence that low level concentrations of H_2S are ubiquitous at this plant site. When weather conditions are stable, the odor of H_2S is detectable some distance from the plant. Chrome-plated plumbing fixtures throughout the administration and laboratory building show visual evidence of corrosion, probably caused by plant air effluents as well as H_2S that is liberated from the non-potable water used to irrigate the grounds.

Based on the information gathered during this survey, it is reasonable to conclude that everyone who works at this plant is exposed to H_2S at a level above normal background. The average H_2S exposure, from Table III, to all the workers sampled during the three-day sampling period was 0.3 ppm, assuming all non-detected values to be 0.1 ppm as previously stated. Although these values seem rather low when compared to the concentrations in the various process areas, they are probably correct because these areas are only occasionally entered by the plant operators.

The evaluation criteria discussed in Section VII is not directly applicable to these results. The only full-shift criteria is the 10 ppm recommendation of ACGIH. None of the H_2S air levels exceeded this criteria. However, the 10 ppm ceiling recommended by NIOSH has the potential for being exceeded by almost any worker in the plant based on the H_2S concentrations in the various process areas (Table VI).

The average level of 15.2 ppm in the thickener exceeds the NIOSH recommended standard of 10 ppm, and the average levels (6.8 ppm and 7.8 ppm) in the clarifier and trickling filters were close enough to the recommended criteria that, more than likely, there are 15-minute periods during the day when 10 ppm is exceeded. These three process areas are covered by aluminum dome canopies. These structures are ventilated by drawing outside air in through the crown of the dome and exhausting the air down to grilles in an exhaust duct located around the outer periphery of the structure directly above the circular weir. The exhaust air is discharged outside and can be scrubbed with water spray devices. Operators enter these areas on a catwalk above the sewage that runs to the center of the tank. The area samples discussed previously were taken from the catwalk about midway to the center of the room. Since fresh air is continually coming in through the roof, these samples may not be representative of the highest concentrations that could exist in the structures. Higher readings could probably be obtained closer to the weir and especially close to the common supernatant collection point. In any case, because of the physical and chemical properties of H_2S and its unpredictable warning properties, the clarifiers, thickeners, and trickling filters should be considered as areas of potential hazard by the workers.

The purpose of the medical component of our investigation was to assess the prevalence of symptoms and disease conditions known to be associated with exposure to hydrogen sulfide. The lists of symptoms and diseases were derived from previous studies of workers acutely exposed to H_2S?8,9 . The result of repeated human exposures to H_2S has not been well researched.

The frequency of symptoms in Table VII among all workers seems high, judging empirically. However, our attempts at analysis by exposure category in Table IX revealed that for five of the six most prevalent symptoms, the intermittent exposure group was affected most often. This suggests that either our exposure classification was erroneous, or that intermittent exposure may cause more symptoms. A similar result is obtained when examining the history of subacute and chronic conditions: the intermittent exposure group had the highest percentage of workers affected by the four most frequent conditions. Further interpretation of this medical data is hampered by the absence of an unexposed comparison population, and the lack of human data on the effects of intermittent exposure.

Nevertheless, it is possible, based on previous studies, to say that the peak exposure measured at the Papillion plant are immediately dangerous to human life. The lower exposures (still above 10 ppm H_2S) commonly found around the plant also represent a hazard, and may cause adverse health effects over a worker°s lifetime. These long-term effects could not be identified by our single cross-sectional study.

C. OTHER EXPOSURES

Exposure to sewage sludge ash has received little attention to date. In 1980, NIOSH investigated respiratory complaints from employees exposed to sludge ash from an oil-fired incinerator[10]. The major components (greater than 1% by weight) of the ash at this plant were aluminum, calcium, iron, and magnesium. The workers' symptoms had resolved by the time the investigation occurred. A second investigation, in 1981, found severe dermatitis among workers exposed to a mixture of dried sewage sludge and fly ash from the exhaust fan of a sludge incinerator[11]. In this case, the sludge was pretreated with an anionic amine polymer and entered the incinerator containing 5% chromate, with a pH of 11. The investigators determined that in this case the caustic nature of the sludge caused chemical skin damage. It should be noted that chromates can also cause allergic skin disease in sensitive individuals.

Based on the two previous studies, it is possible that workers are at risk of respiratory irritation when exposed to airborne sludge ash. In addition, the sludge itself may be irritating to the skin after treatment with anionic amine polymers.

The pesticides we saw in the storage area included pyrethrins and carbamate compounds for outdoor usage. The preparations were standard commercial concentrations and should pose no unusual hazards when used in accordance with label instructions.

