FACE 86-38: Three Dead, One Critical in Industrial Septic Tank in Georgia

INTRODUCTION

On July 16, 1986, four employees of a liquid waste hauling company were pumping out an industrial waste tank at a chicken hatchery when the accident occurred. The liquid waste had been pumped out and one of the workers entered the tank to loosen and remove sludge from the bottom and sides of the tank when he was overcome by toxic fumes. In an effort to rescue the downed worker, a second workman entered the tank and was overcome. The third and fourth workers entered the tank and were overcome in a similar manner. Before the fourth worker entered the tank he ran inside the hatchery to get help. When employees of the hatchery arrived at the opening of the tank, the fourth worker was found in the tank semiconscious and the other three were unconscious.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The employer is a small local septic tank service company that pumps, cleans, and repairs residential and commercial waste and septic tanks. The company consisted of the owner and four employees. The company had no written safety policy or program. Safety was the responsibility of the individual worker.

SYNOPSIS OF EVENTS

A hatchery had contracted with the septic tank service company to pump out a 2,000-gallon waste water holding tank (5 feet by 7 feet by 10 feet) and to clean out any accumulated sludge on the bottom and sides of the tank every 2 months. The waste tank received waste water from the hatchery which contained chlorinated caustic cleaners (dilute potassium hydroxide and sodium hypochlorite), residue from egg disinfectant (a formulated quaternary ammonium compound), chick down, and some afterbirth and egg shells. No human waste went into this tank. A separate tank was used for employees' wash rooms in the hatchery. The waste water tank was cleaned every 2 months on a Wednesday when the hatchery is operating with a reduced workforce. On Wednesdays no waste water should be going into the tank.

Four workmen for the septic tank service company arrived at the hatchery shortly after 9 a.m. on July 16, 1986. The steel cover was removed from the tank, exposing the 25-inch square opening into the concrete waste water holding tank. The liquid waste was vacuum drawn from the tank into a tank truck. After the liquid was drawn down to the sludge level (approximately 14 inches), a hoe-like tool was used to loosen the sludge. A workman was lowered through the 25-inch square opening via a hose tied to a 5-gallon bucket. The workman, once inside the tank, filled the bucket with sludge which was then pulled out and dumped. This procedure was repeated until all of the sludge was removed from the tank. This same procedure had been used to clean this tank for the past 5 years. At approximately 10 a.m. one of the workmen reported to the office manager of the hatchery that the workmen were in trouble and was down (overcome) in the tank. The fire department was called immediately and arrived on the scene within 10 minutes. It is doubtful if any of the victims recognized this as a confined space with its associated life threatening hazards. The workmen did not test the atmosphere prior to entry, did not use isolation procedures or forced air ventilation. None of the workmen were wearing personal protective equipment or respiratory protection and apparently only one worker used the ladder.

Workmen from the hatchery went outside to assist the downed workmen and found an unattended ladder protruding from the tank opening. Apparently, the worker who requested help secured a ladder from the hatchery. The office manager stated, upon looking into the tank, that all four men were down, of which three were unresponsive. A fan was brought from the hatchery and used to blow fresh air into the tank. The fire department and EMS personnel arrived on the scene and immediately initiated rescue procedures. Two fire department rescuers donned protective gear and self-contained breathing apparatus to remove the men from the tank. All four men were transported to a local medical center. Two were pronounced dead on arrival, and two remained critical. One of the two critical died a week later. Investigation of the incident and tests performed by the OSHA compliance officer at the site revealed no appreciable amounts of chlorine. However, the atmosphere contained 2,500 ppm CO_2 and 50 ppm ammonia. Tests were negative for H_2S.

The medical examiner reported a strong chlorine odor on one of the victims while performing an autopsy.

Note:

The tank had been cleaned the same way for 5 years without incident. The following aspects of this incident may have varied from previous occasions and could have contributed to this accident:

a. The tank was not isolated from the hatchery and if anything was flushed down the drain, it would enter the tank where a man was working.

b. The chemicals used in the plant are not compatible if mixed. There exists the possibility of chlorine gas being liberated in the tank if the chemical cleaners were mixed in the right concentration.

c. Toxic gases are also liberated when sludge material is disturbed. Cleaning the sludge in the bottom of the tank could have released toxic gases.

d. The ambient temperature on July 10, 1986, was 104 degrees F.

CAUSE OF DEATH

The medical examiner stated the men died of hemorrhagic pneumonitis as a result of chlorine exposure.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Companies contracting to have a service performed on their property should implement and enforce a safety program to be followed by the contractor.

Discussion: The company that contracts out work to be performed on their property and assumes the contractor is an expert and adheres to safety procedures can be operating on a dubious assumption. Especially when hazardous tasks such as confined space entry are contracted out, outside contractors should be required to comply with a written safety policy that includes safe work procedures, and these requirements should be enforced by the company. For confined space entry, the recommendations in NIOSH Publication No. 80-106, "Working in Confined Spaces" should be used.

Recommendation #2: The septic tank service company should develop comprehensive policies and procedures for confined space entry, where confined space entry is required.

Discussion: All employees who are required to work in confined spaces should be aware of potential hazards, possible emergencies, and specific procedures that are to be followed. Prior to entry into a confined space, the following should be addressed:

1. Is entry necessary? Can the tank be cleaned from the outside?

2. Has a permit been issued for entry?

3. Has the air quality in the tank been tested?

   - Oxygen supply at least 19.5%
   - Flammable range less than 10% of the lower flammable limit
   - Absence of toxic air contaminants

4. Have employees and supervisors been trained in selection and use of personal protective equipment and clothing?

- Protective clothing
- Respiratory protection
- Hard hats
- Eye protection
- Gloves
- Life lines
- Emergency rescue equipment

5. Have employees been trained for confined space entry?

6. Is ventilation equipment available and/or used?

FACE 87-20: Two Workers Die in Digester Unit in New Mexico

INTRODUCTION

On December 1, 1986, four workers at a wastewater treatment plant were attempting to repair a leak and clean out a pump in the pipe gallery (a small room containing pipes and valves between two digester units) when the accident occurred. The workers were in the process of removing the bolts from an inspection plate when the plate was forced open by raw sewage which flooded the room. Two workers died in the unit; one was hospitalized, and one was treated at the hospital and released.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The employer in this incident was a small municipality. The victims worked for the wastewater treatment plant which is under the public works department. The public works department has 60 employees in several different divisions; parks and recreation, library, airport, water treatment, solid waste disposal, and wastewater treatment. Each division has a supervisor which reports to the city public works department supervisor. The wastewater treatment plant has five employees; a supervisor, two operators, one laboratory technician, and one trainee.

New employees are given a brief orientation which consists of a discussion of benefits and operating policy. New employee training is the responsibility of their supervisor. On-the-job training is also provided by the supervisor or experienced/certified operators. No safety training or safety meetings are conducted at the wastewater treatment plant. The employees are not trained in confined space hazards or safe entry procedures. Confined space entry procedures are included in the operating manual.

SYNOPSIS OF EVENTS

On December 1, 1986, the employees of the wastewater treatment plant reported for work at 8 a.m. and proceeded with routine daily operations. One of the first things done each day is a walk-through inspection of the plant. The two plant operators were doing the walk-through inspection when they discovered a pump was leaking in the pipe gallery. The operators reported the leak to the plant supervisor immediately. The supervisor instructed both operators and a trainee to accompany him to the digester unit to check and repair the leak. The men proceeded to the pipe gallery (approximately 13 feet by 15 feet by 13 feet deep), which was located between the primary and secondary digesters. The four workmen descended the spiral staircase into the pipe gallery to repair the leaking pump. The supervisor instructed the trainee to remain on the stairs because of the tight working conditions around the pump. One of the operators closed the two valves to the secondary digester. However, the two valves to the primary digester remained open. It was assumed all four valves were closed. The supervisor was in the process of removing the eight bolts from the inspection plate (located between the valves for the primary and secondary digesters) when the plate popped up. Some raw sewage was discharged; however, this discharge stopped. Apparently the pump, which was clogged, moved and this movement caused this momentary sewage discharge. The supervisor continued to remove the bolts from the inspection plate. All but three bolts had been removed from the inspection plate when raw sewage began spraying into the room. The trainee stated, "when the raw sewage began spraying into the room it was difficult to see because of the heavy spray and the discharge sounded like a jet engine." The supervisor and the two operators frantically attempted to locate the open valves. However, the room was beginning to flood with raw sewage. The sewage level was 3 feet deep within a few minutes and the men decided to get out. The operators and the trainee climbed the stairs and exited to the outside before they noticed that the supervisor did not follow them. All three returned immediately to the pipe gallery and found the supervisor slumped over in the sewage at the bottom. One of the operators attempted to pull the supervisor out of the sewage. The operator was overcome and fell into the sewage. The other operator and trainee attempted to rescue the downed workers; however, they realized they were in trouble so they exited immediately.

