Physical Hazards

Drowning

FACE 87-05: Owner/Foreman of Construction Company Dies in 15 Foot-deep Manhole in California

INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH), Division of safety Research (DSR) is currently conducting the Fatal Accident Circumstances and Epidemiology (FACE) Project, which is focusing primarily upon selected electrical-related and confined space-related fatalities. The purpose of the FACE program is to identify and rank factors that influence the risk of fatal injuries for selected employees.

On October 14, 1986, the owner/foreman of a construction company (the victim) was found face down at the bottom of a 15 foot-deep manhole in approximately three feet of muddy water. Four workers entered the 24-inch diameter opening and removed the victim from the manhole without any ill effects. Resuscitation efforts failed to revive the victim, who was pronounced dead by the attending physician at a local medical clinic. The incident occurred at a park.

CONTACTS/ACTIVITIES

The Water Pollution Control Federation (WPCF) notified the Division of Safety Research of this fatality and requested assistance. This case has been included in the FACE Project. On October 11, 1986, two research industrial hygienists conducted a site visit, met with the park ranger, interviewed two comparison workers and a representative of the employer, and interviewed a surrogate for the victim.

BACKGROUND/OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The construction company has 13 employees and had been subcontracted to install a sewage collection system which consisted of 20,000 feet of 6- and 8-inch pipe and 80 manholes.

The prime contractor has written safety rules. Safety meetings discussing basic safety issues relevant to the job being performed are conducted on a regular basis by the prime contractor and the subcontractor. No training had been given concerning confined space entry; however, this subject had been discussed by the prime contractor and the subcontractor as a future training need, since the workers would be required to enter the manholes previously installed.

SYNOPSIS OF EVENTS

Prior to the day of the accident the manhole involved in this incident had tilted about 10 degrees because heavy rains caused the backfill to settle unevenly. An effort to straighten the manhole resulted in extensive damage to a section of the concrete cylinder, five to seven feet below the ground surface. This damage permitted mud and water to seep into the manhole. At the time of the accident the manhole had not yet been connected to any of the sewer lines which had been laid.

On October 14, 1986, the subcontractor's construction crew was installing a section of sewer pipe, approximately 100 feet south of the manhole where the accident occurred. The owner/foreman (the victim), who was operating a backhoe, requested that one of the workers remove the manhole cover so that the victim could "check the grade". The victim then finished excavating the trench for the section of pipe that the crew was installing. Shortly after completion of the excavation, one of the workers observed the victim walking towards the manhole. About fifteen minutes later the worker looked into the manhole and saw the victim face down in the muddy water at the bottom. He immediately called to the other crew members for help.

In response, two workers climbed down into the manhole to rescue the owner. One of the workers feeling "breathless and nauseated", due to what he felt was excitement and exertion, climbed back out. Two other workers entered the manhole, placing a chain around the victim, and assisted in pulling the victim out of the manhole. None of the other workers who entered the manhole experienced any ill effects. The workers then began cardiopulmonary resuscitation (CPR) on the victim until the rescue squad arrived. The victim was rushed to a nearby medical clinic where he was pronounced dead about 90 minutes after being removed from the manhole. Although there were no witnesses to the accident, the medical examiner's report suggests that the victim slipped and fell while entering the manhole, was knocked unconscious, and subsequently drowned in the water at the bottom. If this is the case, it is not clear why the victim felt he needed to enter the manhole since the grade could have been checked from the outside and thus entrance into the confined space would not have been necessary.

An industrial hygiene consultant firm was contacted by representatives of the park. The consultants tested the atmosphere in the manhole and another manhole further east the day after the incident. Their findings indicated that the air samples contained "... normal levels of oxygen (20.5%) in both manholes ...". Tests for carbon monoxide, carbon dioxide, and other gases were "...well below levels that would be noxious".

It should be noted that the unconscious "man down" is often due to a hazardous atmosphere. A hazardous atmosphere and the impromptu rescue response that occurred during this incident could have easily resulted in multiple fatalities, which are typical of many confined space-related incidents.

CAUSE OF DEATH

The medical Examiners report indicates that the victim was knocked unconscious from falling and drowned.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: A trained standby person should remain outside of the confined space when a worker enters or works inside. The standby person should visually monitor the tasks being performed inside and should be able to communicate with the worker(s) inside the confined space.