X. RECOMMENDATIONS

Recommendations made in this report are intended for use by the City of Omaha in improving working conditions in this plant. Some are interrelated and need to be considered in sequence and others are independent. NIOSH is available at any time to assist the city in the development of plans to implement these recommendations or to assist in the assessment of their effectiveness once installed.

1. The physical and chemical nature of the sewage as it moves down the sewer line over the 25 miles needs to be studied from the perspective of preventing the growth of bacteria causing the formation of H_2S. Aeration at some point may reduce anaerobic conditions and retard growth. It may also be possible to add chemicals along the line at some location and accomplish the same end result. In any case, a competent consulting firm should be retained to study the conditions and recommend corrective action.

2. The various ventilation systems throughout the plant should be evaluated. Although the H_2S concentrations in the bar screen area were reduced by reversing the Parshall Flume supply fan, this should only be viewed as a temporary measure. Discharging high concentrations of H_2S to the outside at ground level may result in exposures to groundskeepers, as well as creating an opportunity for H_2S to be drawn into the building through various inlets. Also, the large circular duct connecting the pump engine room and Parshall Flume fan should be dismantled. This was used in the winter to supply warm air into the Parshall Flume area, and that practice should be eliminated. Since the fan is now reversed, all possibilities of cross connection would be removed. A brief tour of the roof over the pump room revealed several possibilities for entrainment of contaminated air. The exhaust from the internal combustion engines discharge on the roof in close proximity to the supply fan intakes. There are two other supply and exhaust fans in the same area that may be too close, and these entrainment possibilities should be minimized. The ventilation systems in other areas of the plant should also be evaluated to see if they are operating in accordance with the design specifications. Some clarifier doors were closed and some were open. Whichever is correct should be enforced at all times.

3. In order for the plant to continue to operate under conditions similar to those that existed during our investigation, several areas in the plant need to be continuously monitored for H_2S. At a minimum, these areas would be the bar screen area and the thickeners. Alarms or lights outside these areas should signal when concentrations exceed 10 ppm H_2S. Workers entering these areas for emergency repairs should only do so if they are accompanied by a portable continuous monitor with an alarm. Lights and alarms should also be installed on critical ventilation devices in a location where the workers have to enter the area. All of these monitoring devices should also be installed so that the signals are read in some other location in the plant that is continually staffed.

4. The city should develop a comprehensive health and safety plan for the plant. Surveillance of environment conditions in the plant and of the workers should be included. Procedures for monitoring and entry into potentially contaminated areas should be a part of the plan, including training for all plant personnel.

5. The manner in which in-plant wastes are delivered into the wet well might be modified to limit the liberation of H_2S from this wastewater.

6. The practice of irrigating the grounds with non-potable water from this plant should be stopped.

7. A maximum effort should be recommended to reduce hydrogen sulfide exposures to meet the NIOSH standard of 10 ppm TWA. If this is accomplished, no medical monitoring is recommended.

8. Workers entering the incinerators for maintenance should follow confined space entry precautions and be provided with personal respiratory protective equipment.

9. Pesticide usage should conform with label instructions and accepted safety precautions[12].

XI. AUTHORSHIP AND ACKNOWLEDGEMENTS

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XII. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 4676 Columbia Parkway, Cincinnati, Ohio 45226. 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 the NIOSH Publications Office at the above address.

Copies of the report have been sent to:

A. Omaha City Engineer
B. Papillion Creek Plant Manager
C. Nebraska Department of Health
D. EPA, Region VII
E. NIOSH, Region VII
F. OSHA, Region VII

XIII. REFERENCES

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Table I

EMPLOYEE JOB DESCRIPTION

Papillion Creek Wastewater Plant
Omaha, Nebraska

A.	Plant Manager	1
B.	Secretary	1
C.	Supervisor of Operations	1
D.	Shift Foreman	3-5
E.	Operators	23
F.	Computer Operator	1
G.	Semiskilled Laborers	3
H.	Laborers	7
I.	Stationary Engineers	17
J.	Custodial Foreman	1
K.	City Maintenance Supervisor	1
L.	Maintenance Mechanics	14
P.	Painter	1

Table II

ASSIGNED EXPOSURE GROUPS

Omaha Papillion Creek Wastewater Treatment Plant
HETA 83-440

Low Exposure Group: This group spends the majority of their time in the office building or outdoors. The response rate for this group was 92% (11/12 workers).