Upon leaving the unit, they notified the lab technician who called the fire department and rescue squad. Within 5 minutes the fire department and rescue squad arrived on the scene. The pipe gallery had now

flooded completely (13 feet deep) and raw sewage was running out the doorway. The fire department pumped the sewage level down in the room and removed the downed supervisor and operator. Both men were pronounced dead at the scene by the coroner.

CAUSE OF DEATH

The coroner's report listed both deaths as drowning.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: The employer should develop proper work procedures and should adequately train employees to maintain and repair the sewage system. This training should include recognition of potential hazards associated with failures within those systems.

Discussion: The workers were not provided with safe operating procedures (i.e., equipment malfunction) or training in hazard recognition. Without adequate work procedures, each worker assumed the other had shut down the digester valves. No one was assigned specific responsibilities or tasks. Therefore, only two of the four were closed.

Recommendation #2: The employer should develop comprehensive policies and procedures for confined space entry.

Discussion: All employees who are required to work in confined spaces should be aware of potential hazards, possible emergencies, and specific procedures that are to be followed. Prior to entry into a confined space, the following should be addressed:

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

2. Has a permit been issued for entry?

3. Has the air quality in the confined space been tested?

   - Oxygen supply at least 19.5%
   - Flammable range less than 10% of the lower flammable limit
   - Absence of toxic air contaminants

4. Has the confined space been isolated/locked out from other systems?

5. Have employees and supervisors been trained in selection and use of personal protective equipment and clothing?

   - Protective clothing
   - Respiratory protection
   - Hard hats
   - Eye protection
   - Life lines
   - Emergency rescue equipment

6. Have employees been trained for confined space entry?

7. Is ventilation equipment available and/or used?

8. Is the air quality tested when ventilation system is operating?

Recommendation #3: Employers should provide some type of pressure sensing device(s) on lines to determine if the line is under pressure when valves are closed.

Discussion: A pressure sensing device on the sewage lines would have alerted the workers to the pressure on the line thereby requiring a check to determine what valves were not closed. Without some type of pressure sensing device on the lines it is impossible to determine line pressure, if valves are functioning properly, etc.

FACE 87-26: Worker Dies After Lifting Access Cover on Acid Reclaim Storage Tank in Virginia

INTRODUCTION

On December 14, 1986, a shift supervisor (the victim) at a synthetic fiber manufacturing plant was in the process of thawing out a frozen pipe to a 6,100-gallon acid reclaim storage tank. After lifting the tank access cover the victim collapsed on top of the tank with his head down inside the adjacent tank. Resuscitation efforts were attempted by the fire department rescue squad. The victim was pronounced dead at the scene by the local medical examiner.

Another confined space-related fatal accident occurred within the same plant approximately 1 month prior to this accident. A separate evaluation of that accident is given in FACE report 87-25.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The employer in this incident is a synthetic fiber manufacturing plant that has approximately 1,200 employees consisting mainly of maintenance and production workers, pipefitters, mechanics, and machinists.

The company has a plant safety program. New employees receive a basic plant safety orientation from the safety training supervisor and a handbook which discusses general employee safety. All production employees receive fork lift truck safety training. New employees also receive on-the-job training for specialized procedures required in certain manufacturing processes. There is a written hazard communication (i.e. right-to-know) program that addresses various department-specific hazards throughout the plant and a written policy on confined space entry procedures. All employees working in or near confined spaces are expected to be familiar with the confined space entry procedures; however, there does not appear to be an effective means to make employees aware of the potential hazards associated with these tasks.

Safety meetings are conducted monthly among company management to discuss problems and to reinforce existing safety programs; however, safety meetings are not conducted regularly within the various plant departments.

SYNOPSIS OF EVENTS

On December 14, 1986, at about 9:30 a.m. two workers, under the direction of the shift supervisor (the victim), were attempting to thaw an above-ground pipe line. The frozen line ran from an acid sump tank at ground level to a 6,100 gallon fiberglass acid storage tank at the top of a six-story building. This closed system contained a "raw acid" solution (approximately 9 percent sulfuric acid, 23 percent sodium sulfate, 1 percent zinc sulfate, and 66 percent water) which comes from the spinning operation of synthetic fiber production. Also present in the tank are hydrogen sulfide (by-product) and carbon disulfide (used in the manufacturing process) gases. Starting from the acid sump tank on the ground and working towards the acid storage tank on the roof, the two workers and the victim began thawing the frozen solution in the pipe by opening the pipe at various access points and running steam lines through the pipe. During this procedure, the acid storage tank was still in use, receiving acid from the fiber spinning process from other pipe lines.

The victim and a worker climbed on top of the storage tank in an attempt to thaw the section of pipe entering the storage tank. Although the workers and victim had been instructed previously that day by a management official of the company not to go on top of the acid storage tanks without the protection of safety harnesses and respirators, neither employee was equipped with a respirator or a safety harness. The victim removed the tank access cover and stuck his head down inside the hole, apparently to determine if the pipe was frozen where it entered the tank. One of the workers pulled the victim back by the collar and warned him not to lean into the tank. The victim and worker then climbed down from the tank and began disconnecting and thawing other sections of the pipe. A short time later the victim

climbed back up on top of the storage tank and, although there were no eyewitnesses, apparently attempted to thaw the pipe where it entered the storage tank from inside the tank. Approximately 15 minutes later the two workers noticed that the victim was not present and after a brief search they found the victim lying on top of the storage tank with his head down in the tank access hole. One of the workers pulled the victim from the top of the storage tank to the top of an adjacent tank and checked him for a pulse, but found none. The other worker called the local fire department rescue squad which arrived approximately 8 minutes later and attempted to resuscitate the victim. The victim was pronounced dead at the scene by the local medical examiner.

An atmospheric test of the acid storage tank was conducted by the employer shortly after the accident. This test revealed levels of hydrogen sulfide greater than 1000 parts per million.

CAUSE OF DEATH

The medical examiner's autopsy report lists the cause of death as hydrogen sulfide and carbon disulfide poisoning.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: The employer should initiate comprehensive policies and procedures for confined space entry.

Discussion: All employees who work in or around confined spaces should be aware of potential hazards, possible emergencies, and specific procedures to be followed prior to entering a confined space. Although the employer does have written policies and procedures for confined space entry, they should be expanded to include all required aspects of a confined space entry program. These procedures should minimally include the following:

1. Posting of all confined spaces.
2. Air quality testing to determine adequate oxygen supply, adequate ventilation, and the absence of all toxic air contaminants;
3. Monitoring to determine a safe oxygen level is maintained inside the confined space;
4. Employee and supervisory training in confined space entry;
5. Employee and supervisory training in the selection and usage of respiratory protection;
6. Emergency rescue procedures;
7. Availability, storage, and maintenance of emergency rescue equipment.

Current written confined space procedures of the employer do address items #2 and #3 above; however, these procedures were not followed in this incident. Current written confined space procedures do not adequately address the other requirements listed above. The present procedures should also be carefully reviewed and modified as necessary in order to reflect sound confined space entry practices.

Recommendation #2: The employer should insure that employees are trained in hazard recognition and safety awareness for all potentially hazardous tasks.

Discussion: Although the employer has a written hazard communication program and safety policy (including confined space entry procedures) there appears to be no effective means of communicating hazards recognition and safety awareness to employees. When confronted with potential on-the-job hazards, employees should be able to recognize these hazards and take appropriate corrective actions.

Recommendation #3: The employer should implement and enforce its safety program.

Discussion: Although the employer has a written safety policy (including written confined space entry procedures), it appears that these policies and procedures were not being followed by supervisory personnel. Management should ensure that its safety policies and procedures are put into practice by all department supervisory personnel as well as plant laborers and enforcement procedures should be implemented to improve employee compliance with the safety program.

Recommendation #4: The employer should implement an improved housekeeping program.

Discussion: Section 5.5 of the employers safety policy states, "Housekeeping is often a barometer of attitudes concerning safety, quality and cost." Maintaining work areas in a clean and orderly condition will improve worker safety. Procedural references to housekeeping in the safety policy should be strictly followed.

FACE 87-45: One Dead, One Near Miss in Sewer in Kentucky

INTRODUCTION

On May 15, 1987, two laborers for the city sewer department entered a 15-foot-deep sewer manhole into an oxygen deficient atmosphere. When help arrived, both men were unresponsive. The men were removed from the manhole and transported to a local hospital. Prolonged resuscitation efforts were unsuccessful and one worker was pronounced dead by an attending physician 2 hours later. The second worker was treated and released.

BACKGROUND/OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The employer in this incident is a small municipality which has 474 employees. The victim worked for the sewer department which has 14 employees: a superintendent, assistant superintendent, 2 crew leaders, 2 brick masons, 2 pipe layers, 3 operators, and 3 laborers. The municipality had no written safety policies or confined space entry procedures at the time of the accident. Safety on the job has been handled on an informal basis and left up to the individual worker.

