Atmospheric Hazards

Oxygen Deficient Air

FACE 86-37: Workers Die in Underground Valve Pit in Oklahoma

INTRODUCTION

On July 10, 1986, a three-man crew was attempting to shut down a 24-inch water main when the accident occurred. One worker entered the 10-foot-deep valve pit through the 22-inch manhole opening via a built-in steel ladder (steel rungs secured into the concrete wall) and a few minutes later called for help. One of the workers on top went in to assist and was overcome. The third worker started in and realized he would soon be in trouble. He immediately exited and called for help. Both workers died at a local hospital.

BACKGROUND/OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The employer in this incident is a midwest city. The victims worked in the water distribution division of the water and sewer department. The water and sewer department has a total of 736 employees in 9 divisions. Other divisions include: waste water collection, waste treatment, raw water supply, engineering, utilities service, pre-treatment, and sludge removal. The water distribution division has 140 employees that are responsible for maintaining water service for the city (i.e., conduct inspections and make necessary repairs to water lines, add new service, etc.). The water distribution division has a supervisor, crew leaders, and crew workers.

New employees are given a half day orientation which consists of a discussion of benefits and operating policy of the city. When they report to their respective department for work (e.g., the water and sewer department), each new employee is given a small 66-page safety indoctrination. 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, city policy requires that each confined space be tested prior to entry. The supervisors have necessary testing equipment available to test a confined space atmosphere for oxygen (O_2), hydrogen sulfide (H_2S), and methane (CH_4).

SYNOPSIS OF EVENTS

On July 10, 1986, a work crew for the water distribution division of the water and sewer department was running a water service from one side of the street to the opposite side. The men were boring under the street with an air ram when they hit a 24-inch water line and water started gushing from the bore hole, flooding the street. The crew leader notified the supervisor (by two-way radio in the truck) of the line rupture and the crew was instructed to close valves at three different locations to shut off the water supply to the 24-inch line.

The three men proceeded to the first valve pit (approximately 200 yards away) and closed the gate valve. The men then proceeded to the second valve pit (approximately 2 miles away). A crew worker entered the chamber (6 feet by 8 feet by 10 feet) and after 2 or 3 minutes called for help. The crew leader on the outside went in to assist the downed worker and was overcome. The third worker started in and realized he was in trouble and exited immediately to call for help.

The fire department and rescue squad arrived on the scene within a few minutes and started rescue procedures. Two firemen donned full turnout gear with self-contained breathing apparatus (SCBA) and entered the valve pit to remove the workmen. The firemen had four 30-minute, 2215 PSI, 45 cubic feet cylinders lowered into the pit and discharged them in an attempt to improve the air quality. Both workmen were removed and transported to a local hospital by the EMS where they died a short time later.

After the men were removed from the valve pit, the fire department tested the atmosphere and found:

O_2	17% and 18%
H_2S	Negative
CH_4	Negative
CO	Negative

CAUSE OF DEATH

Asphyxia due to oxygen deficiency.

NOTE: While doing the evaluation of this incident, the safety manager and the NIOSH research industrial hygienist tested two manholes for O_2, H_2S, and CH_4. A manhole approximately 1 mile upstream of the accident site had an O_2 level of 20.0 percent, H_2S and CH_4 were negative. The second manhole tested was approximately 2 miles downstream of the accident site and the O_2 level was 3.0 percent, H_2S and CH_4 were negative. Any workman entering a confined space with a 3% O_2 atmosphere is entering a death chamber. Also, both valve pits checked had stagnant water in the bottom (2 or 3 inches) and the steel valves were rusting.

The valve pit where the accident occurred was at a busy intersection so it was not opened and tested. It should also be noted that this valve pit had not been open in 3 years.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Employers should be certain employees are aware of hazards associated with the tasks they are performing.

Discussion: The victims were aware of the requirements for having the valve pits tested before entry. However, during an emergency situation (shutting down a water main because of a break), the valve pit was not tested for oxygen and safe work practices were not followed. The only consideration was to shut off the water.

Recommendation #2: Employers should provide specific information in their employee safety manuals, especially when tasks to be performed are life threatening.

Discussion: The employees safety manual devotes two pages to confined spaces and includes general recommendations. The safety manual states entry should not be "considered safe until it has been determined to be free of harmful gases and to contain sufficient oxygen to sustain life." Ambiguous phrases such as "determined to be free" and "sufficient oxygen to sustain" should be clarified. Also, who is responsible for testing the atmosphere and making recommendations regarding safe work practices in confined spaces can be found in the NIOSH Publication No. 80-106, "Working In Confined Spaces." A safe oxygen level is stated (19.5%) and flammability limits (not to exceed 10 percent of the lower flammability limit), and toxic air contaminants (not to exceed the limits referenced in 29 CFR Part 1910, Sub Part Z) are specified. Testing shall be done by a qualified person prior to entry. This publication also defines and provides recommendations on hot work, isolation, purging, ventilating, entry and rescue, training, posting, safety equipment, clothing, etc.