Job titles included

Plant manager
Secretary
Plant supervisor
Foreman II
Process Control Analyst
Semiskilled laborers
Custodial Foreman

Intermittent exposure group: This group enters high hydrogen sulfide areas intermittently to perform repairs. Duration of exposure depends on the job--it may last full-time for two weeks. The response rate for this group was 96% (23/24 workers).

Job titles included

Laborers
Maintenance Supervisor
Maintenance Mechanic I
Maintenance Mechanic II
Painter
Partsman I
Partsman II

High exposure group: These workers often are assigned to work in or operate processes in high-hydrogen sulfide areas. The response rate for this group was 69% (20/29 workers).

Job titles included

Stationary Engineer I
Stationary Engineer II
Operators

TABLE III

H_2S PERSONAL SAMPLING RESULTS

Omaha Papillion Creek Wastewater Treatment Plant
HE 83-440

Sample #	Job Title	Date	Shift	Vol. l	Tube Reading ul	H_2S Conc. ppm
1	Mechanic II	10/18/83	Day	5.2	0	n.d.
2	Mechanic I	10/18/83	Day	3.3	0	n.d.
3	Mechanic II	10/18/83	Day	9.5	2	0.2
4	Mechanic II, Solids loading	10/18/83	Day	7.9	10	1.3
5	Mechanic II, Reactor Area	10/18/83	Day	7.9	17	2.2
6	Operator, Digester	10/18/83	Day	6.6	0	n.d.
7	Operator, Clarifier & Smplg.	10/18/83	Day	6.1	2	0.3
8	Foreman	10/18/83	Day	5.4	1	0.2
9	Operator, Vacuum Filters	10/18/83	Day	6.1	0	n.d.
10	Operator, Rover	10/18/83	Day	7.2	0	n.d.
11	Stat Eng., Reactor	10/18/83	Day	8.2	0	n.d.
12	Operator, Trickling Filter	10/18/83	Day	2.1	2	0.9
13	Operator, Solid Wastes	10/18/83	Day	5.6	10	1.8
44	Operator, Digester	10/19/83	Morning	4.7	1	0.2

TABLE III
(continued)

H_2S PERSONAL SAMPLING RESULTS

Omaha Papillion Creek Wastewater Treatment Plant
HE 83-440

Sample #	Job Title	Date	Shift	Vol. l	Tube Reading ul	H_2S Conc. ppm
45	Operator, Vacuum Filter	10/19/83	Morning	6.4	2	0.3
46	Operator, Vacuum Filter	10/19/83	Morning	6.2	2	0.3
47	Stat. Eng., Incinerator & Boiler	10/19/83	Morning	1.7	0	n.d.
48	Operator, Reactor or Incinerator	10/19/83	Morning	4.9	0	n.d.
49	Operator, Solids Loading	10/19/83	Morning	1.9	0	n.d.
50	Foreman	10/19/83	Morning	7.8	0	n.d.
51	Operator, Clarifier & Samples	10/19/83	Morning	7.3	2	0.3
57	Operator, Reactor	10/19/83	Day	6.4	0	n.d.
58	Operator, Vacuum Filters	10/19/83	Day	6.9	6	0.9
59	Operator, Clarifiers	10/19/83	Day	5.9	0	n.d.
60	Operator, Grit Pumps	10/19/83	Day	8.8	0	n.d.
61	Operator, Solid Wastes	10/19/83	Day	8.5	15	1.8
62	Operator, Grit Pumps	10/19/83	Day	5.3	0	n.d.

TABLE III
(continued)

H_2S PERSONAL SAMPLING RESULTS

Omaha Papillion Creek Wastewater Treatment Plant
HE 83-440

Sample #	Job Title	Date	Shift	Vol. l	Tube Reading ul	H_2S Conc. ppm
83	Operator, Reactor	10/19/83	Evening	4.1	0	n.d.
84	Operator, Reactor	10/19/83	Evening	6.0	0	n.d.
85	Operator, Vacuum Filter	10/19/83	Evening	7.9	0	n.d.
86	Operator, Samples	10/19/83	Evening	6.6	0	n.d.
87	Operator, Clarifier	10/19/83	Evening	6.9	0	n.d.
88	Operator, Solids Handling	10/19/83	Evening	6.3	0	n.d.
89	Operator, Digester	10/19/83	Evening	5.4	0	n.d.
90	Laborer	10/19/83	Evening	0.6	0	n.d.
101	Operator, Solid Wastes	10/20/83	Day	8.6	0	n.d.
102	Operator, Vacuum Filter	10/20/83	Day	6.0	1	0.2
103	Operator, Clarifier	10/20/83	Day	6.9	0	n.d.
104	Operator, Raw Pump Station	10/20/83	Day	8.2	1	.2
105	Operator, Raw Pump Station[1]	10/20/83	Day	--	--	--
106	Operator, Raw Pump Station	10/20/83	Day	6.0	2	0.3

