Atmospheric Hazards

Inert Gases and Simple Asphyxiants

FACE 85-02: Two Rescuers Die in Fracturing Tank in West Virginia Gas Field

INTRODUCTION

On October 4, 1984, two workers died while attempting to rescue a third worker who had entered a fracturing tank at a natural gas well. A total of four men entered the tank and were overcome by natural gas. The two workers who died drowned in 30 inches of liquid (water, gas, acid, and possibly oil) which had been released into the tank during "blow down" procedures. The other two workers, both rig hands, required medical treatment at local hospitals.

SYNOPSIS OF EVENTS

On the day of the accident, at approximately 7:30 a.m., a five-man crew assembled in the office of the field supervisor to receive their instructions for the day. The crew consisted of two service rig hands (hereafter designated "rig hands") and their supervisor, the service rig operator (hereafter designated "operator"). In addition, the rig supervisor (hereafter designated "supervisor") and the service rig tool pusher (hereafter designated "tool pusher") were assigned to the crew so that the supervisor could instruct the tool pusher in the assembly job. The crew was informed that they were to "blow the well down" (relieve the internal pressure). If they could get the pressure down to acceptable levels, they were to start putting the tubing down. All members of the crew were familiar with the procedures necessary to blow down the well and insert the tubing. The crew began to work by about 8:30 a.m.

When the well is "blown down," gas, water, acid, and occasionally oil are released. These substances are directed into the fracturing tanks through two-inch steel "flow back" lines. Because of the pressure exerted on these lines, they are secured to the tanks with safety chains. When sufficient steel lines are not available to plumb in all of the tanks, a high-pressure, double-walled, two-inch rubber hose, called a Kelly hose, is used as a flow back line. When the Kelly hose is used, it must be tied down, both to the inside and outside of the tank, to prevent it from whipping around when the well is flowing during blow down.

By approximately 9:30 a.m., the well had blown down sufficiently to begin inserting the tubing, so the operator and one of the rig hands began to disconnect the well from the fracturing tanks. The remaining members of the crew (the supervisor, tool pusher, and one rig hand) were near the service rig, assembling the down hole equipment when they heard the operator yell that the rig hand was in the tank. The operator then entered the tank himself. Despite the warnings by the rig supervisor to stay out of the tank, the other rig hand entered the tank, followed by the tool pusher. When the supervisor got to the top of the tank and looked in, he could see two of the men and they were unresponsive and "dazed looking." He immediately got off the tank and opened the valves to release the water in the tank. He then called for help on the truck radio.

When the call was received at the office, the rescue squad was notified, and arrangements were made to have the supervisor of a second crew meet the ambulance and give them directions. In the meantime, the rig hands from the second crew proceeded to the site to provide additional assistance, and other supervisors and employees proceeded to the site as well.

When the two rig hands from the second crew arrived, they helped the supervisor remove two clean-out panels at the bottom of the tank. By this time, most of the liquids had been drained from the bottom of the tank. When the panels were removed, the bodies of the operator and tool pusher were found lying on the bottom of the tank. One of the rig hands was found standing in the tank, but was unresponsive; the other rig hand, also unresponsive, was found attempting to climb up the internal support bars of the tank, but appeared ready to fall. The two rig hands who had entered the tank and survived the incident reported that within 10 to 15 seconds of entering, they were overcome by the gas. They could not remember anything past that point.

The autopsy reports indicated that the rig operator and the tool pusher died by drowning due to asphyxiation.

CONCLUSIONS/RECOMMENDATIONS

The following factors contributed to this fatal accident:

1. "Blowing the well" releases water, acid, oil, and natural gas into the fracturing tanks. In this area of the country, the primary component of natural gas is methane (75 to 85 percent). Although methane is not considered a toxic gas, it is a simple asphyxiant. In high concentrations, it displaces the oxygen required to sustain life. When methane is present in concentrations exceeding 20 to 30 percent (by volume), the inspired air is usually oxygen deficient, and signs and symptoms of oxygen deficiency may be noted. In addition, methane is an anesthetic at high concentrations. Either oxygen deficiency or the anesthetic qualities of methane could account for the workers' being overcome so quickly.

2. The use of a Kelly hose as a flow back line necessitates entry into a confined space to secure the line to prevent it from whipping around when it's under pressure. Had a sufficient number of metal flow back lines been available, the need to enter the tank would have been precluded.