FACE 86-48: 28 Year-Old Dies in Rescue Attempt in Drainage Pit in Illinois

INTRODUCTION

On August 17, 1986, the owner of a sewer service company and three workmen were in the process of cleaning out a 12-foot deep drainage pit when the accident occurred. The owner entered the pit and experienced euphoria within a few minutes and became incoherent. Two of the workers attempted rescue and were unsuccessful. One of the rescuers died.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The employer is a one-man sewer cleaning operation with absolutely no safety program. The owner has a pickup truck that he uses to transport a portable electrically powered routing machine that is used to clean out sewer lines. The owner of the company generally works alone; however, when the job requires more than one person, he will pick up temporary, unskilled workers from off the street. The victim had worked on a few small jobs for the employer before this job. No employee training or personal protective equipment was provided or "needed," according to the employer.

SYNOPSIS OF EVENTS

A sewer service company had been contracted to clean out a water run-off drainage pit (12 feet deep and 24 inches in diameter) and to unclog and clean out a drain line to the street. The drainage pit is located outside the delivery door of a metal window framing operation. The operation is basically a dry process; therefore, any drainage to the pit would consist of rain water, leaves, and debris from the roof and parking lot. A drain line from the drainage pit to the street was blocked shut by this debris and resulted in run-off water filling the 12-foot deep pit until it overflowed. The owner of the sewer service had worked on and off for two weeks in an attempt to drain the pit and unclog the drain line. Work was done in the evening or on weekends so that access to the delivery door could be maintained so that the business was not interrupted. On Saturday, August 17, 1986 (the day of the accident), the owner and three workers arrived at the site at approximately 10:30 a.m. This was the first day on this job for the victim and a 22-year-old worker. A fourth worker had worked on several different occasions for the owner. Upon arrival at the site, the owner opened the manhole cover to the drainage pit and went in, shimmying down the concrete block walls. No ladder was provided for entry or exit. A rope tied to a bucket was used to remove liquid and sludge from the pit. The owner in the pit would fill the bucket and one of the workmen would pull it out, dump it, and return the bucket to the pit.

After filling and emptying the bucket approximately 20 times, the owner requested a beer and his cigarettes. He was handed a beer and his cigarettes and work proceeded. Within a few minutes, the owner, still in the pit, became euphoric — singing, praying, and stating, "this stuff is really bad." The 22-year-old noticed the owner was in trouble and decided to enter the drainage pit in a rescue attempt. An electric extension cord was tied around the chest of the 22-year-old worker and he was lowered into the pit. When he reached the bottom he tried to untie the cord but was unable to because he stated his fingers were numb. The victim pulled the 22-year-old out of the drainage pit and went in to assist the downed owner. The victim tried to lift the semi-conscious owner up the shaft, but was overcome and fell down with the owner now on top of him. The fire department was summoned and arrived within 10 minutes. Both workers were removed from the drainage pit. Both men were transported to a local hospital where the rescuer was pronounced dead. The owner was treated and released. The blood alcohol level for the rescuer (victim) was negative; however, the owner (survivor) had levels significantly above the state's legal limit for intoxication.

CAUSE OF DEATH

Asphyxia due to oxygen deficiency.

Investigation Notes:

- Atmospheric tests done by the fire department revealed the O_2 level to be less than 5 percent at the bottom of the pit on the day of the accident.

- During the site visit field evaluators observed that the manhole cover was off the drainage pit and that the 12-foot deep pit was half full of water. Also, an extension cord had been run under the metal delivery door into the pit to supply electricity to a pump. The extension cord was below the water level. FACE field evaluators removed the extension cord from the pit to prevent a possible electrocution. No work was being done on the day of the site visit.

RECOMMENDATIONS/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.

5. Emergency rescue procedures.

Air quality (O_2 level and CO_2 level) was not tested prior to entry. O_2 and CO_2 testing devices should be ordered and used for testing the atmosphere. 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.

Recommendation #2: 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. For confined space entry, the recommendations in NIOSH Publication No. 80-106, "Working in Confined Spaces" should be used.

FACE 86-54: Insufficient Oxygen Level in Sewer Claims the Life of Plumbing Contractor in Georgia

INTRODUCTION

On September 15, 1986, a plumbing contractor and two co-workers were in the process of laying out a new sewer line for an industrial building under construction when the fatal accident occurred. The owner of the plumbing company entered the manhole opening and descended into a 15-foot deep sewer to measure a stub out location for the new sewer line. Co-workers were unsuccessful at rescue attempts. The owner was removed by the fire rescue squad and pronounced dead on arrival at a local hospital. Atmospheric tests revealed oxygen level at the bottom of the sewer to be 6 percent.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The victim operated a small plumbing contracting company and employed two other workers. The company did not have a written safety program or confined space entry procedures. At the time of the accident this company was under a subcontract agreement with a larger plumbing and heating contractor (employing 10). This larger contractor did not have confined space entry procedures either.