Since the accident, the municipality has drafted up basic confined space entry procedures. These procedures aren't all inclusive for confined space entry; however, they are in writing and confined space training was initiated.

SYNOPSIS OF EVENTS

On the morning of May 15, 1987, two laborers (the victim and a co-worker) were assigned the task of cleaning out a drainage ditch. After completing this assignment, the men reported back to the sewer department. At 11:30 a.m. the superintendent informed the two workers that the engineering department had reported a blockage in a sewer manhole adjacent to a sewage lift-station. The two laborers were instructed to take the sewer cleaning machine (a tank truck with a vacuum cleaning system and water jet) to the stopped up manhole and wait for the engineering department workers to arrive. The two laborers drove the sewer cleaning machine to the location of the manhole. They arrived at the manhole at approximately 1 p.m. and positioned the truck so that the manhole could be cleaned. One of the workers (the victim) removed the 22-inch diameter manhole cover, while the other worker was preparing equipment on the truck. After removing the manhole cover, the victim observed two boards stuck in the sludge (the sludge level was up 3 feet in the 12-foot-deep manhole and had formed a crust). The victim descended via an attached steel rung ladder into an untested, oxygen deficient atmosphere and attempted to remove the two boards stuck in the sludge." The co-worker noticed the victim had entered the manhole and went to investigate. The co-worker stated that "the victim was staggering, gagging, vomiting, and then fell face down on the sludge. The co-worker called the sewer department and reported a man was down in the manhole and was in trouble. The superintendent told the worker to wait for help, not to enter the manhole. The co-worker entered the manhole in a rescue attempt and passed out, falling backwards, face-up.

When the engineering crew arrived (shortly before the emergency squad and fire department) both men in the manhole were unresponsive. The engineering crew lowered an 8-inch-diameter vacuum line from the sewer cleaning machine into the manhole and turned on the vacuum system.

The vacuum system quickly evacuated the air in the manhole, causing fresh make-up air from the exterior of the manhole to enter the manhole. The co-worker regained consciousness and stood up. A rope was lowered into the manhole and he was pulled out. Two firemen entered the manhole (with SCBA) and removed the victim. All four men (the victim, the co-worker, and the two firemen) were transported to a local hospital. Resuscitation efforts were continued on the victim for 2 hours, but were unsuccessful. The co-worker and the two firemen were treated and released.

CAUSE OF DEATH

The coroner listed the cause of death as "prolonged acute exposure to sewer gas—aspiration of foreign material."

NOTE: While conducting this evaluation, the sewer manhole was tested for O_2, H_2S and CH_4. The results of these tests:

O_2	7%
H_2S	Negative
CH_4	Negative

RECOMMENDATION/DISCUSSION

Recommendation #1: The employer should develop a comprehensive safety program for confined space entry that clearly documents procedures for safe entry.

Discussion: All employees who work in or around confined spaces should be aware of potential hazards, possible emergencies, and specific procedures to be followed prior to entering a confined space. These procedures should include, but not be limited to:

1. Air quality testing to determine adequate O_2 level.
2. Ventilation of the space to remove air contaminants.
3. Monitoring of the space to determine a safe oxygen level is maintained.
4. Employee training in confined space entry, testing, and use of personal protective equipment (respirators, clothing, etc.).
5. Emergency rescue procedures.

Air quality was not tested prior to entry. Testing devices should be ordered and used for testing the atmosphere for O_2, H_2S, and CH_4. Training on correct use of these devices, plus calibration of each should be stressed. Respirator training, fitting, and proper maintenance procedures should be required of all employees.

FACE 87-67: Two Construction Workers Die Inside Sewer Manhole in Indiana

INTRODUCTION

On July 21, 1987, a worker for a construction company entered a 7-foot-deep sewer manhole that had a toxic and oxygen deficient atmosphere. When the worker collapsed, another worker entered the manhole in a rescue attempt and also collapsed. Both workers were pronounced dead at the scene.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The employer in this incident is a family-owned construction company with approximately 50 workers (mostly laborers and heavy equipment operators). The majority of the company business involves general excavation and the construction of water systems, sewers, and roads. The company has a written, 1-page safety policy which addresses employee responsibility, general safety guidelines, confined space safety, and reporting injuries.

It is the responsibility of each employee to read this policy. All management level employees are trained in cardiopulmonary resuscitation (CPR). Other than the CPR training, there is no formal classroom safety instruction for employees. Tool box meetings are held monthly to discuss basic safety issues. On-the-job safety is the responsibility of each employee.

No training is given on confined space entry; however, company policy requires that each manhole be tested and ventilated prior to entry. The company has gas monitoring devices available at the main office to test confined spaces for oxygen (O_2), hydrogen sulfide (H_2S), and methane (CH_4). It should be noted that the company also experienced a confined space fatality 5 years prior to this incident.

SYNOPSIS OF EVENTS

On July 21, 1987, at approximately 11 a.m. a company work crew (a 36-year-old foreman with 17 years' experience with the company, a 50-year-old heavy equipment operator with 21 years' experience with the company and two laborers) began clearing brush in a vacant field in preparation for setting grade stakes to extend an existing sewer line for a new housing subdivision. At 11:30 a.m. when the two laborers broke for lunch, the foreman and equipment operator both left to look for an existing sewer manhole.

Although there were no eye witnesses to the incident, it is presumed (based on circumstantial evidence) that the following occurred: The foreman and equipment operator, upon locating the sewer manhole, removed the manhole cover. In an effort to check the existing sewer grade, the foreman then entered the 7-foot-deep manhole through a 24-inch diameter "manway" opening, and collapsed at the bottom. In an attempt to rescue the downed foreman, the equipment operator entered the manhole and also collapsed.

After lunch, when the foreman and equipment operator did not return to the field that was being cleared, the two laborers began to search for them. At approximately 1:30 p.m. the two laborers found the foreman and equipment operator at the bottom of the manhole with their heads submerged in about 12 inches of water. One of the laborers told two other company workers (who had just arrived at the scene) to call for an ambulance. When the rescue squad from the local fire department arrived (after approximately 15 minutes), two fire department rescuers donned self-contained breathing apparatus (SCBA's), entered the manhole and, using ropes and harnesses, removed the two victims from the manhole.

Fire department and emergency medical service (EMS) personnel noted that the two victims were "obviously dead," and they were pronounced dead at the scene by the county coroner. After the victims were removed from the manhole, the atmosphere of the manhole was tested by a private analytical laboratory and by the City Water Pollution Control Maintenance Department. Results of these tests are as follows:

O_2 at depth of 3 feet 15.7%

O_2 at depth of 6 feet 7.2%

CH_4 at depth of 6 feet 2%

H_2S at depth of 6 feet 0.1 and 0.2%

CO at depth of 6 feet >5%

Investigator's Comment:

The foreman and equipment operator were both employed by the company 5 years previous to this incident when the company experienced its first confined space fatality.

CAUSE OF DEATH

Autopsies were performed on both victims. The cause of death for both men was listed as asphyxiation.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Employers engaged in the business of sewer construction or maintenance should assure that workers are trained sufficiently in recognition and awareness of confined space hazards they may encounter in the daily performance of their duties.

Discussion: According to the employer, the work being performed at the construction site did not require the workers to enter any sewer manhole. However, the foreman did enter the manhole without testing and ventilating the atmosphere of the manhole prior to entry as required by company safety policy. The fact that this is the second confined space fatality incident within the past 5 years (resulting in three confined space fatalities) underscores the importance of employee training in safe confined space work practices.

Recommendation #2: The employer should develop and implement a more comprehensive safety policy with specific procedures for confined space entry.

Discussion: The 1-page safety policy devotes one paragraph to confined space entry: "Employees shall not enter manholes, underground vaults, chambers, tank, silos, or other similar places that receive little ventilation, unless it has been determined that the air contains no flammable or toxic gases or vapors. Ventilate thoroughly, detectors are available at office."

Phrases such as "...unless it has been determined..." and "ventilate thoroughly..." should be expanded and clarified to describe a detailed confined space entry procedure. Also, the individual(s) responsible for testing the atmosphere and making recommendations for safe entry should be identified. Minimally, the following confined space safe work practices should be addressed in the company safety policy and implemented on the job:

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

2. Has a company safe entry permit been issued?

3. If entry is to be made, has the air quality in the confined space been tested?

   - Oxygen supply at least 19.5%
   - Flammable range less than 10% of the lower flammable limit
   - Absence of toxic air contaminants

4. Have employees and supervisors been trained in selection and use of personal protective equipment and clothing?

   Protective clothing

   - Respiratory protection
   - Hard hats
   - Eye protection
   - Gloves
   - Life line
   - Emergency rescue equipment

5. Have employees been trained for confined space entry?

6. Have employees been trained in confined space rescue procedures?

7. If ventilation equipment is needed, is it available and/or used?

8. Is the air quality tested when the ventilation system is operating?

The two fatalities would have been prevented if these recommendation had been followed. Specific recommendations regarding safe work practices in confined spaces can be found in NIOSH publications 80-106, "Working In Confined Spaces," and 87-113, "A Guide to Safety in Confined Spaces."

