The National Institute for Occupational Safety and Health (NIOSH)

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Wastewater Treatment Plant Operator Drowns in Recirculation Pit in Iowa

FACE 9123

SUMMARY

A 21-year-old operator at an aerobic wastewater treatment plant drowned in the plant's recirculation pit after apparently falling into the pit while performing general maintenance duties. The victim had been assigned the task of hosing down foam in an adjacent transfer pit. The recirculation pit and transfer pit were located on the outside of the operations building of the wastewater treatment facility. The adjoining pits formed one large, 11-feet-deep rectangular compartment divided by a 1-foot-thick concrete wall. The outside perimeter was fenced off with aluminum railings, with one gate for entry into the pits. There were two large openings over the recirculation pit, and one opening over the transfer pit. The operator was in the process of hosing down the transfer pit, when the plant superintendent left the plant to give a contractor a ride downtown. The superintendent stopped at a lift station to take flow readings before returning to the plant. Thus while the operator was unobserved, he apparently stepped or fell into the recirculation pit. When the plant superintendent returned to the treatment plant, he heard one of the recirculation pumps hammering. After shutting off the flow into the pit and letting it drain, he discovered the victim at the bottom, against one of the pump inlets.

The NIOSH investigator concluded that, in order to prevent future similar occurrences, employers and employees should:

- **conduct job hazard analyses of worker tasks required in the operation of the wastewater treatment plant, and use the results to develop a written safety program and task-specific safe work procedures**
- **develop and implement confined space entry procedures**
- **relocate the gate used to access the recirculation/transfer pits**
- **provide fall protection equipment for employees that work over areas where fall hazards exist**
- **provide atmospheric testing equipment for testing confined spaces at the facility and ensure that atmospheric testing is conducted before workers either enter confined spaces or initiate work near open pits.**

INTRODUCTION

On May 25, 1988, a 21-year-old male operator at a wastewater treatment plant drowned after apparently falling into the plant's recirculation pit while performing general maintenance duties. On July 31, 1991, the Commissioner of Labor for the State of Iowa notified the Division of Safety Research (DSR) of this fatality and requested technical assistance. On August 12, 1991, a DSR investigator traveled to the incident site to conduct an investigation. The DSR investigator met with the city administrator, the director of public works, the assistant superintendent of public works, the superintendent of the wastewater treatment plant, the current operator of the wastewater treatment plant, the retired

superintendent of the wastewater treatment plant (who was superintendent at the time of the incident), the parents of the victim, and a labor safety and health consultant with the Iowa Division of Labor. The consultant provided DSR with a copy of the OSHA reports and the files related to this case. The DSR investigation included photographing the incident site, obtaining diagrams and drawings of the plant operation, sampling and monitoring atmospheric conditions at the incident site (recirculation pit) and surrounding operations (aeration basin, clarifier basin, aerobic digester basin, transfer pit, pump room, and operations building), and sampling atmospheric conditions at several manholes and pump stations throughout the city. The city administrator provided DSR with copies of photographs taken the day of the incident, along with statements from city employees and the Emergency Medical Services (EMS) crew.

The employer involved in this fatality was a small municipality with 56 employees. The public works department had five employees, including two–the plant superintendent and the operator–who worked at the wastewater treatment plant. The municipality had no written safety program or confined space entry program. On-the-job training was provided for new employees.