SYNOPSIS OF EVENTS

On September 15, 1986, the victim and two other workers were planning to install a sewer line from a building to the main sewer line in the street at a construction site. The sewer vault was entered through a manhole in the middle of the street. The manhole was 2 feet in diameter and 15 feet deep. In an effort to measure the length of the sewer line snub, the victim entered the manhole and descended a fixed ladder to the bottom. The sewer line snub extended from the vault, 15 feet towards the construction site. Upon reaching the bottom of the sewer he complained of a strong odor and then passed out. The other two workers that remained outside entered the manhole in an attempt to rescue the victim. However, before they could reach the victim, they both became dizzy and exited the manhole. Several unsuccessful rescue attempts delayed notification of the fire department rescue squad for approximately 20 minutes.

The rescue squad arrived in 5 minutes. Rescue squad personnel entered the sewer using self-contained breathing apparatus, life lines, and other personal protective equipment. The victim was removed approximately 8 minutes after the arrival of the rescue squad. Attempts to resuscitate the victim were unsuccessful. The victim was then transported to the local hospital where he was pronounced dead.

Prior to entry the employer did not test the atmosphere or ventilate the sewer vault. The victim and the workers were not aware that entering the manhole might be hazardous. Prior to entering the manhole, the workers argued over who would go into the manhole. Their concern at that time was the depth of the hole. Additionally, the water company had informed the contractor of the location of the snub line, but the victim wanted to double check the distance. No confined space entry procedures were used by the workers. The atmosphere was tested after the victim was removed and was found to contain 20 percent methane, 6 percent oxygen, and was negative for hydrogen sulfide and carbon dioxide.

CAUSE OF DEATH

Asphyxia due to oxygen deficiency.

RECOMMENDATION/DISCUSSION

Recommendation #1: Employers should be certain employees are aware of the hazards associated with the tasks they are performing. Additionally, employees should be aware of all safety procedures to be followed and the reasons for these procedures.

Discussion: Both the plumbing company and the larger contractor were not aware that a manhole was a confined space and as such was a hazardous place to enter. Neither company had any confined space procedures to follow when entering a manhole.

Recommendation #2: Employers 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. The procedures should minimally include the following:

1. Air quality testing to assure adequate oxygen supply, adequate ventilation, and the absence of all toxic air contaminants;

2. Monitoring of the space to determine a safe oxygen level is maintained;

3. Employee and supervisory training in confined space entry;

4. Employee and supervisory training in the selection and usage of respiratory protection;

5. Emergency rescue procedures;

6. Availability, storage, and maintenance of emergency rescue equipment.

The air quality was not determined before the worker entered the manhole and no ventilation was maintained. The air quality was not monitored for toxic air contaminants and oxygen level. Respirator training and proper maintenance procedures should be required of all employees

FACE 87-06: Two Dead, Five Injured in Confined Space Incident in Oregon

INTRODUCTION

On October 10, 1986, a self-employed contractor (specializing in backflow devices) was in the process of inspecting the backflow valve on the city water line at a sawmill when the accident occurred. The contractor descended into the underground vault which housed the water line and backflow device and collapsed. The shipping supervisor of the sawmill attempted to rescue the contractor and collapsed.

BACKGROUND/OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The self-employed contractor was a one-man operation that according to the state investigators had no safety program or confined space entry procedures. The contractor was licensed and certified by the state to inspect and approve/certify backflow prevention devices.

The sawmill where the accident occurred cuts large timber into marketable sizes that are shipped around the world. The sawmill cuts approximately 7 million board feet of lumber a month and has 110 employees. The sawmill has a written safety policy and holds monthly meetings to discuss safety issues with the workers and management. A collateral duty safety officer conducts walk-through safety inspections and reports safety problems to the management. The sawmill does not have confined space entry procedures. However, the management stated the manhole where the men died is not entered by mill employees.

SYNOPSIS OF EVENTS

The sawmill where the accident occurred has a city water line running underground (through a vault) along the front of their property. The below ground vault which measures 12 feet long, 6 feet wide, and 8 feet deep with a 30-inch manhole at the ground level was installed in 1978 to house a backflow device on the city water supply from possible contamination in the event of a negative pressure on the water line. The sawmill's fire protection system is connected to this water supply; therefore, a backflow device is required. The city requires the annual inspection of backflow devices by a person trained and certified in cross connection control.

The independent contractor (the victim) called the superintendent of maintenance on October 6, 1986, to set up a date and time to inspect the backflow device on the water line. The date and time mutually agreed upon was October 10 at 3:30 p.m. The contractor arrived at the sawmill at 3:30 p.m. on October 10 and proceeded with the inspection, which he had completed annually for the past 3 years. The steel cover was removed by the contractor and a ladder was lowered into the 8-foot deep vault. There were 14 inches of water in the bottom of the vault.