1 - Pump died, data not included in analysis

TABLE IV

H_2S AREA SAMPLING RESULTS

Omaha Papillion Creek Wastewater Treatment Plant
HE 83-440

Sample #	Location	Date	Shift	Vol. l	Tube Reading ul	H_2S Conc. ppm
17	Bar Screen Area	10/18/83	Day	1.9	90	47[1]
23	Grease Skim & Grease Control	10/18/83	Day	8.4	0	n.d.
27	Clarifer	10/18/83	Day	6.4	56	8.8
31	Trickling Filter	10/18/83	Day	5.4	65	12
40	Bar Screen Area	10/18/83	Day	1.6	90	56
52	Grease Skimming	10/19/83	Morning	9.1	52	5.7
53	Outside Bar Screen Area Door	10/19/83	Morning	7.7	53	6.9
54	Mezzanine, Top of Bar Screen	10/19/83	Morning	8.4	54	6.4
55	Thickener	10/19/83	Morning	8.0	90	11.3
				56	Clarifier	
#7	10/19/83 Morning	7.4	70	9.5		
64	Bar Screen Area	10/19/84	Day	7.3	29	4.0
66	Vacuum Filter Area	10/19/83	Day	8.6	4	0.5
69	Thickeners	10/19/83	Day	4.7	65	13.8
73	Gas Collection Room in Digester	10/19/83	Day	7.0	1	0.1
76	Clarifier #7	10/19/83	Day	8.5	44	5.2

TABLE IV
(Continued)

H_2S AREA SAMPLING RESULTS

Omaha Papillion Creek Wastewater Treatment Plant
HE 83-440

Sample #	Location	Date	Shift	Vol. l	Tube Reading ul	H_2S Conc. ppm
78	Outside Bldgs.	10/19/83	Day	5.6	0	n.d.
91	Bar Screen Area	10/19/83	Evening		0[2]	
92	Vacuum Filter	10/19/83	Evening	6.3	2	0.3
93	Gas Room	10/19/83	Evening	6.2	1	0.2
94	Thickener	10/19/83	Evening	.03	4	133
95	Clarifier	10/19/83	Evening	7.6	45	5.9
107	Bar Screen Area	10/20/83	Day	3.6	90[3]	>24.9
110	Thickeners	10/20/83	Day	4.4	90	20.4
113	Clarifier #7	10/20/83	Day	6.0	20	3.3
116	Clarifier #9	10/20/83	Day	7.3	25	8.3
120	Trickling Filter	10/20/83	Day	9.8	35	3.6

1 Two-hour sample.

2 Dead pump.

3 Tube completely discolored.

TABLE V

H_2S AREA SAMPLE SUMMARY

Omaha Papillion Creek Wastewater Treatment Plant
HE 83-440

Operation	Date		H_2S Conc. ppm
Bar Screen Area	10/18	Day	47.
	10/18	Day	56.
	10/19	Morning	6.4
	10/19	Day	4.0
	10/20	Day	25.
Grease & Grit Area	10/18	Day	n.d.
	10/19	Morning	5.7
	10/19	Day	0.5
	10/19	Evening	0.3
Clarifier	10/18	Day	8.8
	10/19	Morning	9.5
	10/19	Day	5.2
	10/19	Evening	5.9
	10/20	Day	3.3
	10/20	Day	8.3
	Avg.		6.8
Thickener	10/19	Morning	11.3
	10/19	Day	13.8
	10/19	Evening	133.[1]
	10/20	Day	20.4
	Avg.		15.2
Trickling Filter	10/18	Day	12.
	10/20	Day	3.6
	Avg.		7.8
Gas Collection Room	10/19	Day	0.1
	10/19	Evening	0.2
	Avg.		.15

[1]Pump malfunction not included in average.