Discussion: A person trained in emergency rescue procedures, assigned to remain on the outside of the confined space for communication and visual monitoring of the person inside is of utmost importance and might have prevented this fatality.

Recommendation #2: Employers should develop a comprehensive safety program that clearly documents procedures for safe entry into confined spaces.

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. Standby person outside the space for communication and visual monitoring.
6. Emergency rescue procedures.

Even though normal oxygen levels were found in air samples taken from two manholes after the accident, entry into confined spaces should not be attempted until atmospheric testing of the confined space insures that the atmosphere is safe. This testing requirement applies to all confined spaces, including those under construction. Testing must be done by a qualified person prior to entry.

Recommendation #3: Property owners contract construction projects should require that a safety program be implemented. The owner should assure that all safety requirements are enforced.

Discussion: When hazardous tasks such as confined space entry are to be performed by contractors or subcontractors, the contract should require compliance with safe work procedures. These requirements should be enforced by the company letting the contract. Specific recommendations regarding safe work practices in confined spaces can be found in the NIOSH Publication No. 80-106, "Working in Confined Spaces". This publication also defines and provides recommendations on hot work, isolation, purging, ventilation, communication, entry and rescue, training, posting, safety equipment, clothing, etc.

FACE 90-14: Municipal Sewer Maintenance Worker Drowns Inside Sewer Wet Well

INTRODUCTION

The employer in this incident is a municipality with 46 public works employees, including 10 sewer workers. The victim had been employed by the municipality for 11 months (the entire time as a sewer maintenance worker). The public works department has a safety policy and confined space entry procedures, but no confined space rescue procedures. The director of the public works department is responsible for the safety program. Public works employees attend monthly safety meetings where job safety issues are discussed and training is occasionally given. The victim had previously attended a 1-hour training session on confined space safety, and a 1-hour training session on the use of supplied-air respirators since his employment began with the public works department.

INVESTIGATION

A sewer maintenance crew was assigned the task of cleaning out a sewer wet well. The crew consisted of four sewer maintenance workers (including the victim) and the foreman for the water and sewer department. The wet well is 20 feet deep, 6 feet in diameter and is located next to an underground sewage lift station. Two feet below the top of the wet well is an 18-inch-diameter sewer inlet pipe. The sewage discharge line (sewer pump intake) forms an elbow with the vertical end 1 foot above the bottom of the wet well. Eight feet below the top of the wet well is a steel grating platform. The grating has three removable sections which rest on a framework of steel "I" beams. Access into the wet well is through a 24-inch-diameter manway opening located at ground level.

The crew arrived at the site at 8:30 a.m., and turned on the lift station pumps. This lowered the sewage level to approximately 2 feet from the bottom of the wet well. With the foreman present, the victim entered the wet well through the manway (without first testing or ventilating the wet well atmosphere) and climbed down the side on steel rungs. He was wearing a pressure demand supplied-air respirator with an auxiliary, escape-only SCBA, and a full-body harness. The harness was secured to a winch cable. The other end of the cable was attached to a power winch on the front end of a maintenance truck.

After climbing down to the grating level the victim installed an inflatable rubber sewer plug into the inlet sewer pipe. The pipe was flowing about one-third full with sewage. The plug was inflated (using an air hose attached to a cylinder of compressed air) until it closed off the pipe and stopped the flow of sewage. However, the employer did not ensure that the following sewer plug manufacturer's recommendations were adhered to during the installation of the plug: (1) the pipe be cleaned out prior to insertion of the plug, (2) the plug be installed with a back-up system (i.e., gate valve), (3) the plug be anchored in place, and (4) the plug be checked to ensure proper inflation to 30 PSI.

A co-worker entered the wet well (without any respirator or harness/hoisting device) and assisted the victim in removing the 2-foot by 6-foot center section of grating. Co-workers at the street level lowered an 8-inch-diameter suction hose into the wet well from a sewer vacuum truck. The victim descended below the grating to the bottom of the wet well with the end of the suction hose and began vacuuming out the remaining sewage and solid waste material. Within a few minutes, the victim removed the respirator facepiece, complaining to the co-worker (who was standing directly above him on the grating) that the respirator was in his way.