At 4:00 p.m. a truck driver stopped at the sawmill office to inquire about a load of lumber he was to pick up. When he walked out of the office he noticed the victim's truck and an open manhole close to where he would have to drive through. He walked over to the open manhole and saw a body in the water at the bottom of the vault. The driver went back to the office and reported a man was down in the vault. The emergency squad was called by the secretary. After calling the emergency squad, the secretary and truck driver went outside to the manhole. The secretary called for help and the first to arrive at the scene was the shipping supervisor, who entered the vault in a rescue attempt. A few seconds later, one of the maintenance men arrived on the scene and descended into the vault to assist in the rescue. Neither man was wearing respiratory protection and within 2 or 3 minutes both men had passed out.

Two policemen arrived at the scene, entered the vault (without respiratory protection), and had to be helped out. The paramedics arrived and attempted rescue (without respiratory protection) and also had to be helped out. The firemen arrived on the scene, donned their breathing apparatus, and went in to remove the three men at the bottom. Two were face down in the water (the contractor and the shipping supervisor) and the third man (the maintenance man) was in a sitting position against the wall, his head was not in the water.

The three men removed from the hole (the contractor, the shipping supervisor, and the maintenance man), the two policemen, and the two paramedics were transported to a local hospital. The contractor and shipping supervisor were pronounced dead on arrival by the attending physician. The maintenance man was hospitalized in serious condition. The two policemen and two paramedics were treated and released.

Test of the atmosphere in the vault by the state investigators revealed the following:

O_2	7%
CO_2	>3%
% LEL	Negative
H_2S	Negative

NOTE: The state investigator surmised that the algae bloom and bacterial action in the water resulted in 0 percent free O_2 in the water. CO_2 (waste product from bacterial action and algae growth) was liberated, displacing O_2 level in the vault.

CAUSE OF DEATH

Asphyxiation due to drowning.

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: Companies contracting out work to be performed on their property should require as part of the contract that the contractor adhere to all safety rules. Particularly 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: If the employer has any confined spaces, comprehensive policies and procedures should be developed 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 task be completed 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?

Recommendation #3: Public service employees (i.e. police officers, emergency rescue workers, and firemen) that respond to emergency situations involving confined spaces should be trained in confined space hazards and rescue procedures.

Discussion: Public service employees are required to respond to a wide variety of emergency situations. These personnel must be trained in and be aware of the following in order to be properly prepared for emergencies involving confined spaces:

1. Recognition of Confined Spaces

2. Hazardous Atmospheres

   - Oxygen deficient or enriched
   - Flammable
   - Toxic
   - Irritant or Corrosive

3. General Safety Hazards

   - Mechanical/Electrical
   - Communicative
   - Thermal
   - Noise
   - Structural barriers
   - Limited space
   - Size of opening(s)

4. Rescue Procedures

   - Respiratory protection
   - Protective clothing
   - Harness
   - Life lines
   - Standby person

Recommendation #4: Employees, self-employed contractors, and others that are required to work in confined spaces should be trained in confined space entry as part of the certification process.

Discussion: All employees who are required to enter or work in confined spaces should be given adequate training in confined space hazards and safe work practices. For confined space entry, the recommendations in NIOSH Publication 80-106, "Working in Confined Spaces" should be used. The certification process for the state should include training that addresses confined spaces that may be encountered while performing the duties for which the contractor was certified.

FACE 87-23: General Maintenance Person Asphyxiated Attempting to Repair Water Leak

INTRODUCTION

On October 21, 1986, a general maintenance person was asphyxiated when he became lodged in a water meter pit.

BACKGROUND/OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The victim worked as a general maintenance person for a construction company which employed 13 persons. The construction company provides construction-related maintenance for a local chain of restaurants. The safety functions at the construction company are managed by the Director of Operations. A written safety policy and a comprehensive safety program exist. Management personnel also conduct weekly staff meetings including discussions of safety-related matters.

SYNOPSIS OF EVENTS

On the morning of October 21, 1986, a supervisor for the construction company instructed a maintenance person (the victim) to inspect and repair a leaking water valve. The water valve (a screw handle type) controlled the flow of water from the municipal water system to a local restaurant. After the supervisor instructed the victim, he then left the site of the restaurant to check on another job.

As there were no eye witnesses to the accident, the following scenario is based on inspection of the accident site and from interviews conducted with supervisors from the construction company and the state OSHA compliance officer.

Apparently, the victim proceeded to the fiberglass water meter pit (14" diameter x 4' deep) approximately 25 feet from the side of the restaurant where the water valve was located. The water meter pit was buried in the ground and the top of the pit was at ground level. A metal cap was attached to the rim of the water meter pit and a water meter with an in-line shut off valve, a screw handle water valve, and the municipal water line were located in the pit. The valves were approximately 36 inches below the top of the pit (or ground level). The victim removed the metal cap covering the pit and placed the cap on the ground next to the pit opening. He then knelt beside the opening on both knees and reached into the pit until his head, both arms, and part of his shoulders were inside the water meter pit. Apparently, the victim became stuck upside down in the opening and could not free himself, causing asphyxiation due to positional deprivation of air.