INVESTIGATION

The wastewater treatment plant where the incident occurred was an aerobic-type treatment plant that served a population of approximately 1,300 people. The plant consisted of an aeration basin (where the raw sewage entered and, when recirculated, activated sludge was pumped), a clarifier basin, an aerobic digester basin (the digested sludge was removed at this location), an operations building (the recirculation pit and transfer pit was located on the outside of this building), and four lagoons. The recirculation pit was 18 feet 6 inches long by 6 feet wide by 11 feet deep. The transfer pit was 9 feet 10 inches long by 6 feet wide by 11 feet deep–both pits formed one large rectangular compartment, divided by a 1-foot-thick concrete wall, with one opening over the transfer pit, and two openings over the recirculation pit (Figure 1). The plant was generally automated; i.e., transfer of activated sludge to the aerobic digester was performed automatically, at a predetermined rate of flow. The plant was operated by two individuals–the plant superintendent and the plant operator. The superintendent was responsible for the overall operation of the plant, laboratory sampling and analysis, etc. The plant operator was responsible for general maintenance around the plant, i.e., taking flow readings, general clean-up, hosing down foam on the clarifier basin and the transfer pit, hosing around the grating on the aeration basin, checking the pumping system to detect problems, and other maintenance as needed.

[Note: The day before the incident, the aerobic digester was shut down to allow the digested solids to settle to the bottom of the digester. Digested sludge was to be pumped out of the bottom of the digester into a sludge-hauling truck and the supernate (liquid from the digester) drained off into the recirculation pit, where it would be mixed with the activated sludge and returned to the aeration basin.]

On the morning of the incident, the plant operator (victim) arrived at the plant at approximately 7:00 a.m. The superintendent arrived approximately 15 minutes later. He had stopped on the way to the plant to take flow readings from a local dairy plant. When the superintendent arrived at the treatment plant, he was met by the sludge hauler (the city contracted to have digested sludge removed from the aerobic digester and hauled away) and the plant operator (victim). The sludge hauler stated that someone had removed the sludge trough from the plant, a piece of equipment which he needed for sludge removal. The superintendent agreed to drive the sludge hauler to town to recover the necessary equipment and the hauler's pickup truck. Before leaving, the superintendent told the plant operator (victim) that the foam in the transfer pit would probably need hosed down.

The superintendent drove the sludge hauler into town, dropped him off, stopped at one of the lift stations to record flow readings, and returned to the plant. When he got back to the plant (approximately 7:30 a.m.), the superintendent went inside the operations building. He noticed that one of the recirculation pumps was hammering (cavitating). Upon checking the control panel, the superintendent observed that recirculating pump number 2 was not operating properly. The superintendent went outside and looked into the recirculation pit (Figure 2) and noticed the sewage level was elevated, although it had not reached the high water level (Figure 3). The superintendent checked the area for the operator (victim) and could not find him. The superintendent feared that the operator had fallen into the pit. He immediately shut off the flow of sewage to the recirculation pit, leaving the pumps running to drain the pit. (There were three return lines from the recirculation pit, each with a 30-horsepower pump with a capacity of 2,600 gallons

per minute (gpm); however, only two pumps were on at any given time.) When the water level dropped, the superintendent could see the victim at the bottom of the pit against the number 2 return line, a 12-inch-diameter opening with a steel rebar grate across the inlet (Figure 3).

The superintendent immediately went inside and shut off the recirculation pumps, called 911 and radioed for other city workers to assist. He then went back to the recirculation pit, entered opening number 1 by stepping onto the metal grating, and jumped down to the victim. The superintendent pulled the victim away from the inlet and held him partially out of the sewage (approximately 1 foot deep). Three workers from one of the public utilities arrived within 2 to 3 minutes, and two of them entered the recirculation pit and assisted the superintendent in lifting the victim up to the metal grating (Figure 2).

The Emergency Medical Service (EMS) arrived and one of the technicians went down to the metal grating where the victim had been laid on his back. The victim had “no pulse and no respiration.” Ventilation was started by EMS in an attempt to revive the victim. The victim was removed from the recirculation pit, and cardiopulmonary resuscitation (CPR) was started. Within a few minutes, a second emergency squad arrived and transported the victim to the hospital. CPR was continued on the way to the hospital, along with oxygen administration. Upon arrival at the hospital, the victim was started on advanced life support.

Since this incident occurred over 3 years prior to the NIOSH investigation, and there were no witnesses, it was not possible to reconstruct the immediate events leading to the victim’s death. The following scenario is offered as a plausible explanation of what may have occurred.