Approximately 30 minutes later, the sewer plug gave way, causing sewage to flood the wet well. On hearing the noise, the foreman ran to the manway and yelled for the two workers to get out. Another co-worker turned on the winch and began raising the cable. Within 15 seconds the level of sewage inside the wet well was up to the grating. The co-worker who was standing on the grating reached down through the opening in the grating and made an unsuccessful attempt to grab the victim who was submerged. During this rescue effort, the winch cable became entangled in the grating support beams. As the sewage level continued to rise, the co-worker was forced to climb up further and was ultimately helped out of the wet well by other co-workers. An attempt was also made to start up the pumps inside the lift station. However, the pumps were air-locked and therefore, would not pump the sewage out.

The fire department rescue squad was notified and arrived within 10 minutes. By this time the sewage was about 2 feet above the grating. Fire department rescuers (wearing SCBA) entered the wet well, freed the entangled winch cable, removed the victim, and began administering cardiopulmonary resuscitation. The victim revived and was transported to the intensive care unit of a local hospital where he died approximately 11 hours later.

CAUSE OF DEATH

The coroner listed the cause of death as drowning.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: The employer should ensure that workers follow the sewer plug manufacturer's recommendations on the installation and use of sewer plugs.

Discussion: The sewer plug manufacturer recommends the following before performing work upstream or downstream from an inflatable sewer plug:

(1) the use of a back-up system such as a gate valve;

(2) properly cleaning the pipe where the plug will be installed, since debris inside the pipe (i.e., hard objects, encrustations, grease, etc.) can cause plug damage, an improper seal, and/or plug slippage;

(3) securing the plug in place with the use of appropriate restraining rope, cable, etc., to solid anchoring points upstream from the plug; and

(4) inflating the plug to the correct air pressure (according to the plug size and using an appropriate air pressure gauge).

Even properly inflated it is questionable that the plug would have been able to withstand the amount of pressure exerted by the sewage without the restraining cable properly anchored in place. At any rate, none of the above recommendations were followed. Had they been followed, this fatality might have been prevented.

Recommendation #2: The employer should develop, implement and enforce specific confined space entry procedures.

Discussion: Although the employer had written confined space entry procedures, they were not followed or enforced. For example, the wet well in this incident was not tested prior to entry. This requirement was part of the written confined space entry procedures of the public works department, and the foreman was present during the wet well cleaning procedure. Also, the co-worker entered the wet well without wearing a supplied-air respirator/SCBA and the victim removed the supplied-air respirator/SCBA he was wearing after descending to the bottom of the wet well. The employers' confined space rescue procedures were also deficient. For example, although the victim wore a full body harness secured to a winch cable, confined space rescue was not addressed in the written procedures at all. Confined space entry procedures should be specific to each type of confined space e.g., wet wells, lift stations, utility vaults, sewer manholes, etc. 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 Spaces." 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? For example, sewer vacuum cleaning devices are currently available that will allow workers to clean out wet wells from street level.

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

3. Are confined spaces posted with warning signs (where feasible)?

4. 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 less than 10% of the lower explosive limit
   - Absence of toxic air contaminants?

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

   - respiratory protection
   - lifelines
   - emergency rescue equipment
   - protective clothing?

6. Are workers being properly trained in confined space entry?

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

8. Are employees being continuously trained in confined space rescue procedures?

9. Is ventilation equipment available and/or used?

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

Recommendation #3: The employer and other municipalities should consider installing self-priming wet well sewer pumps by retrofitting, or replacing old pumps as they are taken out of service.

Discussion: Properly installed, a self-priming sewer pump would prevent an air-lock whenever the wet well is manually pumped out below the level of the pump intake. In this incident, if the pumps in the sewage lift station had been self-priming, they could have been immediately activated, possibly preventing the fatality which resulted.

Recommendation #4: Rescue equipment should be appropriate for its intended use.

Discussion: Although the victim was wearing a full-body harness secured to a winch cable, the power winch being used was not rated for lifting humans. It is recognized that any type of rescue/lifting device might have become entangled in the grating supports. However, a hoisting device designed for lifting humans will not subject the individual being lifted to crushing hazards. This is especially important if any part of the body becomes caught during an emergency lift (even though in this incident crushing injuries were not apparent).

Recommendation #5: The employer should ensure that workers use the provided respiratory protective equipment in accordance with instructions and training received as required by CFR 1910.134(a)(3).