NOTE: The victim was observed drinking alcoholic beverages before starting work on the morning of the accident. A blood alcohol analysis of postmortem blood found a concentration of ethanol of 188 mg/dl (0.18%). The legal intoxication level for Indiana is 0.10%. Of the 129 occupational electrical-related or confined space-related fatalities evaluated by NIOSH, as part of the FACE program, this is the second incident where the use of drugs or alcohol have been identified as contributory factors.

CAUSE OF DEATH

The coroner's report listed the cause of death as positional asphyxia.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Supervisory personnel should routinely monitor employee performance to determine if employees have impaired physical and mental capabilities which may be related to the use of alcohol, illegal or over-the-counter drugs, or prescription medications.

Discussion: This fatality occurred because the victim's physical and mental capabilities were impaired by the ingestion of alcohol. Supervisory personnel should be trained to recognize changes in job performance as they may relate to alcohol or drug use and in accepted and proven methods of dealing

with these problems. Employees should not be assigned tasks when impaired physical and mental capabilities are observed, but should be taken to medical personnel who are trained to deal with these problems.

Recommendation #2: Supervisory personnel should identify, evaluate, and address all possible hazards associated with the job site.

Discussion: When employees are expected to work alone at job sites, the area should first be evaluated and all possible hazards identified and addressed by supervisory personnel. The location of the water valve inside the water meter pit required the use of extension tools, thereby eliminating the need to enter the water meter pit (even partially).

FACE 87-39: Farm Worker Asphyxiated in Grain Silo in Indiana

INTRODUCTION

On November 1, 1986, a 51-year-old farm worker (for unknown reasons) entered an oxygen limiting silo through the top opening and was asphyxiated.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The employer is a privately owned farm which has one full-time worker and one part-time worker. The farm has no written safety program. Safety is left up to the individual worker. However, the owner has standing orders that no one is to enter any of the silos.

SYNOPSIS OF EVENTS

On November 1, 1986, the owner of the farm and his full-time employee (the victim) were filling an 80-foot-high silo with alfalfa silage at the farm's feed lot. The feed lot has four 80-foot-high oxygen limiting silos. On the day before this incident one of the other silos had been filled with alfalfa silage to within 5 feet of the top and sealed.

Around 3 p.m. on the day of the incident, the farm owner told the victim he had to go into town. While the owner was gone, the victim was to clean up the spillage around the silo being filled and to put away the equipment. When the laborer had completed these tasks he could go home.

A part-time employee at the farm arrived at 4 p.m. Upon arrival, he noticed the tractor's engine was running; however, the victim could not be found. The part-time employee went home and brought his parents back to help look for the victim. The father noticed a 10-foot ladder was located under the ladder permanently attached to the silo filled previously. (The 10-foot ladder was needed to access the first rung of the ladder permanently attached to the silo.) The part-time employee proceeded up the ladder searching for the victim. When he reached the top of the silo, he observed that someone had opened the 17-inch diameter hatch, removed the breather bags, and tied them off on the top of the silo. The part-time employee looked into the silo and did not see anyone. The father then ascended the silo, looked inside, and saw the victim approximately 10 feet from the opening. The father yelled down to his wife to go for help. The father then entered the silo and crawled over to the victim. The victim was unresponsive. The father pulled the victim over to the opening where he was assisted by his son in removing the victim from the silo.

The emergency call was responded to by the county sheriff's office, the volunteer fire department, ambulance personnel, and the farm owner. Fire department personnel began CPR on top of the silo and CPR was continued during transport to a nearby hospital. The victim did not respond to resuscitative efforts and was pronounced dead in the emergency room.

CAUSE OF DEATH

The coroner's report stated "accidental suffocation as a result of aspiration of plant material." The coroner's verdict and the sheriff's report proposed similar scenarios; when the victim opened the door on top of the silo, he was overcome by fumes (nitrous oxide) and fell through the opening into the silo.

NOTE: Following interviews with the farm owner and his advisor, the manufacturer of the silo, and review of the sheriff's report and the coroner's verdict, these points of interest and unanswered questions were brought out.

- No one "except the owner" is to enter the silos, when silo entry is required.
- The silo entered was filled and the top hatch sealed the previous day. The farm owner and the victim were filling another silo on the day of the incident.

- The victim moved the ladder from the silo being filled to the silo previously filled, climbed to the top of the silo, opened the hatch, removed the breather bags, and tied the bags to the top of the silo. The coroner and police reports state that the victim fell through a 17-inch diameter opening and crawled or staggered approximately 10 feet from the opening to the side of the silo.

- The work procedure assigned (cleaning around the silo being filled) did not require ascending or entering the silo previously filled.