The procedure for hosing down foam in the transfer pit was to use a gasoline-powered, 3-horsepower pump (100 gpm capacity), placing the suction end of the hose in the transfer pit or in the nearby lagoon for water. Then using a spray or fan nozzle, the foam in the transfer pit could be hosed down from the outside of the railing. However, it was noted that this procedure, hosing down the foam, was sometimes done from inside the railing. This meant the worker would be standing on the fiberglass panel (55 inches by 60 inches) over the recirculation pit, or on the fiberglass panel (58 inches by 60 inches) over the transfer pit, or on the 8-inch cement curb around the front of the pit. The victim may have been hosing down the transfer pit from inside the railing, with the suction side of the hose in the lagoon, when the hose nozzle apparently became clogged with weeds from the lagoon and would no longer spray. The victim may have exited the pit area to find the other nozzle, returned with a different nozzle and re-entered the pit area (the spare hose nozzle was found near opening number 1), then tripped, slipped, or lost his balance and fell through opening number 1 (Figure 4). Alternatively, he may have realized that the pump was still running and had to be shut off before he could change nozzles. If so, he may have turned to exit the pit area in order to shut off the pump, when he stepped or fell into the pit through opening number 2. The victim either struck the metal grate 5 feet below opening number 1, then fell into the turbulent sludge present in the recirculation pit, or fell directly into the sludge through opening number 2. Once in the sludge, he was sucked to the bottom and trapped against number 2 return line inlet.

ATMOSPHERIC TESTING

Atmospheric testing was conducted at the wastewater treatment plant on August 13, 1991. The atmosphere in the recirculation pit and the atmosphere in the transfer pit were tested for hydrogen sulfide (H_2S), oxygen (O_2), and methane (CH_4). The H_2S and CH_4 tests were all negative; O_2 tests indicated 20.7% oxygen. The investigator tested the area around the digester, aeration basin, clarifier basin, and pump room. Neither H_2S or CH_4 was detected; all O_2 levels were between 20.4% and 20.7%. The atmosphere in the recirculation pit and the transfer pit was tested four times that day, and all readings were similar.

At approximately 3:00 p.m. on August 13, 1991, the DSR investigator requested that the digester be shut off so the conditions would be similar to the day of the incident. On August 14, when the DSR investigator arrived at the plant to start testing, the digester was still off and the supernate was flowing into the recirculation pit. This attempt to recreate conditions similar to those at the time of this incident did not effect the gas readings to any noticeable degree. There were no odors present inside or outside of the plant on any of the 3 days during the investigation. The DSR investigator concluded there was evidence suggesting only trace presence of toxic gases in the recirculation pit (H_2S 0.3 ppm), which does not represent any health hazard.

The three rescuers in the recirculation pit did not experience any ill effects. If the pit contained H_2S, or was oxygen deficient, it is possible that the rescuers would have been affected by these adverse conditions. In addition, if H_2S had been present in significant concentrations, the distinctive rotten egg odor could have been noted in the surrounding areas. It should be noted that air quality at wastewater treatment plants is always a potential area of concern. Adverse atmospheric conditions (oxygen deficiency, toxic or flammable atmospheres) have been responsible for more fatalities in confined spaces than any other hazard/condition.

On August 14, 1991, the atmospheres in the recirculation and transfer pits were continuously monitored for H_2S, CH_4, and O_2 for 20 minutes of each hour for 6 hours straight. Atmospheric conditions were also tested at the aeration basin, the clarifier basin, the aerobic digester, the operations building and along the number one lagoon. Results of the gas test were:

H_2S 0.3 ppm (highest level recorded)

CH_4 0.0 lower explosive limit (lel)

0_2 20.5%.

Gas readings were taken at seven additional sites, four manholes in the municipality, at two lift stations, and at a water pump station. Neither H_2S nor CH_4 were detected, and 0_2 readings were all above 20%, with the exception of one manhole that had a reading of 19.4%.