TABLE VI

H_2S GRAB SAMPLE CONC., PPM

Omaha Papillion Creek Wastewater Treatment Plant
HE 83-440

Date	Time	Wet Well & Bar Screen Area: Parshall Flume	Wet Well & Bar Screen Area: Mezzanine	Wet Well & Bar Screen Area: Top	Wet Well & Bar Screen Area: Above Ground Discharge	Clarifier	Thickeners	Trickling Filter
10/18/83	8:30	--	30-40	--	--	10	15	--
10/18/83	10:40	--	40-50	--	--	10	15	--
10/18/83	13:20	--	75-80	--	--	--	--	--
10/18/83	15:10	--	125	--	--	--	--	--
10/18/83	17:30	--	7*	--	--	--	--	--
10/18/83	23:45	--	200**	50-60	--	--	--	--
10/19/83	8:10	--	0	--	--	10	25-30	--
10/19/83	10:30	10	0	--	40	--	--	--
10/19/83	1:30	75	3-5	--	20	--	--	--
10/19/83	4:30	150	3-5	--	120	--	--	--
10/19/83	23:05	175	15	--	150	--	--	--
10/20/83	7:45	100	5	1	50	5	25-30	2
10/20/83	12:40	--	100**	75-80	--	2	22	--
10/20/83	15:50	75	25	1-2	--	5	15-20	15

* Supply air fan to wet well reversed.
** Supply air fan down.

Table VII

FREQUENCY OF SYMPTOMS

Omaha Papillion Creek Wastewater Treatment Plant
HETA 83-440

Symptom (previous 2 weeks)	Percent of 54 workers reporting symptom (n=54)			
	1-6 times	7-13 times	Daily	Total*
Coughing	35	9	17	61
Eye irritation	41	4	13	57
Nose irritation	44	4	6	54
Diarrhea/abdo. cramping	43	9	2	54
Severe headaches	39	2	7	48
Nausea	39	6	2	47
Chest tightness	33	7	6	46
Unus. difficulty sleeping	33	11	2	46
Unusual fatigue	35	2	6	43
Unusual mood depression	31	6	4	42
Blurred vision	22	4	7	33
Unusual nervousness	26	4	2	31
Dec. short-term memory	28	0	2	30
Numbness, tingling, pains	18	6	6	30
Decreased concentration	24	2	2	27
Giddiness/drunken feeling	20	6	0	26
Vomiting	13	2	2	17
Difficulty walking	13	0	0	13

*Percentages may not add up exactly due to rounding error.

Table VIII

REPORTED SUBACUTE/CHRONIC CONDITIONS

Omaha Papillion Creek Wastewater Treatment Plant
HETA 83-440

Condition	Percent of all respondents (n=54)
Told by someone else that personality had changed	35
Loss of appetite	28
Loss of sex drive	26
Bronchitis (physician-diagnosed)	22
Irregular heartbeat	20
Blood in urine	9
Pneumonia (physician-diagnosed)	7
Pulmonary edema (physician-diagnosed)	4
Difficulty having children	0

Table IX

PRESENCE OF SYMPTOM AT LEAST ONCE (Percent)

Omaha Papillion Creek Wastewater Treatment Plant
HETA 83-440

	EXPOSURE GROUP		
Symptom (previous 2 weeks)	HIGH (n=17)*	INTERMITTENT (n=23)	LOW (n=20)
Coughing	47	84	55
Eye irritation	53	78	54
Severe headaches	50	70	36
Diarrhea/abdominal cramping	50	68	64
Nausea	44	65	36
Unusual mood depression	32	65	36
Nose irritation	59	62	64
Chest tightness/difficulty breathing	41	62	73
Unusual difficulty sleeping	50	59	64
Unusual fatigue	38	59	64
Blurred vision	29	57	18
Unusual nervousness	29	54	36
Numbness, tingling, shooting pains	24	41	45
Decreased short-term memory	26	38	36
Giddiness/drunken feeling	24	38	18
Decreased concentration	41	32	0
Vomiting	12	24	18
Difficulty walking	15	16	18

*n equals the number of workers in each category.

Table X

HISTORY OF SUBACUTE/CHRONIC CONDITION (Percent)

Omaha Papillion Creek Wastewater Treatment Plant
HETA 83-440

	EXPOSURE GROUP		
CONDITION	HIGH (n=11)*	INTERMITTENT (n=23)	LOW (n=20)
Told by someone else of a personality change	38	57	18
Loss of appetite	24	43	18
Decreased sex drive	24	38	36
Bronchitis (Physician diagnosed)	29	35	0
Irregular heartbeat	18	32	36
Blood in urine	0	16	18
Pneumonia (Physician diagnosed)	18	0	18
Pulmonary edema (Physician diagnosed)	18	0	0
Difficulty having children	0	0	0

*n equals the number of workers in each category.

Table XI

H_2S PERSONNEL SAMPLES BY EXPOSURE GROUP, PPM

Omaha Papillion Creek Wastewater Treatment Plant
HE 83-440

	Group		
	LOW	INTERMITTENT	HIGH
	Management	Operations	Maintenance
# of Samples	3	32	5
Average	0.10	0.30	0.78

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