- A representative of the manufacturer of the silo stated the convection potential of the silo gases would be vented when the first cam (of four cam latches) was released on the hatch on top of the silo. After being closed for 24 hours the O_2 level inside the silo would be less than 10 percent and the CO_2 level would be in excess of 25 percent. Also, small quantities of nitrous gases (nitrous oxide and dioxide) could be present. Since CO_2 and NO_2 are heavier than air, they would not come out the top except through the convection current potential, which would be released immediately upon removal of the hatch. The heavier than air gases would settle along the top of the silage. The gases coming out of the top opening would have a pungent odor and cause some eye irritation; however, these gases would not be sufficient concentration to overcome the worker.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Personnel evaluating this accident and formulating conclusions should reevaluate these conclusions, as they do not coincide with the sequence of events.

Discussion: The coroner's verdict stated the victim was overcome by nitrous oxide, fell into the silo, and died of suffocation as a result of aspiration of plant material. As stated, the cause of death was apparent. However, the possibility that opening the hatch, pulling out the breather bags, tying these bags off at the top, and then passing out from the nitrous oxide, falling through a 17 inch diameter opening, and crawling away from that opening is extremely remote. The silo manufacturer's representative stated the gases would be vented when the fist cam on the hatch was opened. By the time all four cams were opened and the hatch removed, the interior of the silo should have reached equilibrium with the exterior. Residual gases heavier than air would remain inside the silo.

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

Discussion: All employees who are required to work in or around confined spaces should be aware of potential hazards, possible emergencies, and specific procedures that are to be followed. NIOSH Publication No. 80-106, "Working in Confined Spaces" was left with the employer as a reference for developing confined space entry procedures. 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
   - Gloves
   - 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 the ventilation system is operating?

FACE 87-57: Parks and Recreation Director Dies in Oxygen Deficient Atmosphere in West Virginia

INTRODUCTION

On July 15, 1987, the parks and recreation director of a small town in West Virginia died when he entered a manhole at the municipal swimming pool. The director had entered the 18-foot-deep manhole to instruct one of the life guards on how to switch from one sump pump to another.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The employer in this incident is a small municipality which has 75 employees in seven departments (public works, police, fire, sanitation, parks and recreation, finance and administration, and water). The victim was the director of the parks and recreation department. Each department director reports to the mayor. The municipality has no formalized written safety program. Each department has operating instructions, e.g., the wastewater treatment plant has written procedures provided by equipment manufacturers. The only safety training provided is on-the-job training and use of common sense.

SYNOPSIS OF EVENTS

On July 15, 1987, at approximately 1 p.m., the director of the parks and recreation department (victim) arrived at the newly constructed municipal swimming pool and was going to instruct one of the life guards on the procedure for switching sump pumps. The two sump pumps, which are used to pump subsurface drainage water from the pool area to a nearby creek, are located adjacent to the pool, at the bottom of a manhole (4 feet diameter by 18 feet deep with a 2-foot diameter manway). Metal rungs permanently fixed into concrete provide access to the equipment located in the manhole. The procedure for switching from one sump pump to another requires a person to enter the manhole, descend approximately 9 feet, reach across to the opposite side of the 4-foot wide space, unplug one twist lock receptacle (not moisture proof or designed for us in wet environments) from one sump pump, and plug in the other sump pump to the 208 volt, three phase receptacle.

The director and the life guard proceeded to the sump pump manhole, where the director removed the steel cover from the manway. The director then entered the manway and descended via the fixed rungs into the interior of the manhole, which had not been opened in 2 months. The water in the manhole was approximately 7 feet deep, since the circuit breaker feeding power to the sump pump motor had previously tripped. However, pump control power was still available in the manhole. When the director had descended approximately 11 feet into the manhole, he started shaking as if he were convulsing, let go of the rung he was holding on to, and fell backwards into the water. This was witnessed by the life guard who had remained on the outside of the manhole to observe the procedure for switching the pumps. The director had not touched electrical lines to the sump pumps before this occurred. His feet and lower legs were in the water.

The life guard did not enter the manhole to attempt rescue because he was concerned about electrical/electrocution hazards. The life guard ran to the maintenance/pump room area (approximately 100 yards) and reported to one of the maintenance men that the director was in trouble in the sump pump manhole. The circuit breakers were switched off, the fire department/emergency rescue was called, and a maintenance man observed the director under the water and stated that the victim was unresponsive. The maintenance man entered the manhole (without respiratory protection) and at that time experienced difficulty breathing when he reached the water level (7 feet from the bottom). Because he was concerned about the electrical connections in the manhole, he exited the manhole and called to a co-worker to shut off the main breaker for the entire area. The main breaker was shut off (which removed the control power) and he re-entered the manhole (without respiratory protection); however, he was unable to reach the victim (not sure of the depth) so he exited again. The fire rescue squad arrived about the same time the maintenance man had exited the manhole for the second time. Two firemen entered the manhole (without respiratory protection) after being informed the power was off and removed the victim. The victim was

unresponsive when removed and cardiopulmonary resuscitation was started immediately. The victim was transported to a local hospital where unsuccessful life saving efforts were continued for 30 minutes.