FACE 88-33: Electroplater and Four Co-Workers Die from Asphyxiation in Metal Plating Vat

INTRODUCTION

On June 28, 1988, a 25-year-old male electroplater (victim) died after entering a metal plating vat he was cleaning. Four male co-workers also died when they entered the vat in rescue attempts.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The employer is an electroplating company with 31 employees, most of whom are electroplaters. Employees with at least 1 year of experience had attended a one-time training session on chemical hazards from a hazard communication training company. New employees receive a brief orientation on the chemicals used in the plating operation and the location of Material Safety Data Sheets (MSDS), and then take a "chemical awareness test" which is a review of the information received. Electroplaters are required to wear personal protective equipment (boots, gloves, aprons and safety glasses). Acid-mist cartridge-type respirators had been issued to two electroplaters and the wastewater treatment operator, but were available for use by any of the workers.

At the time of the incident the employer had no written safety program, no plant emergency procedures, no on-going safety training, no confined space safe entry procedures, and did not conduct safety meetings with employees.

SYNOPSIS OF EVENTS

The company uses a series of open-top steel tanks to acid treat metal parts with a metal finish of either zinc, chrome, nickel, brass, copper, or cadmium. Two parallel lines of tanks, separated by a 5-foot-wide removable metal grating walkway, are located in the zinc plating room. Below the walkway is a concrete drainage pit. The only ventilation the zinc plating room receives is from two exhaust fans on the ceiling about 20 feet above the tanks, five open windows (at the time of the incident the windows were closed), and one open door.

The end tank (4 feet wide by 5 feet deep) on the south side of the zinc plating line is used as a holding tank for excess zinc cyanide that drips from the finished metal parts suspended above the tank. Approximately once a year the tanks are cleaned out by an industrial cleaning and waste hauling company. One day prior to the incident the waste hauling company had completed pumping out the tanks; however, the holding tank still contained about 2 inches of zinc cyanide sludge on the bottom.

During the night shift, the plating company employees were cleaning and rinsing the tanks in preparation for changing from cyanide process to acid plating process. Chemicals for the new process were to be added to the tanks and the plating operation was to resume the following morning. During the cleaning process, the metal grating between the two tank lines was removed. This resulted in the top of the end holding tank being 8 feet above the surface of the drainage pit floor. A ladder was used to reach the top of the tank.

In a cleaning procedure that had never been attempted before, the victim manually pumped between 1 and 2 gallons of 1 percent muriatic acid solution from a 55-gallon drum (which the victim had placed nearby for cleaning and rinsing purposes) into the zinc cyanide holding tank, and then climbed into the tank. The tank had not been tested or ventilated before entry. The victim was not wearing any respiratory protective equipment and the only personal protective equipment (PPE) he was wearing were gloves, boots and an apron. Within a few minutes hydrogen cyanide vapor formed in the tank due to a chemical reaction between the muriatic acid and zinc cyanide. About 4 minutes after he had entered the tank, co-workers observed the victim trying to climb out but then falling back into the tank. Four co-workers entered the tank in an attempt to rescue the victim. They were wearing varying amounts of PPE but no respiratory protective equipment. They all collapsed inside the tank. Other co-workers, seeing these workers collapse, also made varying rescue attempts. By this time, as the chemical reaction continued,

most of the co-workers who entered the zinc plating room were unable to even get close to the holding tank because of the hydrogen cyanide vapor. However, one co-worker (without respiratory protection) removed one of the four collapsed co-workers (who was bent over the top of the tank with his head down inside) and administered cardiopulmonary resuscitation.

The city police, state police, and fire department were notified. Personnel from these departments arrived within approximately 15 minutes and began removing the workers from the zinc cyanide holding tank. Fire fighters were wearing full turnout gear (standing PPE for fire fighters) with self-contained breathing apparatus (SCBA). Police officers were not wearing any respiratory protective equipment or PPE.

The rescue effort was hampered because police and fire department personnel were initially unaware that hydrogen cyanide vapor was involved. During the rescue effort they became suspicious that hydrogen cyanide vapor might be involved after learning from plant employees that zinc cyanide and acids were used at the plant. The hydrogen cyanide vapor permeated the exposed skin and the leather protective "turnout gear" when they removed the victims from the tank. As a result, 17 police officers and fire fighters received toxic exposures, and the turnout gear became contaminated. A further complication was the uncertainty between responding agencies as to who should take command of the rescue effort, including administering emergency medical care and securing the contaminated area from unauthorized entry. This disorganization continued for nearly 2 hours before the premises were finally sealed off.

The county coroner pronounced the electroplater (victim) and three of the co-workers attempting rescue dead at the scene. The fourth co-worker was taken to the local hospital where he died 2 days later. In addition to the 5 fatalities, 30 individuals received medical treatment for toxic exposure to hydrogen cyanide vapor:

2	company workers hospitalized
10	company workers treated and released
1	police officer hospitalized
3	police officers treated and released
13	fire fighters treated and released
1	medical examiner treated and release
TOTAL	30

Seven hours after the incident began, a private environmental and hazardous waste consulting firm (contracted by the employer) collected air samples at the plant for analysis of toxic air contaminants. Concentrations of hydrogen cyanide vapor measured 1.0 milligram per cubic meter (mg/m^3) immediately outside the plant door, and 6.0 mg/m^3 immediately outside the zinc cyanide holding tank. Analyses for other toxic air contaminants were negative. Sample collectors were unable to obtain air samples from inside the holding tank at that time. After collecting these samples the consulting firm added a chemical to neutralize the chemical reaction inside the holding tank and then ventilated the building using portable blowers. The following day the consulting firm analyzed the air inside the holding tank; hydrogen cyanide vapor was present at a concentration of 2.0 mg/m^3.

It is assumed that the concentration of hydrogen cyanide vapor inside the holding tank was at least 60.0 mg/m^3 (the level immediately dangerous to life) at the time of the incident. This is based on the acute effect of the vapor on the workers.

CAUSE OF DEATH

The county coroner listed the cause of death for all five electroplaters as asphyxiation due to overexposure to hydrogen cyanide vapor.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: The company should develop and implement a written safety and training program. This program should include the recognition of hazards and safe work methods.

Discussion: The company had no written safety program or policy. Any training at the plant was on-the-job, with little emphasis on safety and health. The victim (age 25) was an electroplater with 3 1/2 years experience. All four co-workers who died (ages 19, 21, 29, and 29) were electroplaters with less than 8 months experience. Using muriatic acid to clean out the zinc cyanide holding tank had never been attempted before because vapor would be produced by adding muriatic acid to zinc cyanide. (In fact, two active chemicals such as zinc cyanide and muriatic acid should never be kept in the same area.) Additionally, entry into the tank without adequate ventilation, PPE, and respiratory protection implied the employees generally did not recognize the hazards associated with the plant operation, the use of Material Safety Data Sheets (MSDS), the reactivity and toxicity of chemicals, methods of working safely, plant emergency procedures, and the proper use of PPE, including respiratory protection.

A preliminary hazard analysis of the entire operation should identify hazardous areas (physical, chemical, environmental, etc.), conditions, and tasks that are performed. This is especially important when a new work task is initiated. In this case, a new cleaning procedure was attempted without identifying potential hazards. Based upon the hazard analysis, safety procedures can be developed and implemented. For example, the method of plating metal parts and cleaning out the zinc cyanide holding tank should be evaluated to determine if either process could be changed to minimize or eliminate exposure to cyanide or the need to enter the tanks. Less hazardous chemicals should be substituted where possible. Tank entry was considered necessary to clean the sludge build-up inside the zinc cyanide holding tank after the level became too low to pump. If removal methods were mechanically incorporated inside the tank, sludge build-up would not occur and manual cleaning of the tank would not be necessary. Other methods should be used for the removal of sludge and liquid waste from the tank before exposing workers to this hazard.

Environmental monitoring and control should be established. The facility did not have an effective ventilation system and during the tank cleaning process only two ceiling fans were used to provide air circulation. Ventilation rates should meet industrial hygiene standards for areas where workers are exposed to potentially hazardous chemicals. Ventilation should be maintained close to maximum efficiency and the adequacy of the system should be evaluated by monitoring of the work environment.

Recommendation #2: The employer should develop and initiate comprehensive policies and procedures for confined space entry.