Discussion: The public works confined space entry procedures require workers to wear a supplied air respirator the entire time while work is being performed inside sewer wet wells. Additionally, the victim had received training on the use of the supplied-air respirator that he wore. In spite of this, the victim removed his respirator facepiece while working at the bottom of the wet well and was allowed to remain in the well and continue working without wearing the respirator (even though the victim's supervisor was present). Also, while the victim was working at the bottom of the wet well, the co-worker entered the wet well and climbed down to the grating level without wearing any respiratory protection. Even though supplied-air respirators are not rated for use under water, if the victim had not removed the facepiece, it may have given him enough time to climb out when the wet well flooded.

FACE 90-17: Sewer Worker Dies When Inflatable Sewer Plug Bursts

ITRODUCTION

The employer involved is a municipal utility with 1100 public works employees. Approximately 200 of the employees are sewer maintenance workers and wastewater treatment plant operators. The victim had been employed by the municipality for 23 years as a sewer maintenance worker. The public works department has a full-time safety and health manager and a full-time safety and health specialist. A safety policy exists but there are no confined space entry procedures for sewer maintenance workers. However, the victim and other sewer maintenance workers had participated in a 2-hour training session on confined space safety within the past year.

INVESTIGATION

A crew of 10 sewer maintenance workers (including the victim) was assigned the task of diverting the flow of sewage in a 6-foot-diameter sewer main branch in preparation for installing some adjustable weirs (weirs are flow diversion devices). Access into the sewer main was provided by a diversion gate chamber located below a concrete drive area in an underground parking garage for a large building. The gate chamber was 12-1/2 feet deep and approximately 10 feet wide by 16 feet long and located on top of a sewer main diversion branch which formed a "Y" configuration (Figure). The chamber had a 2-foot by 4-foot hatch with hinged steel covers and steel rungs built into the side of the chamber for access. The bottom of the chamber consisted of a removable aluminum grating over the sewer main and a concrete floor between the branches of the "Y". The top of the grating in both branches was approximately 12 inches above the surface of the sewage, which normally flows at a height of 5 feet. The chamber housed a 3/8-inch-thick, 6-foot by 9-1/2-foot aluminum slide gate in each branch of the sewer main. The purpose of the slide gates is to divert the flow of sewage for sewer maintenance purposes. Since the slide gates had not been operated for several years they had become stuck in the "open" position. Therefore, the crew used an inflatable sewer plug to block off the right branch of the sewer main, diverting all of the flow to the left branch of the sewer main (Figure).

The workers installed the sewer plug by lowering the deflated plug into the gate chamber, floating it several feet downstream into the right branch of the sewer main and anchoring it in place with a tethering line. An air line connected to an air compressor (rated at 90 PSI) on the surface was attached to an air valve on the sewer plug. The victim, who was initially above ground, began operating the compressor to inflate the plug and checking a pressure gauge on the air line at the compressor to ensure that the pressure in the sewer plug did not exceed 7 PSI (according to the sewer plug manufacturer's recommendations). The foreman sent a sewer maintenance worker (co-worker) into the chamber to check on the plug. The foreman then walked about 30 feet away to examine a manhole. The victim left the compressor running unattended (for unknown reasons), entered the gate chamber, and began inspecting the installation of the sewer plug. By this time, the plug had expanded and closed off the right branch of the sewer main. The diverted sewage was flowing at its normal height of 5 feet into the left branch of the sewer main. The bottom edge of the slide gates were level with the surface of the sewage flow. The victim was standing on the grating between the plug and the right sewer branch slide gate, while the co-worker was standing on the grating in the left sewer branch on the opposite side of the right branch slide gate (Figure). A few minutes later (after the compressor had been running for approximately 20 minutes), the plug burst, forcing sewage and air into the chamber and out the access hatch. The force of the explosion broke and lifted the grating the victim was standing on, bulged out (approximately 6 inches) the 3/8-inch-thick aluminum slide gate in the right sewer branch, and broke a fluorescent light fixture on the ceiling of the parking garage 10 feet above the chamber access hatch. Evidence gathered after the incident suggests that the force of the explosion pushed the victim up against the concrete ceiling of the chamber. The victim then fell into the right branch of the sewer main and was washed downstream with the surge of sewage. The co-worker was not injured and was able to climb up the chamber rungs where he was helped out by the foreman.

The rescue squad from the city emergency medical service (EMS) was notified and arrived at the site in 5 minutes. After a 40-minute search, EMS personnel discovered the body of the victim submerged under the sewage flow, against the bar screen of a sewage pumping station approximately 200 yards downstream from the gate chamber. EMS personnel noted that the victim was dead at the scene.