CAUSE OF DEATH

After completing an autopsy, the medical examiner determined that death was due to drowning in water. This occurred when the victim, who had arteriosclerotic coronary artery heart disease, collapsed after entering an oxygen deficient environment.

INVESTIGATIVE NOTATIONS

- First report of fatality was listed as an electrocution. Upon investigating the incident, this was truly possible. This manhole was installed as part of the new pool construction in November 1986. The contractor installed two sump pumps, two float switches (one for each sump pump), and twist-lock cord and plug connectors at the 9-foot level for pump motor and pump control power. Neither the receptacles nor the plugs were approved for wet environments. The receptacles were taken apart by the electrical consultant hired by the city, and both had damage to the wiring connections and were heavily rusted. This deterioration is apparently what led to tripping the circuit breaker which fed to the pump motor and the subsequent rise of water in the manhole.

- *The engineering consultant hired by the city conducted a voltage test (power restored) to measure the potential between the water in the manhole and the stainless steel pool. A copper wire was lowered into the water and the reading was less than .05 of a volt.*

- *After the voltage test was completed, the sump pump was turned on and the water was pumped down to the 1-foot level. When the water level exceeds 1 foot, the pump turns on automatically.*

- *The atmosphere in the manhole was tested on July 17, 1987, for O_2, CH_4, and H_2S. The results of those tests were:*

  O_2 - 14%
  CH_4 - Negative
  H_2S - Negative

- *The manhole was closed on July 17, 1987, and reopened on July 20, 1987, and tested again. The results of those tests were:*

10:00 a.m.	*O_2*	*14%*	*10:10 a.m.*	*O_2*	*17%*
	CH_4	*Negative*		*CH_4*	*Negative*
	H_2S	*Negative*		*H_2S*	*Negative*

  Because the manhole has a lateral branch to an adjacent manhole, which opens to a creek, a static air condition will change rapidly to a dynamic condition when the top is opened.

- *On the day of the accident, the manhole had not been opened for 2 months and contained 7 feet of water. From the atmosphere test readings on July 17, 1987, and July 20, 1987, it is likely that the O_2 level was less than 10 percent when the victim entered.*

RECOMMENDATIONS/DISCUSSION

Recommendation #1: The employer should take corrective action to remove the electrical hazard(s) from the sump pump manhole and bring the electrical system into compliance with the latest edition of the National Electrical Code (NEC).

Discussion: The electrical connections in the manhole are not approved or designed for use in wet environments. The connection box at the top of the manhole is not moisture proof. The twist lock

receptacles (at the 9-foot level) have been under water. The silt, corrosion, and electrolysis evident in these receptacles (less than 9 months) are classic examples of what can occur when the wrong type of receptacles are used in an environment subject to moisture and/or flooding. The switching changeover operations from one pump to the other could be done by means of switches located in a covered protected area above the ground (not in the manhole) and need not be at the manhole site in the public access area of the pool. Also, ground fault circuit interrupters should be installed.

Recommendation #2: The employer 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 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. 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?

Recommendation #3: Public service employees (i.e. police officers, emergency rescue workers, and firemen) who respond to emergency situations involving confined spaces should be trained in confined space hazards and rescue procedures.

Discussion: Public service employees are required to respond to a wide variety of emergency situations. These personnel must be trained in and be aware of the following in order to be properly prepared for emergencies involving confined spaces:

1. Recognition of Confined Spaces

2. Hazardous Atmospheres

   - Oxygen deficient or enriched
   - Flammable
   - Toxic
   - Irritant or Corrosive

3. General Safety Hazards

   - Mechanical/Electrical
   - Communicative
   - Thermal
   - Noise
   - Structural barriers
   - Limited space
   - Size of opening(s)

4. Rescue Procedures

   - Respiratory protection
   - Protective clothing
   - Harness
   - Life lines
   - Standby person

FACE 87-59: 73-Year-Old Self-Employed Pump Service Contractor Dies in Well in Maryland

INTRODUCTION

On June 27, 1987, a self-employed water pump service contractor died after falling to the bottom of a 50-foot-deep water well at a private residence.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The employer was a privately owned well service company and the owner (victim) was the only employee. There was no written safety program on confined space entry procedures.

SYNOPSIS OF EVENTS

On June 27, 1987, a self-employed water pump service contractor (victim) was responding to a call from a private residence when the accident occurred. The owner of the private residence called the victim the previous day and stated something was wrong with his water system because, "they had no water in the house." The victim responded to the call on the morning of June 27 (Saturday) and proceeded to check out the water system. No problems were found in the house so the victim decided to check out the well, which was located adjacent to the house. The well was approximately 50 feet deep, 2 feet in diameter, and cased with concrete rings to the bottom. The victim opened the cover to the well and hung a chain type ladder (approximately 10 feet down) into the well. The victim was going in to check the piping leading from the well to the house. As he descended the chain ladder into the well, he either slipped or was overcome by an oxygen deficient atmosphere and fell down the shaft of the well. The owner, who witnessed the fall, called the fire/rescue squad immediately.