Discussion: All employees who work in or around confined spaces should be aware of potential hazards, possible emergencies, and specific procedures to be followed prior to entering a confined space. These procedures should minimally include the following:

1. Posting confined space warning signs on all tanks in the plant
2. Air quality testing to determine adequate oxygen supply, adequate ventilation, and the absence of all toxic and flammable air contaminants
3. Monitoring to ensure a safe oxygen level is maintained inside the confined space
4. Employee and supervisory training in confined space entry
5. Employee and supervisory training in the selection and usage of respiratory protection
6. Identification of chemicals, possible chemical reactions, and chemical exposures
7. Hazards communication of potentially hazardous chemicals and chemical reactions
8. Development of site specific work plans and procedures that address the task being performed, emergency access, and egress
9. Training for proper selection of personal protective clothing, based on exposures.
10. Emergency rescue procedures
11. Availability, storage, and maintenance of emergency rescue equipment

The air was not monitored for toxic air contaminants and oxygen level before the workers entered the zinc cyanide holding tank. Specific recommendations regarding safe work practices in confined spaces can be found in NIOSH publications 80-106, "Working in Confined Spaces" and 87-113, "A Guide to Safety in Confined Spaces".

Recommendation #3: The employer should develop and implement a comprehensive respirator program, including either quantitative or qualitative fit testing and training in the use and limitations of air-purifying respirators.

Discussion: The employer did not have any SCBA's or supplied air respirators in the plant. The employer did provide acid-midst cartridge-type respirators; however, employees were not trained on their use and limitations. Employees were also not given physical examinations to determine if they were capable of wearing a respirator. The cartridge-type air-purifying respirator used by some of the workers in this incident was not the proper respirator for entering and cleaning a tank. A positive pressure SCBA should have been used. Adequate respirator selection should be according to criteria in the NIOSH Respirator Decision Logic (NIOSH publication #87-108) for assigning respirators in the plating operation; following these criteria will prevent workers from wearing inappropriate respirators for the task assigned.

Recommendation #4: Fire fighters, police personnel and others responsible for emergency rescue should be trained in confined space rescue and hazardous material emergencies.

Discussion: Fire and police department rescuers in this incident were not adequately trained in confined space rescue procedures. Many were also unaware of the hazards of hydrogen cyanide vapor. A "level A" totally encapsulated protective suit should have been worn in the rescue effort. Additionally, adequate means of exit from the confined space (such as life lines, harnesses, or man lifts) were not incorporated into the rescue attempts. Emergency rescue teams should be cognizant of all hazards associated with confined spaces, including rescue problems, and should wear proper PPE and devices for emergency egress. The conventional leather turnout gear worn by the fire fighters did not give adequate protection against hydrogen cyanide vapor.

City and county fire departments should establish a registry of confined spaces and toxic/explosive substances for specific companies within the area in which they serve. Such a registry should provide not only the name of the substance, but also sufficient information so that emergency response personnel will have sufficient information to plan a safe rescue. The development of a chemical hazard emergency plan should be coordinated with other involved agencies so that combined rescue efforts are organized and effective.

FACE 89-28: Two Maintenance Workers Die After Inhaling Hydrogen Sulfide in Manhole

INTRODUCTION

On January 31, 1989, a 29-year-old male maintenance worker (the victim) entered a sewer manhole to repair a pipe, and collapsed at the bottom. In a rescue attempt, a 43-year-old male maintenance worker (co-worker victim) entered the manhole and also collapsed. Both workers (hereinafter referred to as initial victim and co-worker victim) were pronounced dead at the scene.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The employer is an animal hide tanning company with 24 employees. The company operates a plant which has been in existence for 27 years (4 years under its present ownership). Most of the employees are tanning laborers (12 employees), drum operators (3 employees), and maintenance workers (2 employees). The victim had been with the company for nearly 4 years. Two months before the incident he had been promoted to the position of maintenance worker. The co-worker had been with the company for 6 years. He had been a maintenance worker for the last 4 years.

The company has a safety committee consisting of the two department heads, a union steward, and a foreman. The committee meets each week to discuss and follow up on needed safety improvements at the plant. Material safety data sheets (MSDS) on the various chemicals used in the plant are available throughout the plant. The company has a written safety policy consisting of plant safety rules and procedures for machine safety, chemical safety, and manhole entry. However, none of these rules and procedures was implemented. In addition, regular safety meetings for plant workers were not held.

SYNOPSIS OF EVENTS

The plant uses up to 120,000 gallons of water per day to process animal hides. After primary treatment, the wastewater is discharged into a series of lagoons approximately 400 yards from the plant. A gate valve located in a concrete manhole between a retention lagoon and a discharge lagoon regulates the flow of wastewater discharged. The manhole is 10 feet deep with an inside diameter of 4 feet. The top of the manhole has a 2-foot-square opening with a locked steel cover. Steel rungs on the inside of the manhole provide access to the bottom.

The manhole normally operates with about 3 feet of wastewater at the bottom. Rising vertically from a horizontal pipe at the bottom of the manhole is a 12-inch-diameter plastic overflow pipe. This pipe extends to 18 inches below ground level. The wastewater discharge volume was periodically adjusted by a worker who would partially enter the manhole (to about shoulder height and without entering the water), reach over and turn the gate valve This adjustment was made on a routine basis without testing or ventilating the manhole atmosphere. (Since the incident, the company has extended the valve stem to a level above the ground, thereby eliminating the need for workers to routinely enter the manhole to adjust the valve.)

On the day of the incident the maintenance foreman assigned the two maintenance workers (initial victim and co-worker victim) the task of repairing a crack in the top of the overflow pipe. Although there were no eyewitnesses, evidence suggests that at about 11 a.m. the initial victim entered the manhole without first testing and ventilating the inside. Presumably, the initial victim, while standing on the steel rungs inside the manhole, began to repair the broken pipe with the co-worker victim observing the work from the top, handing down tools and supplies as needed. Hard hats and steel toe boots were the only personal protective equipment worn by the workers. While repairing the broken pipe, the initial victim was apparently overcome by hydrogen sulfide gas. He fell into approximately 3 feet of wastewater and sludge at the bottom of the manhole. Presumably in a rescue attempt, the co-worker victim entered the manhole, also lost consciousness, and fell to the bottom.

At about 11:45 a.m., the maintenance foreman came to the manhole to tell the two workers it was lunchtime. When he looked into the manhole, he saw the co-worker victim at the bottom facedown in

the water. The foreman did not see the initial victim, who was totally submerged in the wastewater. The foreman entered the manhole in an attempt to pull the co-worker victim out, but could not move him. The foreman became dizzy and felt like he was losing consciousness, so he climbed out. He then fell unconscious on the ground next to the manhole. When he regained consciousness approximately 15 minutes later, he ran to the plant office and notified plant personnel of the emergency. A call was placed to the emergency medical service (EMS) and the local fire department while four plant workers ran to the site. Another plant worker, who had been a local volunteer fire fighter, grabbed a self-contained breathing apparatus (SCBA) from the plant office and drove to the manhole site. The four plant workers who had arrived on foot each briefly entered the manhole in unsuccessful rescue attempts. None of these workers wore respiratory protection. They were all able to exit the manhole without any noticeable ill effects. The worker who arrived with the SCBA entered the manhole wearing the SCBA, but was also unsuccessful in his rescue attempt.

Fire fighters from the local fire department arrived at the scene approximately 15 minutes after being notified. One of the fire fighters donned an SCBA, entered the manhole and tied a rope around the co-worker victim's chest. Rescue personnel then hoisted him up out of the manhole. The initial victim's body was located and removed from the manhole in the same manner. When local EMS personnel arrived, they noted that the initial victim and co-worker victim were obviously dead for some time. Therefore, cardiopulmonary resuscitation was not attempted and the county coroner pronounced both workers dead at the scene. The foreman was hospitalized, treated for hydrogen sulfide exposure, and released 2 days later. The other five plant workers and the fire fighter who entered the manhole were treated for hydrogen sulfide exposure and released the same day.

Six days after the incident, a compliance officer from the state OSHA office conducted an investigation. During the investigation the atmosphere of the manhole was tested for hydrogen sulfide (H_2S). At first, a gas monitoring device capable of measuring concentrations up to 100 parts per million (ppm) was used. When measurements indicated that the concentration of H_2S at the bottom of the manhole exceeded 100 ppm, a gas monitoring device capable of measuring H_2S concentrations up to 500 ppm was used. A measurement of 200 ppm H_2S was obtained just inside the manhole opening.

CAUSE OF DEATH

The medical examiner listed the cause of death for both workers as anoxia due to hydrogen sulfide inhalation.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: All employers should develop and implement a safety program to protect their employees.

Discussion: The company did not have a formal safety program established. Although the company had written safety rules and procedures, they were not implemented. There were also no safety training or safety meetings conducted for plant workers. A logical first step in developing a safety program is to identify all potential hazards. One way is by analyzing the sequential steps in routine operations to identify potential hazards, and attempting to develop procedures or other control analysis is known as job hazard analysis. Additionally, each specific job involves hazards particular to that job or the working environment. The company should therefore develop and implement a safety program as outlined in NIOSH publications 77-101, "Health and Safety Guide for the Tanning Industry," and 76-157, "Good Work Practices for Tannery Workers."

Recommendation #2: The employer should develop and implement specific confined space entry procedures for each type of confined space.