3. There were no written or verbal safety policies or procedures for safe entry into a confined space. Appropriate procedures would have required testing for oxygen and/or methane levels prior to entry.

4. There were neither policies nor procedures for emergency rescue from a confined space.

5. The workers had not received specialized training for entering confined spaces. The employees stated that they knew what a confined space was. However, they had never received any training classes to inform them about the potential hazards associated with confined spaces, let alone training in confined space entry or emergency procedures.

Recommendation #1: A confined space policy and appropriate procedures should be established by the company. The policy and procedures should indicate the areas designated to be confined spaces, conditions where entry to confined spaces is authorized (for example, when the tanks need to be fiberglassed), procedures to be followed before entry is permitted (testing, entry permit, training, lockout/tagout procedures, etc.), and rescue procedures. Emergency response by office personnel appeared to be good during this incident; however, an emergency procedure should be established, documented, and practiced.

Recommendation #2: A training program should be developed by the company to ensure that workers who are expected, in the course of their work, to enter and work in confined spaces, have knowledge of the hazards they may encounter, are fully cognizant of the requirements of the confined space evaluation and entry procedures, and are versed in emergency rescue procedures.

Recommendation #3 : A procedure which makes metal flow back lines mandatory is needed. This would eliminate the need for entry into the fracturing tanks to either secure or disconnect Kelly hoses. Bars welded across the top opening to the tank would eliminate unauthorized entry into the field. When entry to the tank is authorized, both clean-out panels on the bottom of the tank should be opened. This gives two emergency entries/exits. If safe entry dictates the need for a top opening, the welded bars could be removed.

FACE 85-40: City Water Worker Dies When Overcome by Natural Gas Vapors in a Confined Space in Ohio

INTRODUCTION

On July 1, 1985, an industrial meter reader employed by a mid-sized city in Ohio began his workday as usual at 7:30 a.m. He did not return to the garage at quitting time (4:00 p.m.) and was found face down in a meter vault at 6:45 p.m.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

This city has a population of 235,000 and employs approximately 2,500 permanent and temporary workers. There are six major departments, one of which is the Department of Public Service. The Department of Public Service has several bureaus, including the Public Utilities Bureau. The Public Utilities Bureau has four divisions: Utility Services, Water Supply, Water Pollution Control, and Water Distribution. The victim was employed by the Water Distribution Division. This division employs 145 full-time and up to 25 seasonal workers. There are six industrial meter readers, two of which are assigned to reading meters at any one time. (Meter readers work individually.)

A deputy to the mayor is the designated safety officer and 90 percent of his time is spent handling labor relations and the remainder of his time is spent dealing with safety-related issues.

SYNOPSIS OF EVENTS

On July 1, 1985, route assignments were received by the meter readers at 7:30 a.m. The victim (a 42-year-old meter reader) was assigned 76 accounts to be read that day. The victim had traded the original route assigned for a route with which he was unfamiliar. Industrial meters may be located in basements, at ground level, or in meter vaults and any one route may include all of these meter locations. The victim did not return to the garage at the usual quitting time of 4 p.m. This is not unusual because workers are occasionally late. At 5 p.m. when the victim still had not returned and he did not respond to dispatch calls, the police were notified. At 6:45 p.m. a passerby reported that the meter reader was down in a manhole and a fire rescue unit was dispatched to the accident site. The victim was found face down in the vault. The vault had approximately 4 1/2 inches of water in it. Resuscitation efforts were unsuccessful and the victim was pronounced dead at 9:31 p.m.

The victim had read 33 out of the 76 assigned meters when he reached the accident site. His supervisor felt that this should have taken until approximately 1:30 p.m. The victim was familiar with this vault, having seen it at the time of installation; however, this was the first reading of this newly installed meter. The vault was installed in May 1985 and was inspected for compliance with city regulations at that time. During this inspection, it was noted that the manhole cover did not have holes required for sufficient ventilation. The manhole cover was to be checked for compliance at this meter reading. No holes were present in the cover. According to the employee's supervisor, the victim may have had difficulty in removing the cover because the hook used to pull the lid open was straightened out and a sledge hammer was lying next to the manhole.