CAUSE OF DEATH

The coroner listed the causes of death as asphyxiation by aspiration of food bolus, and blunt force injuries

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Where worker entry into sewers is necessary, slide gates should be used instead of, or in conjunction with, inflatable sewer plugs.

Discussion: Slide gates provide a more positive method for diverting/controlling the flow of sewage for maintenance purposes, and should be utilized where possible. In this incident, because the slide gates had not been used for quite some time, they had become inoperative. Slide gates of this type should be properly maintained and operated regularly to ensure their proper function.

Recommendation #2: Employers should ensure that sewer workers follow all sewer plug manufacturer's safety recommendations and other safety precautions relevant to the safe installation and use of inflatable sewer plugs.

Discussion: Although some of the plug manufacturer's recommendations were followed, an important precaution for the use of this type of sewer plug was not followed. The following precaution is stated on the first page of the sewer plug installation instructions: "Under no circumstances should anyone be in the pipe or manhole when the stopper (plug) is being inflated or deflated." The victim left the air compressor running unattended. He had been trained in the manufacturer's recommendations which stipulate that this size plug was to be inflated to only 7 PSI. The air pressure inside the plug may have exceeded the recommended pressure of 7 PSI, thus causing the plug to rupture. (The burst test pressure for this plug is 21 PSI.) Another safety recommendation given by the plug manufacturer (also stated on the first page of the sewer plug instructions) was not followed: "When working under submerged conditions, as a safety precaution, the stopper should be filled with water to its appropriate pressure." According to the manufacturer, filling the plug with water instead of air when the plug is submerged will greatly reduce the force of a rupture.

Recommendation #3: Employers of sewer maintenance workers should develop and implement a comprehensive confined space entry program as outlined in NIOSH publication 80-106, "Working in Confined Spaces," and 87-113, "A Guide to Safety in Confined Spaces."

Discussion: Confined space entry procedures should address each type of confined space that sewer maintenance workers are required to enter (i.e., diversion chambers, wet wells, lift stations, utility vaults, sewer manholes, sewer mains, etc.). At a minimum, the following items should be addressed:

1. Is entry necessary? Can the assigned task be completed from the outside? For example, a sewer monitoring camera could be lowered into a sewer diversion gate chamber which would allow workers to perform inspections from the outside.

2. Is a confined space safe entry permit issued by the employer before each confined space is entered.

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:

    - respiratory protection
    - lifelines
    - emergency rescue equipment
    - protective clothing

6. Have employees been trained for confined space entry? NOTE: The fire department that responded to this emergency is one of the best equipped and trained in the country. As a result of this preparedness, potential injury and fatalities to their personnel was avoided.