Discussion: Although the company had confined space procedures for entering the sewer manhole, they were not implemented. Also, the company's existing confined space procedures do not fully address every basic procedure; however, if the existing procedures had been closely followed, the two fatalities

in this incident may have been prevented. The company has other types of confined spaces (i.e., drums, pits, tanks, etc.) with no written entry procedures. Although these types of confined spaces are not entered on a routine or even an occasional basis, they should still be covered by specific procedures for entry. The company should therefore 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 Space." 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 safe entry permit been issued by the company?

3. Are confined spaces posted with warning signs and are confined space procedures posted where they will be noticed by employees?

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

   - Oxygen supply at least 19.5%
   - Flammable range less than 10% of the lower explosive limit
   - Absence of toxic air contaminants

5. Have employees and supervisors been trained in the selection and use of:

   - Protective clothing
   - Respiratory protection
   - Hard hats
   - Eye protection
   - Gloves
   - Lifelines
   - Emergency rescue equipment?

6. Have employees been trained for confined space entry?

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

8. Have employees been trained in confined space rescue procedures?

9. Is ventilation equipment available and/or used?

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

Recommendation #3: The employer should develop and implement a comprehensive respirator program as required by 29 CFR 1910.134, including either quantitative or qualitative fit testing and employee training in the use and limitations of SCBA and air-purifying respirators.

Discussion: Although the company had an SCBA in the office and provided escape only hydrogen sulfide gas masks (not for confined space entry) for plant workers and drum operators, employees are not trained in their use to determine if they are capable of wearing and respirator. It should be noted that 3 months prior to this incident, a state OSHA compliance officer had cited the company for failure to provide an employee respirator program. The absence of a respirator program contributed to the fatalities and the potential hazards associated with the unsuccessful worker rescue efforts in this incident. Respirators should be selected according to criteria in the "NIOSH Respirator Decision Logic" (DHHS (NIOSH) Publication No. 87-108). Additional information on the characteristics and use of respirators is available in the "NIOSH Guide to Industrial Respiratory Protection" (DHHS(NIOSH) Publication No. 87-116).

FACE 90-30: Carbon Monoxide Kills Three Volunteer Fire Fighters Inside Well in Pennsylvania

SUMMARY

Three volunteer fire fighters died inside a well after being exposed to carbon monoxide from the exhaust of a portable gasoline engine-powered pump. The incident occurred after four fire fighters from a volunteer fire department responded to a request from a local resident to remove the remains of a dead animal from a 33-foot-deep water well. The fire fighters decided to first pump the water out of the well (approximately 12 feet of water). One fire fighter climbed down into the well on an aluminum ladder and built a wooden platform at the 15-foot level. A second fire fighter climbed down into the well to help position a 9-horsepower gasoline engine-powered pump being lowered down to the platform. The two fire fighters started the engine but were unable to prime the pump. Within a few minutes the first fire fighter became dizzy and exited the well. The second fire fighter remained in the well and became unconscious. In a rescue attempt the first fire fighter climbed back down into the well, turned the engine off, and then collapsed unconscious over the engine. By this time, the engine had run for approximately 8 to 9 minutes. Within minutes several other volunteer fire fighters responding to radio emergency calls arrived at the scene. Over the next 3 hours, eight volunteer fire fighters entered the well in rescue attempts. Only two of the rescuing fire fighters wore supplied-air respirators (SCBA type). The first fire fighter was rescued and revived. The second fire fighter and two other fire fighters attempting rescue died. NIOSH investigators concluded that, in order to prevent future similar occurrences, volunteer fire departments should:

- develop and implement a confined space entry and rescue program
- develop and implement a respiratory protection program to protect volunteer fire fighters from respiratory hazards
- ensure that fire fighters are properly trained in the use of gasoline powered engines/pumps and the life-threatening hazards of carbon monoxide in a confined area
- develop and implement a general safety program to help volunteer fire fighters recognize and control hazards affecting themselves.

INTRODUCTION

On May 1, 1990, a 39-year-old male volunteer fire fighter died inside a 33-foot-deep water well in Pennsylvania while attempting to pump water out of the well. Also, two male volunteer fire fighters (ages 40 and 20) died attempting rescue. On May 4, 1990, officials of the Water Pollution Control Federation (WPCF) notified the Division of Safety Research (DSR) of these deaths and requested technical assistance. On May 23 and May 30, 1990, two research industrial hygienists from DSR traveled to the incident site to conduct an investigation. The investigators spoke with volunteer fire department representatives and fire fighters involved in the incident, and obtained reports from the police and coroner. Photographs of the incident were obtained during the investigation.

The three fire fighters who died in this incident belonged to a volunteer fire department consisting of 170 members (30 of whom are active members) in a town with a population of 400. None of the members of the volunteer fire department receives pay for services performed. The initial fire fighter victim (the second fire fighter to enter the well) had 9 years' experience as an active volunteer fire fighter. The other two fire fighter victims had 3 and 4 years' experience, respectively, as active volunteer fire fighters. The volunteer fire department has no written safety policy, no documented fire fighter safety program, nor any confined space entry/rescue program or procedures. The three victims had received at least 8 hours' training on the emergency use of self-contained breathing apparatus (SCBA).

INVESTIGATION

Four volunteer fire fighters responded to a request from a local resident to remove the remains of a dead animal from a 33-foot-deep well. The concrete well opening measured 18 inches by 22 inches and is located in the middle of a concrete porch at a private residence. The well shaft (from ground level down to a depth of 15 feet) is constructed of concrete and measures 5 feet by 7 feet. Below the 15 foot level, the well is an earthen hole 5 feet in diameter. To remove the remains of the dead animal from the well, the fire fighters decided to pump approximately 12 feet of water out of the well.

The day before the incident, the fire fighters tried to pump the water out of the well by lowering the hoses on two different fire trucks into the well water. However, the truck pumps were not capable of pulling water up 30 feet. The following day, the fire fighters decided to pump the well out using a 9-horsepower gasoline-powered engine pump. As a result of this decision the following sequence of events occurred:

- Fire fighters lowered two aluminum ladders (tied end to end) into the well.
- A fire fighter (first fire fighter) climbed 15 feet down into the well on the ladder and wedged two boards across the well shaft to set the pump on.
- Another fire fighter (second fire fighter) climbed down into the well to help position the gasoline pump.
- The gasoline pump was lowered down to the platform, and the two fire fighters started the engine but were unable to prime the pump.
- Within a few minutes, the first fire fighter became dizzy, exited the well, and collapsed on the ground near the well opening.
- Fire fighters, who remained outside the well noted that the second fire fighter in a crouching position on the platform next to the pump was unresponsive.
- The first fire fighter regained consciousness and, in a rescue attempt, climbed back down into the well, turned the gasoline engine off (the pump engine had run for approximately 8 to 9 minutes), and collapsed unconscious over the pump engine.
- The second fire fighter then apparently fell off the platform face down into the water (6 feet below the platform).
- A third fire fighter climbed down into the well in a rescue attempt, but was unable to lift the first fire fighter and climbed back out.
- A fourth fire fighter called for help on the truck radio, then climbed down into the well with one end of a rope. He tied the rope around the first fire fighter's torso, and collapsed unconscious, falling facedown into the water.
- By this time, other volunteer fire fighters arrived at the scene in response to the radio emergency call, and began pulling on the rope that was attached to the first fire fighter. They were unable to lift him.
- A fifth fire fighter climbed down into the well, placed the first fire fighter on his shoulder and hoisted him out of the well with the help of fire fighters pulling on the rope at the well opening.
- Fire fighters began cardiopulmonary resuscitation (CPR) on the first fire fighter, who regained consciousness. (Up to this time, none of the fire fighters who entered the well wore any type of respiratory protective equipment.)