The vault (a two-piece, precast concrete structure — 15 feet by 9 feet by 8 feet) contains large water lines and an industrial water meter. No other utility services use this vault. An investigation of the vault was undertaken by the local coroner's office. The investigation revealed a faint odor of natural gas. The local gas company was notified about a possible leak. It was later determined that a leak was present in a nearby line and the gas was then turned off. After the vault was determined safe for entry, the interior of the vault was inspected; however, no signs were present that indicated that the victim may have slipped or fallen. Since natural gas was suspected in this accident, the vault was further tested. On July 3, 1985, the gas line was turned on and the vault sealed. The atmosphere in the vault was periodically tested. It was eventually determined that oxygen (17 percent), methane (15 percent), and carbon monoxide (>600 parts per million) were present. On July 10, 1985, the gas line was excavated by hand. A leak was found at a coupling approximately 34 inches from the vault.

CAUSE OF DEATH

According to the coroner/pathologist, the cause of death was cardiovascular collapse due to the acute myocardial ischemia due to inhalation of toxic fumes: "methane and carbon monoxide."

RECOMMENDATIONS/DISCUSSION

Recommendation #1: The city should develop and implement a comprehensive safety program. The Division of Water Distribution should have a documented safety program that identifies safe work practices to be followed. This program should include recognition of potential hazards.

Discussion: The city has no safety program and no written safety policy exists. Additionally, the Division of Water Distribution does not have a written safety policy or manual. Safety training is the responsibility of supervisory personnel and is limited to on-the-job training. The Division of Water Distribution is in the process of starting a new safety program for all employees consisting of four hours of initial training and a monthly, one-hour follow-up. This course needs to be supplemented by a written safety manual.

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

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

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

2. Employee and supervisory training in the selection and usage of respiratory equipment.

3. Development of site-specific working procedures and emergency access and egress plans.

4. Emergency rescue training.

Air quality was not tested prior to entry into the vault. Although oxygen/air quality monitoring devices are now provided for meter readers, training is necessary in proper usage and calibration of these devices. Respirators are now available for emergency use. Respirator training, fitting, and proper maintenance procedures should be completed by all personnel who may be required to use a respirator on the job. Medical evaluations of employees should be conducted to determine if they are physically able to perform the work while using a respirator. Immediate response to an emergency situation could prevent such fatalities. A full-time dispatcher is employed by the division. It would benefit the city to incorporate routine call-in procedures (indicating location, entrance time, and exit time) before confined space entry. (The employer should make full use of the resources they have available.) Guidance concerning proper procedures for confined space entry are discussed in DHEW NIOSH Publication No. 80-106, Working in Confined Spaces.

Recommendation #3: Vault manhole covers should have holes for ventilation.

Discussion: The Division of Water Distribution requires that manhole covers have holes for ventilation. The manhole cover at this accident site did not have the required holes. Although re-inspection was to take place at the time of this meter reading, this vault should not have passed inspection when initially installed and the victim should have been instructed not to enter the vault unless the proper manhole cover was in place.

Recommendation #4: Employers should assign employees tasks that are commensurate with their physical capabilities.

Discussion: The job of reading meters can involve strenuous physical activity. The victim had a history of medical problems. This medical history apparently was not taken into consideration when the victim was initially hired as a meter reader.

FACE 86-13: Worker Dies in Fermentation Tank in Montana

INTRODUCTION

On January 29, 1986, a 35-year-old worker was hosing down the interior (from the outside top opening) of a fermentation tank when the accident occurred. For some unknown reason, the worker entered the tank and was confronted with an atmosphere of 6 percent oxygen (O_2) and 48 percent carbon dioxide (CO_2).

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The victim worked for an alcohol and feed mash producing operation which employs nine workers (including the plant manager). The plant contains 30 stainless steel fermentation tanks, 84 inches in diameter by 88 inches high, which hold approximately 1,200 gallons each. The fermentation process is cyclic so when some tanks are coming down, others are starting up. The victim had been on the job for approximately 3 weeks, and had received on-the-job training only. On-the-job training primarily focused on plant operation with very little emphasis on safety. The only training received regarding confined spaces was a warning not to enter the tanks because of the CO_2 hazard. All on-the-job training is taken from the plant operations manual, with extremely basic safety recommendations. The plant has no written safety policies or confined space entry procedures with the exception of the plant operations manual.