The fire/rescue squad arrived within a few minutes and decided to send in a fireman to rescue the victim. The fireman called down into the well and there was no response from the victim. A fireman with no type of respiratory protection was lowered via a rope attached to a harness into the well. Approximately 10 feet down, the rescuing fireman became incoherent and had to be removed and transported to a local hospital. A second fireman, wearing a self-contained breathing apparatus, was lowered into the well to the level of the victim. The fireman could not find a pulse or get any response from the victim, so he was pulled out of the well. Removal of the victim from the well took over 4 hours and required a retrieval hook manufactured locally. The victim was pronounced dead at the scene.

CAUSE OF DEATH

Not known at this time.

[NOTE: No atmospheric tests were performed during the site visit because the well had been filled with dirt.]

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: 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
   - Gloves
   - 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?

FACE 87-64: Mechanic Asphyxiated Within Steam Service Passageway

INTRODUCTION

On July 25, 1987, while a 35-year-old male mechanic was working (in a concrete vault) in an attempt to regulate the pressure in an 8-inch steam line, a strainer on the steam line ruptured. The victim was trapped in a blocked passageway by the escaping hot steam and died as a result of asphyxiation.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The company which employed the victim manages a small utility operation which generates and distributes steam. The company, which employs 61 full-time and 5 part-time workers, does not have a formal written safety program nor written confined space entry procedures. Training is provided on-the-job and employees are told to "work safely."

SYNOPSIS OF EVENTS

There were no eye witnesses to this incident. The following scenario was developed from an evaluation of the incident site, and from discussions with the vice-president and other management personnel of the company, co-workers, and the state of OSHA compliance officer assigned to the case.

On July 25, 1987, a mechanic (the victim) in the company's customer service department was dispatched to complete a service call. The victim was to reduce the pressure in an 8-inch steam line from approximately 150 pounds per square inch (psi) to 30 psi (the customer's specifications). The steam line is located in a concrete vault measuring 10 feet deep by 9 feet wide by 15 feet long. The top of the vault is covered with removable sections of steel grating. At one end of the vault, a 200-foot passageway leads to the basement of the customer's establishment. A louvered door used for ventilation is located approximately 75 feet into this passageway. Part of the doorway can be opened from the customer's side.

The victim arrived at the site and removed several sections of grating from the top of the vault. A ladder was lowered into the vault for entry. Once inside the vault the victim apparently opened a hand-operated valve on the 8-inch steam line. As the steam (366 degrees F) started surging through the line, the 4-inch strainer, located approximately 1 foot downstream of the 8-inch valve, ruptured.

When the strainer ruptured, hot steam escaped and filled the vault area. In an attempt to escape the steam, the victim proceeded down the passageway until he encountered the louvered door. Unfortunately, the door could only be opened from the customer's side. The victim apparently tried to break through the door, but died as a result of asphyxiation.

Employer, fire department, police department, and rescue squad personnel responded. The steam line was deactivated and the fire department used two fans to vent the passageway. The victim was located approximately 30 minutes after the fans had been started. Fire fighters carried the victim to the customer's basement area where he was pronounced dead. A subsequent investigation disclosed that faulty engineering design, due to erroneous expansion and flexibility calculations, was a contributing factor in the rupture of the strainer.

CAUSE OF DEATH

The medical examiner reported the cause of death as asphyxiation.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Employers should develop and implement comprehensive safety programs. As part of this written safety program, the employer should develop procedures for entry and work in or around confined spaces.

Discussion: Since the employer does not have a written comprehensive safety program, rules and procedures addressing the hazards associated in work of this nature should be developed, implemented, and enforced. Procedures for entry and work in confined spaces should also be developed, implemented, and enforced. One procedure which may have prevented this death is having a designated standby person. This person could have alerted others to open the louvered door to allow the victim to escape. Another relevant procedure is having rescue and emergency procedures established if a worker is in immediate danger of injury or death while in the confined space. The worker should have been provided a self-contained breathing apparatus prior to his entry into the confined space. Use of an alternate air source would probably have prevented this death.

To aid in the development of confined space entry procedures, the vice-president of the company was provided the following:

- A Guide to Safety in Confined Spaces. DHHS (NIOSH) Publication No . 87-113.
- A NIOSH Alert on Confined Spaces. "Request for Assistance in Preventing Occupational Fatalities in Confined Space." DHHS Publication No. 86-110.
- Braddee, R.W., Pettit, T.A. "Warning-Posting of Confined Spaces." Professional Safety, February 1987.

Recommendation #2: Employers should maintain equipment in proper operating condition.

Discussion: Steam traps are designed to remove excessive water condensate from piped steam. A steam trap located upstream from the strainer which ruptured was found to be partially plugged. A poorly operating steam trap might have contributed to the generation of pressure due to water condensate buildup. The employer should institute a preventive maintenance program based on periodic inspection to ensure that all equipment is fully functional.