- A sixth fire fighter donned an SCBA and started down into the well in a rescue attempt, followed by the fifth fire fighter who was not wearing any respiratory protective equipment.
- Within a minute the fifth and sixth fire fighters climbed back out of the well. The sixth fire fighter complained that he was having difficulty wearing the SCBA because of the cramped conditions in the well, and the fifth fire fighter complained of dizziness.
- The sixth fire fighter then removed the SCBA and climbed back down into the well with the end of a rope.
- Upon reaching the platform the sixth fire fighter yelled that he needed help.
- A seventh fire fighter who was not wearing any respiratory protective equipment climbed down to the platform and observed the second, fourth, and sixth fire fighters all floating face down in the water.
- Feeling dizzy, the seventh fire fighter climbed back out of the well and collapsed unconscious on the ground near the well opening.
- An eighth fire fighter donned an SCBA, climbed down into the well, tied the end of a rope around the torso of the sixth fire fighter, and, with the help of fire fighters pulling on the rope at the well opening, began hoisting the sixth fire fighter out of the well. Using this method, they managed to hoist him a few feet above the platform but the rope became entangled in the ladder.
- At this time, the alarm to the SCBA worn by the eighth fire fighter sounded, so the eighth fire fighter climbed out of the well.
- The fifth fire fighter reentered the well (without any respiratory protective equipment), climbed down to where the sixth fire fighter was hanging, untangled the rope from the ladder, placed the sixth fire fighter on his shoulder, and, with the help of fire fighters pulling on the rope at the well opening, hoisted the sixth fire fighter out of the well.
- Emergency medical service (EMS) personnel (who had arrived at the scene approximately 20 minutes after hearing the radio call for help) administered CPR to the sixth fire fighter at the site and in route to a local hospital. Efforts to resuscitate the sixth fire fighter were unsuccessful and he was pronounced dead in the hospital emergency room.
- A ninth fire fighter climbed down into the well (without wearing any respiratory protective equipment) in a rescue attempt, but felt dizzy after reaching the platform so he climbed back out of the well.
- A tenth fire fighter donned an SCBA, climbed down the ladder into the well to the water level, tied the end of a rope around the torso of the fourth fire fighter and began hoisting the fire fighter out of the well using the same technique as before. Again, the rope became entangled in the ladder when the fourth fire fighter was a few feet above the platform.
- After several minutes, the tenth fire fighter was able to free the entangled rope and the fourth fire fighter was finally removed from the well just as the alarm on the tenth fire fighter's SCBA sounded.
- An EMS rescuer then donned an SCBA, climbed down into the well, and hoisted the second fire fighter out of the well using the same hoisting technique as immediately before. (By this time, approximately 3 hours had elapsed from the time that the rescue of the second fire fighter had initially begun.)

- EMS personnel administered CPR to both the fourth and second fire fighters immediately after they were removed from the well and while in route to the local hospital. Both were pronounced dead on arrival by the attending physician.

CAUSE OF DEATH

The coroner listed the causes of death for the second fire fighter and sixth fire fighter as carbon monoxide inhalation, and the cause of death for the fourth fire fighter as drowning, with loss of function due to carbon monoxide inhalation.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Volunteer fire departments should develop and implement a confined space entry and rescue program.

Discussion: Volunteer fire fighters may be required to enter confined spaces to perform either non-emergency tasks or emergency rescue. Therefore, volunteer fire departments should develop confined space entry and rescue programs, that include emergency rescue guidelines and provide procedures for entering confined spaces. A confined space program, as outlined in NIOSH publications 80-106, "Working in Confined Spaces," and 87-113, "A Guide to Safety in Confined Spaces," should be implemented. At a minimum, the following items should be addressed:

1. Is entry necessary? Can the task be completed from the outside? For example, many fire departments use an underwater search and rescue device which consists of several sections of metal tubing connected together with a hook on the end. Such a device can be used to fish the dead animal remains or other objects out of a well without the need for entry. Also, some fire departments in rural areas use water jet pumps, water siphon booster pumps, or high pressure ejector pumps to pump water at depths greater than 15 feet. This type of pump could have been lowered into the well to pump the water out without the need for anyone to enter the well. Measures that eliminate the need for fire fighters to enter confined spaces should be carefully evaluated and implemented if at all possible before considering human entry into confined spaces to perform non-emergency tasks.

2. Has a confined space entry permit for non-emergency entry been issued by the fire department?

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

   - Oxygen supply at least 19.5%
   - Flammable range for all explosive gases less than 10% of the lower explosive limit
   - Absence of toxic air contaminants?

4. Is ventilation equipment available and/or used?

5. Is appropriate rescue equipment available?

6. Are fire fighters and fire fighter supervisors being continuously trained in the selection and use of appropriate rescue equipment such as:

   - SCBA's
   - lifelines
   - human hoist systems offering mechanical advantage
   - protective clothing?

7. Are fire fighters being properly trained in confined space entry procedures?

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

9. Are fire fighters trained in confined space rescue procedures?

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

The American National Standards Institute (ANSI) Standard Z117.1-1989 (Safety Requirements for Confined Spaces), 3.2 and 3.2.1 state, "Hazards shall be identified for each confined space. The hazard identification process shall include, ... the past and current uses of the confined space which may adversely affect the atmosphere of the confined space;... The hazard identification process should consider items such as... the operation of engine powered equipment in the confined space." An evaluation and identification of the hazards of a non-emergency confined space task is imperative so that supervisors can determine if the fire department has the proper equipment and personnel with the appropriate training to enter a confined space. Volunteer fire departments without the appropriate training and/or equipment should not attempt non-emergency confined space tasks.

Recommendation #2: Volunteer fire departments should develop and implement a respiratory protection program designed to protect fire fighters from respiratory hazards.

Discussion: National Fire Protection Association (NFPA) Standard 1404 3-1.2 and 3-1.3 (Standard For a Fire Department Self-Contained Breathing Apparatus Program) state, "Respiratory protection shall be used by all personnel who are exposed to respiratory hazards or who may be exposed to such hazards without warning... Respiratory protection equipment shall be used by all personnel operating in confined spaces, below ground level, or where the possibility of a contaminated or oxygen deficient atmosphere exists until or unless it can be established by monitoring and continuous sampling that the atmosphere is not contaminated or oxygen deficient." Volunteer fire departments should develop and implement a respiratory protection program which includes training in the proper selection and use of respiratory protective equipment according to NIOSH Publications "Respirator Decision Logic" (Publication #87-108) and "Guide to Industrial Respiratory Protection" (Publication #87-116).

Recommendation #3: Volunteer fire fighters should be trained in the use and limitations of gasoline-powered pumps and the hazards of carbon monoxide in a confined area.

Discussion: The fire fighters in this incident operated a gasoline-powered pump while inside a confined space without providing any exhaust ventilation. According to interviews with the fire fighters involved, they were unaware of the hazards that this would create. Noting the gasoline engine size and type, how long the engine had been running, and the atmosphere volume of the well, the carbon monoxide concentration was estimated to be approximately 20,500 parts per million (PPM) (Appendix). For carbon monoxide, this is more than 13 times the "immediately dangerous to life and health" (IDLH) concentration, which is 1500 PPM (according to the NIOSH Pocket Guide to Chemical Hazards).

Recommendation #4: Volunteer fire departments should develop and implement a general safety program designed to help fire fighters recognize, understand, and control hazards affecting them.

Discussion: NFPA standard 1500, 3-1.1 states that "The fire department shall establish and maintain a training and education program with the goal of preventing occupational accidents, deaths, injuries, and illnesses." NFPA standard 1500, 3-1.4 states that "The fire department shall provide training and education for all members to ensure that they are able to perform their assigned duties in a safe manner that does not present a hazard to themselves or to other members." Fire fighters are often requested by residents to perform non-emergency tasks that can endanger the fire fighter's life. As part of the safety program, fire departments should carefully evaluate each task to identify all potential hazards, (e.g., falls, electrocutions, burns, etc.) and implement appropriate control measures.

FACE 92-28: Hog Farm Co-owner and Employee Die of Hydrogen Sulfide Poisoning in Manure Pit

SUMMARY

A 27-year-old male hog farm employee (victim #1) died as a result of hydrogen sulfide poisoning when he entered a manure- waste pit to extract a pump. The 46-year-old farm co-owner, the victim's uncle (victim #2), also died from hydrogen sulfide poisoning when he entered the pit in a rescue attempt. The manure pit was a holding facility for manure that drained from five holding barns on the property before being pumped to a holding pond 150 feet away. When victim #1 and a co-worker tried to pump the manure from the pit, they discovered that the pump intake was clogged. A tripod-mounted come-a-long was positioned directly over the pit so the pump could be extracted for servicing. A 1/4 inch wire rope was attached to an eye bolt at the top of the pump. As the workers tried to raise the pump from the pit, the wire rope broke. The following morning victim #1 went to one of the barns to get a length of rope with a hook at its end to attach to the pump's eye bolt. As he prepared to descend the ladder into the pit, he was warned by his co-worker that poisonous gases might be present in the pit. Victim #1, explaining to the co-worker that he had entered the pit several times in the past and that he would be fine, descended the ladder into the pit. As he reached for the pump, he collapsed and fell into the manure. The co-worker ran to the farm office and called the rescue squad, then contacted the co-owner by two-way radio and told him what had happened. When the co-owner arrived, he decided to enter the pit with a rope to tie around the victim. The co-worker tried to restrain the co-owner from entering the pit, but the co-owner insisted that he had to go into the pit and help his nephew. The co-owner (victim #2) then entered the pit, and, as he attempted to tie the rope around the victim, collapsed on top of the victim. The rescue squad, equipped with self-contained breathing apparatus, removed the victims from the pit. NIOSH investigators concluded that, to prevent future similar occurrences, employers should:

- *identify manure-waste pits as confined spaces and post hazard warning signs at all entrances*
- *instruct farm employees never to enter manure-waste systems unless absolutely necessary, and only when following safe entry procedures*
- *instruct farm employees never to enter a manure pit, or any other confined space, to attempt a rescue operation without proper consideration for their own safety*
- *periodically inspect equipment for physical damage, especially equipment located or used in corrosive environments*
- *equip manure-waste systems with some type of powered ventilation system.*

Additionally, manufacturers of equipment designed for use in manure-waste pit systems should:

- *include warnings on the potential hazards associated with these systems.*

INTRODUCTION

On August 8, 1992, a 27-year-old male farm worker (victim #1) died of hydrogen sulfide poisoning when he entered a manure-waste pit to attach a rope to a pump so that the pump could be removed from the pit. The 46-year-old farm co-owner (victim #2) also died from hydrogen sulfide poisoning when he entered the pit in a rescue attempt. On August 12, 1992, officials from the Minnesota Fatality Assessment and Control Evaluation (FACE) program notified the National Institute for Occupational Safety and Health (NIOSH), Division of Safety Research (DSR) of these fatalities, and requested technical assistance. On September 2, 1992, a DSR safety specialist and two FACE field investigators from the state of Minnesota traveled to the incident site to conduct an investigation. The investigative team reviewed the incident with the farm co-owner and county extension agent, photographed the incident site, and obtained reports from the sheriff, coroner and emergency rescue squad.