On August 15, 1991, the atmospheres in the recirculation and transfer pits were continuously monitored for H_2S, CH_4, and 0_2, 20 minutes of each hour for 4 hours straight. Atmospheric conditions were also tested at the aeration basin, the clarifier basin, and the aerobic digester. Results of gas test were negative for H_2S and CH_4. 0xygen readings ranged from 20.4% to 20.7%.

CAUSE OF DEATH

The medical examiner listed the cause of death as drowning.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Employers should conduct job hazard analyses to identify potential hazards.

Discussion: A job hazard analysis should be conducted for all operations at the plant. Each job/task should be broken down into component parts and analyzed for potential hazards. Once the job hazard analyses are completed, this information can be used in the development of a written safety program and operating procedures for the facility.

Recommendation #2: Employers should develop a written safety program with procedures specific to the wastewater treatment plant.

Discussion: A written safety program should be developed for the wastewater treatment plant that covers all areas of operation. The program should include, but not be limited to, control of hazardous energy (i.e., lockout/tagout of energy sources that have the potential to inflict injury to the exposed employee), electrical safety, personal protective

equipment and clothing, use of respiratory protection (i.e., self-contained breathing apparatus), and address all areas cited in the job hazard analyses.

Recommendation #3: The employer should develop, implement and enforce confined space entry procedures.

Discussion: The employer should develop and implement a confined space entry program as outlined in NIOSH publications 80-106, “Working in Confined Spaces,” and 87-113, “A Guide to Safety in Confined Spaces.” Although the employee was working above the confined space and not in the space itself, confined space procedures should be followed to anticipate problems should entry, including inadvertent entry, occur. At a minimum, the following items should be addressed for each type of confined space:

1. Is entry necessary? Can the assigned task be completed from the outside?

2. Has a confined space entry permit been issued by the employer?

3. Are confined spaces posted with warning signs?

4. If entry is to be made, has the air quality in the confined space been tested for safety based on the following:

* oxygen level at least 19.5%

* flammable range less than 10% of the lel

* absence of toxic air contaminants

5. Are workers and supervisors being trained in the selection and use of:

* respiratory protection

* use of test equipment

* lifelines

* emergency rescue equipment

* protective clothing

6. Are workers being properly trained in working in and around confined spaces?

7. Are confined space safe work practices discussed in safety meetings?

8. Is ventilation equipment available and/or used?

9. Are employees trained in rescue procedures?

10. Is the air quality monitored when the ventilation system is operating?

Recommendation #4: The employer should redesign the surrounding opening into the recirculation pit area so that access is onto a solid surface and not directly into an opening.

Discussion: Entry through the gate at the recirculation pit exposes the employee to an opening measuring 27 inches by 46 inches. The pit opening is the first step inside the railing/gate. The gate should be moved to a location that allows the employee to step onto a solid, safe surface, not a direct opening into the recirculation pit.

Recommendation #5: Employers should provide safeguards and/or fall protection for employees that work over areas where the potential for injury exists.

Discussion: When an employee is required to work around or over areas where the potential for falling exists, appropriate safeguards and/or fall restraints should be used particularly when the potential exists for a fall into an area containing hazardous energy or a hazardous process. Such hazards should be recognized when the job hazard analyses are conducted and the results analyzed. There are various types of safeguards and fall restraints on the market today. Each situation or task may require specific types of protection; therefore, it is essential that all hazards be identified and addressed.

Recommendation #6: Employers should provide atmospheric testing equipment for testing confined spaces prior to entry.

Discussion: All confined spaces should be tested before entry. Also, when employees are required to work over an open pit, it should be tested for possible oxygen deficiency, toxic gases, and flammability. These tests are precautionary and essential.

REFERENCES

National Institute for Occupational Safety and Health, Criteria for a Recommended Standard ... Working in Confined Spaces. DHHS (NIOSH) Publication No. 80-106, December 1979.

National Institute for Occupational Safety and Health, A Guide to Safety in Confined Spaces. DHHS (NIOSH) Publication No. 87-113, 1987.

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