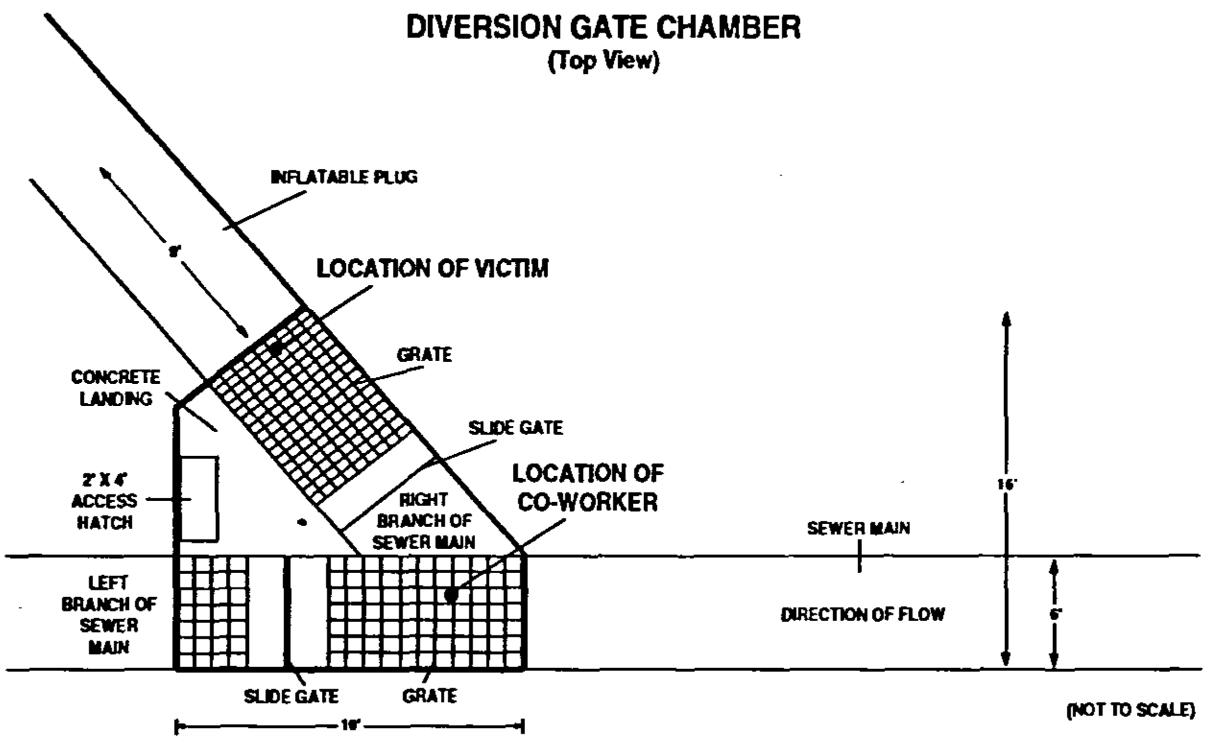

Figure (90-17)

FACE 91-23: Wastewater Treatment Plant Operator Drowns In Recirculation Pit

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. 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 and noticed the sewage level was elevated, although it had not reached the high water level. 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.

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.

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. 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.

FACE 93-17: Two Men Die In Well Cleaning Operation

INTRODUCTION

On May 1, 1993, two self-employed well cleaners (the victims) drowned while conducting well cleaning operations at a residential well site. On June 23, 1993, the Maryland Occupational Safety and Health Administration (MOSH), notified the Division of Safety Research (DSR) of these deaths and requested technical assistance. On July 12, 1993, an environmental health and safety specialist and an engineering intern from DSR conducted a field investigation of this incident. Interviews were con- ducted with the MOSH investigator, the county confined space rescue team, the county volunteer fire department, and the son of victim #2. Photographs were obtained of the incident site. Medical examiner's reports for both victims were also obtained. No atmospheric testing was conducted as the well site had been filled in and sealed.

The investigation was complicated in part by certain factors: the time lapse between the incident and the investigation, the number of emergency responders, the particular sequence of events, and the time frames of these events, and differing perceptions of the series of events occurring in a crisis situation. Therefore, a scenario of this incident was developed after carefully evaluating a diverse mixture of information. The victims in this incident worked part-time as self-employed well cleaners and grave diggers. This was the only source of employment for victim #1. Victim #2 was employed full-time as a truck driver for the county in which the incident occurred. Neither victim had any safety or confined space training. However, both victims were aware that well cleaning was a dangerous job, according to the son of victim #2.

INVESTIGATION

On May 1, 1993 three self-employed well cleaners - a 43-year-old male (victim #1), a 40-year-old male (victim #2), and his 17-year-old son - arrived at the residential well site to clean a shallow (36-inch-diameter by 40-foot-deep) well. They arrived at the work site at 9 a.m. and used a portable gasoline pump to remove water from the well, which was filled to approximately the 20 foot level. The gasoline pump was not adequate to remove all of the water, so the workmen went to a local equipment rental store and rented an electric sump pump to complete the job. They placed the pump at the bottom of the well and pumped out the remaining water to a depth of 6 to 8 inches. The victims did not use any type of respiratory protection, atmospheric test equipment, or ventilation equipment during the well cleaning operation. Victim #1 was lowered into the well at approximately 10:30 a.m. to begin cleaning. A steel bucket, steel cable, and a homemade windlass were used to raise and lower workers, supplies, and muck from the well. The windlass was made of 2-inch by 6-inch wooden boards, crudely designed in an "X" configuration, with a steel bar across the top intersection of the "X" which included a handle at each end. Victim #1 began shoveling muck out of the well and brushing down the sides. Water was the only solvent used to clean the sides of the well. Approximately 1 hour and 15 minutes later, victim #2, at the top of the well, asked victim #1 how much longer before the cleaning job would be completed. Not hearing a response, victim #2 inquired as to the condition of victim #1. There was still no response. The second victim's son asked the homeowner to call 911 (at approximately 11:50 a.m.), stating there was trouble in the well, then requested the homeowner's assistance in lowering his father (victim #2) into the well to rescue victim #1. In a rescue attempt, the son and the homeowner lowered victim #2 into the well on a small wooden (2 inch by 12 inch by 16 inch) board which served as a seat.