The employer was a multi-farm hog-farming operation that processed approximately 10,000 hogs annually. These hogs, separated by different stages of growth, were housed on nine farms in the area. The farm employed 10 workers and had been in operation for 18 years. The employer had no written safety program or safe work procedures. The employer had no previous fatalities.

INVESTIGATION

The manure-waste pit in this incident was 12-feet deep and 49 inches in diameter. It was covered by a 7-inch-thick circular concrete slab with a 28-inch diameter opening in its center. The interior of the pit was accessed by a ladder anchored to the side of the pit. The manure entered the pit through five gravity-fed drains leading from five holding barns. Occasionally, the pump intake, located within the pit, would become clogged with debris from one of the barns. When this occurred, the pump was extracted from the pit using a tripod-mounted come-a-long that was positioned directly over the pit. A 1/4 inch wire rope from the come-a-long remained attached to the eye bolt on the top of the pump at all times.

On the afternoon before the incident, the farm worker (victim #1) and a co-worker went to the manure pit to pump it out, but found that the pump intake was clogged with debris. The men tried to raise the pump from the pit but the 1/4 inch wire rope attached to the eye bolt at the top of the pump broke. The two men then decided to wait until the following morning to repair the pump and replace the wire rope.

On the following morning, victim #1 told the co-worker that he was going to climb down the ladder to attach a new wire rope and hook to the eye bolt on the pump. The co-worker warned the vic-tim not to enter the pit because of the possibility of poisonous gases in the pit. The victim told the co-worker that he had entered the pit several times in the past and had never experienced any problems. He then descended the ladder approximately 9 feet into the pit. As the victim bent over to attach the hook to the eye bolt he collapsed into the manure. The co-worker immediately ran to the office and called the emergency rescue squad, then contacted the co-owner by two-way radio and told him what had happened. The co-owner (victim #2) arrived at the farm, found some rope to tie around the victim, then ran to the pit. The co-worker repeated his warning about the presence of poisonous gases to the co-owner, but the co-owner insisted that he had to try to rescue his nephew. The co-worker tried to physically restrain the co-owner from entering the pit but failed. The co-owner then descended the ladder into the pit, and as he tried to tie the rope around victim #1, he was overcome and collapsed on top of victim #1. The emergency rescue squad arrived 10 minutes after the co-owner entered the pit and approximately 20 minutes after victim #1 was overcome. Using self-contained breathing apparatus, the rescue squad removed the victims from the pit. The victims were transported to the hospital where they were pronounced dead.

Gas readings taken by the FACE team during their investigation showed no measurable levels of hydrogen sulfide or methane, and an oxygen level of 20.4%. It should be noted that on the day of the incident and the preceding day, the temperature was in the mid 90s and the humidity was about 95%; the barometric reading was 30.2 and there was no wind. These conditions would have been favorable for a buildup of hydrogen sulfide and/or methane inside the pit. At the time of the investigation, the temperature was 65 degrees and the conditions were windy.

CAUSE OF DEATH

The coroner listed the cause of death for both victims as hydrogen sulfide poisoning.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Employers should identify manure-waste pits as confined spaces and post hazard warning signs at all entrances.

Discussion: Manure-waste pits, by their design, meet the NIOSH definition of a confined space. A space is considered "confined" if it: 1) has limited openings for entry and exit; 2) has unfavorable natural

ventilation which could contain or produce dangerous air contaminants; and 3) is not intended for continuous employee occupancy. Entrance into confined spaces, as described in this incident, are addressed in NIOSH Publication No. 80-106 (Working in Confined Spaces). Ideally, a manure pit should be ventilated, and the atmosphere within the pit tested prior to entry and monitored while work is being performed. Self-contained breathing apparatus should be utilized by those entering the pit if an oxygen-deficient and/or toxic atmosphere is found to exist. Although such specialized equip- ment and training in the use of this equipment may not be readily available to many farm workers, these workers should, at a minimum be made aware of potential hazards associated with manure-waste pits, such as oxygen-deficient or toxic atmospheres. Signs to alert farm workers of the hazards associated with manure-waste pits should be posted at all entrances. These signs should be understandable to workers who might not be able to speak or read English. In some areas, signs in more than one language might be necessary. NIOSH has prepared an Alert detailing the hazards associated with manure-waste pits on farms (NIOSH Publication No. 90-103). Additionally, NIOSH requests the assistance of agricultural extension agents, farm journals, agricultural associations, and farm equipment manufacturers in alerting farm workers to the hazards associated with manure-waste pits.

Recommendation #2: Employers should instruct farm employees never to enter manure-waste systems unless absolutely necessary and only when following safe entry procedures.

Discussion: In this incident, the manure pit was entered by the first victim on numerous occasions without incident. Previous uneventful entries may lead farm workers to feel safe about entering these pits. Because dangerous gases may be present, a manure-waste pit system should never be entered unless absolutely necessary. If entrance into the pit is necessary, workers must follow safe confined space entry procedures (See NIOSH Publications 80-106 and 90-103). Additionally, a standby person(s) with the capability of removing the person from the pit, if necessary, should be stationed outside the pit. Visual and/or audible contact must be maintained with the person in the pit at all times. If the standby person(s) is not physically capable of removing the person from the pit, then some sort of mechanical lifting device (a winch, hoist, etc.) should be in position over the pit. Anyone entering the pit to perform any work should wear a safety belt or harness and have a lifeline attached to a substantial anchor point outside the pit. This would enable a standby person(s) to remove someone from the pit without entering the pit. Details of a rescue plan must be resolved and understood before entry. Should an emergency develop, a short delay caused by lack of preparation could be fatal.

Recommendation #3: Employers should instruct farm employees never to enter a manure pit, or any other confined space, to attempt a rescue operation, without proper consideration for their own safety.

Discussion: Farm workers should never, under any circumstances, enter a manure pit to attempt a rescue operation unless properly equipped and trained in the use of the equipment and methods required for rescue. The agent that caused the victim(s) in the pit to be overcome will have the same effect on any would-be rescuer, and the rescuer(s) themselves may become a victim. Farm workers should be instructed that if anyone is observed to be unconscious or ill inside a pit, they should immediately contact the local fire department or emergency rescue squad. These squads will have the training and equipment needed to accomplish a rescue without further endangerment to life.

Recommendation #4: Employers should periodically inspect equipment for physical damage, especially equipment located or used in corrosive environments.

Discussion: In this incident, the unwritten standard operating procedure called for the pump to be raised from the manure pit for maintenance. A wire rope was connected to the pump for this purpose; however, when the workers attempted to raise the pump, the wire rope broke. Since the pump was raised from the pit at least once a month for maintenance or repair, a visual inspection for physical damage to the pump, wire rope, or any other components could have been conducted at this time. Any damaged component should be repaired or replaced immediately. This would be especially important for components used in a corrosive environment such as a manure pit.

Recommendation #5: Employers should equip manure-waste systems with some type of powered ventilation system.

Discussion: Ideally, manure-waste systems should be equipped with both supply and exhaust ventilation to eliminate the accumulation of gases. In the case of explosive gases such as methane, the system should be of sufficient size to prevent the gas from reaching its explosive limits and should be of explosion-proof design as defined in the National Electrical Code, Article 100-A. The system may be composed of portable fans, but must be of sufficient capacity to ensure constant circulation of fresh air throughout the waste system, and be of explosion-proof design.

Recommendation #6: Manufacturers of equipment designed for use in manure-waste pit systems should include warnings on the potential hazards associated with these systems.

Discussion: Manufacturers of this type of equipment should provide purchasers with information concerning the potential hazards that may be encountered when using this equipment in manure-waste systems. Information (such as diagrams, etc.) about installing this equipment so that it can be serviced without requiring workers to enter the pit should also be provided.

REFERENCES

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