Using his arms, victim #2 was able to secure his co-worker and was being hoisted up by his son and the homeowner when at approximately the halfway point (20 feet), the board that was supporting the victims started to crack. Victim #2 yelled to his son to lower them back to the bottom of the well. Victim #1 was still semiconscious but unable to assist victim #2 in attempting to exit the well. The two workers made no other attempt to leave the well until rescue units arrived. The first rescue squad to arrive on the scene was the county emergency medical squad (EMS) at approximately 12 noon. The paramedics from the EMS positioned their truck 5 to 7 feet from the well opening in order to use a light to see into the well. A rope was thrown down to the victims but victim #2 was unable to secure the rope around victim #1.

By this time, the well was starting to fill with water (approximately 10 feet deep), and the victims were treading water.

Within 2 to 4 minutes after the first EMS unit arrived, the local volunteer fire unit arrived on the scene. The first rescue unit was promptly ordered by the deputy chief of the local volunteer fire unit to move their vehicle away from the well. At this point, victim #2 was coherent enough to communicate with the rescuers, but was not able to use a rope to exit the well. Victim #1 was not coherent, and was believed to be unconscious. The second rescue unit was equipped for fire rescue. Therefore, they only had 60 minute air tanks on the self-contained breathing apparatus (SCBA); they did not feel there was room in the well for a rescuer with full turn-out gear and an SCBA. The deputy chief of the volunteer fire unit requested a 15-minute (smaller in size) unit be brought to the scene from the fire house, which was approximately 5 miles from the incident scene.

Because victim #2 was going under the water, the volunteer fireman (rescuer #1) preparing to make the descent into the well in a rescue attempt told the deputy chief they did not have time to wait for the 15-minute unit. A decision was made to lower the fireman into the well without any respiratory protection, wearing the bottom half of the turn-out gear, a harness, and a lifeline. The fireman was lowered into the well, which now had approximately 20 feet of water, and was able to reach victim #2 within a few minutes and place a rescue line around him. (The temperature of the water was between 35 and 40 degrees F, as reported by the volunteer fireman.) The rescuing fireman was then hoisted from the well without any ill effects from the atmosphere or the cold water. (Note: the atmosphere was being tested before and after the fireman's entry - the oxygen level was measured at 17% by volume). Victim #2 was then pulled from the well, in an unresponsive condition. Paramedics administered CPR and transported him to the local hospital where he was pronounced dead, after further life-saving efforts were unsuccessful.

The elapsed time for the rescue of victim #2 was approximately 20 minutes after the first EMS arrived on the scene. By the time Victim #2 was removed from the well, victim #1 had been underwater for approximately 30 minutes. The volunteer fire unit was not prepared for an underwater recovery; the decision was made to avoid the risk of losing a firefighter in what was believed to be at this point, a body recovery. They chose instead to wait for the arrival of better equipped units, whose assistance had been requested to retrieve victim #1.

Divers from an adjacent county arrived approximately 40 minutes after the second 911 call. Two divers made separate dives (each equipped with self contained underwater breathing apparatus [SCUBA], full rubberized diving suits, underwater lights, and life lines). The first diver (rescuer #2) found victim #1 at the bottom of the well and managed to get a rope around him; however, when they attempted to raise him from the well, the victim slipped out of the rope and sank back to the bottom. The second diver (rescuer #3) was unsuccessful in his attempt to secure a line to the victim. A volunteer fireman from the local fire department (rescuer #4) entered the well wearing SCUBA; however, he was also unsuccessful in his recovery attempt, and complained of the cold water inhibiting his ability to recover the victim. A specialized confined space rescue team had now arrived from a different county and requested the area be cleared of all those working on the rescue effort. The specialized rescue team sent one of their divers (rescuer #5) wearing SCUBA, a full rubberized suit, life line, underwater lights, and communication equipment into the well. It took approximately 20 minutes for this diver to secure a line to victim #1. Victim #1 was then recovered from the well, approximately 4 hours after the initial 911 call. Victim #1 was pronounced dead at the scene by a forensic examiner.

In summarizing this confined space investigation, there were three major hazards identified: (1) oxygen deficient atmosphere (NIOSH, 1979), (2) toxic (carbon monoxide) atmosphere (NIOSH, 1972), and (3) cold water exposure (Golden, 1976). The medical examiner listed the blood carboxyhemoglobin saturation levels as 37% in victim #1 and 13% in victim #2.

The bacterial action and biomass in the well could have been a source for a small percentage of the carbon monoxide. However, an external source was probably responsible for the largest percentage of carbon monoxide. Testing conducted by the volunteer fire unit indicated that the oxygen level (only gas tested) at the 20-foot level was 17% by volume. When the well was pumped to the bottom, the oxygen level would have likely decreased to 12 to 15% by volume. Under conditions of reduced ambient oxygen concentration, such as the reduced oxygen level in the well, the exposure to carbon monoxide was even more critical.

The water temperature in the well was reported to be between 35 and 40 degrees F. Survival time in water at 32 degrees F is predicted to be less than 15 minutes (Golden, 1976).

CAUSE OF DEATH

The medical examiner listed the cause of death for victim #1 as "drowning complicating carbon monoxide poisoning," and the cause of death for victim #2 as drowning.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Employers involved in well cleaning operations, including the self-employed, should develop and implement a comprehensive confined space entry program.

Discussion: There was no confined space entry program in effect at the residential well site at the time of the incident. The atmosphere was not tested before entry, no mechanical ventilation or respiratory protection was provided, and no rescue plans were developed. Employers, even self-employed well cleaning operations, should develop and implement a written confined space entry program to address all provisions outlined in the following NIOSH Publications: Working in Confined Spaces: Criteria for a Recommended Standard (Pub. No. 80-106); NIOSH Alert, Request for Assistance in Preventing Occupational Fatalities in Confined Spaces (Pub. No. 86-110); A Guide to Safety in Confined Spaces (Pub. No. 87-113); and NIOSH Guide to Industrial Respiratory Protection (Pub. No. 87-116).

A confined space entry program should include the following:

1. written confined space entry procedures
2. evaluation to determine whether entry is necessary
3. issuance of a confined space entry permit
4. evaluation of the confined space by a qualified person
5. testing and monitoring the air quality in the confined space to ensure:
    - oxygen level is at least 19.5%
    - flammable range is less than 10% of the LFL (lower flammable limit)
    - absence of toxic air contaminants
6. training of workers and supervisors in the selection and use of:
    - safe entry procedures
    - respiratory protection
    - lifelines and retrieval systems
    - protective clothing
7. training of employees in safe work procedures in and around confined spaces
8. training of employees in confined space rescue procedures
9. conducting safety meetings to discuss confined space safety
10. availability and use of proper ventilation equipment
11. monitoring the air quality while workers are in the confined space.

Recommendation #2: Volunteer fire departments should identify the types of confined spaces within their jurisdiction and develop and implement confined space entry and rescue programs.

Discussion: Volunteer firefighters may be required to enter confined spaces to perform either non-emergency tasks or emergency rescue. Therefore, volunteer fire departments should identify the types of confined spaces within their jurisdiction and develop and implement confined space entry and rescue programs that include written emergency rescue guidelines and procedures for entering confined spaces. A confined space program, as outlined in NIOSH Publications 80-106 and 87-113, should be implemented. At a minimum, the following should be addressed:

1. Is entry necessary? Can the task be accomplished from the outside? For example, many fire departments use an under- water search and rescue device which consists of several sections of metal tubing connected together with a hook or retrieval device on the end. Such a device can be used to retrieve 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 that 15 feet. This type of pump can be lowered into a well to pump out the water without the need for anyone to enter the well. Measures that eliminate the need for firefighters 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. 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 flammable limit
   - absence of toxic air contaminants?

3. Is ventilation equipment available and/or used?

4. Is appropriate rescue equipment available?

5. Are firefighters and firefighter 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
   - ventilation systems

6. Are firefighters being properly trained in confined space entry procedures?

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

8. Are firefighters trained in confined space rescue procedures?

9. 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 gasoline engine powered equipment in or around the confined space."

Recommendation #3: Volunteer fire departments should develop and implement a respiratory protection program to protect firefighters from respiratory hazards.

Discussion: The 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 protection equipment according to NIOSH Guide to Industrial Respiratory Protection (Publication No. 87-116).

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

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." As part of a safety program, fire departments should carefully evaluate each task to identify all potential hazards, (e.g., falls, electrocutions, burns, unsafe atmospheres, etc.) and implement appropriate control measures.