SYNOPSIS OF EVENTS

The plant operates on two 12-hour shifts, with 4 days on and 3 days off. The late shift consists of two workmen, of whom one is the team leader or shift foreman. After a fermentation cycle is completed the tank is drained and pumped into the separator. At this time it is necessary to hose down the interior of the tank to remove the slurry that adheres to the sides. The workman usually lies down on top of the tank and sprays water through the 18-inch diameter opening located at the center of the tank.

The incident occurred at approximately 9 p.m. on January 29, 1986, after the foreman told the victim to hose down the interior of one of the fermentation tanks that was being drained. It is believed the workman's hat fell into the tank and he was attempting to retrieve it when the fatal incident occurred. The tank agitator had been turned off, which meant the victim had gone over to the control room to turn off the motor before attempting to remove his hat. It is believed the victim leaned in through the top opening, head first, and slipped/fell through the opening and struck his head on one of the agitator blades located at the bottom of the tank. (The coroner's report listed a semi-circular cut above the right eye.) The tank had approximately 12 to 18 inches of fermented slurry in the bottom. The foreman came out of the dehydration (final distillation) room and heard a thumping/thrashing noise in one of the tanks. He checked and found the victim trying to get out of the tank. Unable to reach the victim, he secured a rope and looped it around the victim's arm; however, he was still unable to pull the victim out of the tank. The foreman then called the plant owner and rescue squad. It was approximately 2 hours from the time the victim was discovered until his removal from the tank. The victim was dead when removed.

The atmosphere in the tank was tested by the OSHA Compliance Officer and revealed the atmosphere was 48 percent CO_2 and the O_2 level was displaced to 6 percent.

A by-product of fermentation is CO_2, a simple asphyxiant, which will displace 0_2 in a confined space. This is known by the plant owner and plant manager and is stressed to all employees. The plant owner stated "entry into a tank is forbidden without the approval of the plant manager or plant owner." The owner also stated if the victim had been trying to retrieve his hat from the tank, a nearby pole could have been used.

It should be noted the plant owner has installed a steel bar across the top opening of every tank so entry is impossible without unbolting this bar. Also, the owner has ordered atmospheric test equipment to test the O_2 and CO_2 levels in the tank before any entry is made. It also should be noted the shift foreman

who attempted to pull the victim out of the tank did not enter the tank, which is an all too common response to a man-down in a confined space which frequently results in a double fatality.

CAUSE OF DEATH

The coroner's report listed the cause of death as "asphyxia due to the exclusion of oxygen by carbon dioxide."

RECOMMENDATIONS/DISCUSSION

Recommendation #1: In addition to the operations manual and its limited safety sections, a comprehensive safety program should be developed. As part of this written safety program, the employer should develop procedures for confined space entry.

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

1. Air quality testing to determine adequate O_2 supply and level of CO_2.
2. Ventilation of the space to remove air contaminants.
3. Monitoring of the space to determine a safe oxygen level is maintained.
4. Lockout/tagout procedures to control hazardous energy, i.e., agitator blades.
5. Employee and supervisory training in confined space entry, testing, and use of personal protective equipment (respirators, clothing, etc.).
6. Emergency rescue procedures.

Air quality (O_2 level and CO_2 level) was not tested prior to this unauthorized entry. O_2 and CO_2 testing devices have been ordered 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 plant employees.

The plant manager and owner were provided the following:

- NIOSH Document Criteria for a Recommended Standard, Working in Confined Spaces. DHEW, NIOSH Publication No. 80-106.
- NIOSH Alert on Confined Spaces. DHHS Publication No. 86-110.
- NIOSH Recommended Guidelines - Controlling Hazardous Energy During Maintenance and Servicing. DHHS Publication No. 83-125.

FACE 87-27: Truck Driver Dies While Cleaning Out Inside of Tanker in South Carolina

INTRODUCTION

On August 20, 1986, a truck driver (the victim) for a liquid chemical transport company entered a 6,500-gallon cargo tank mounted on an 18 wheel tractor/trailer to wash out the inside. Within a minute the victim was observed lying unconscious inside the tank. The victim was removed from the tank by the local fire department rescue squad and rushed to a nearby hospital where he was pronounced dead on arrival.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The employer in this incident is a liquid chemical transport company that has approximately 735 employees, consisting mainly of truck drivers and truck service personnel. The company has a main corporate office with numerous trucking terminals distributed throughout the eastern United States. The company has a written safety program. There is a safety officer and five other employees with full-time safety and training responsibilities. A safety committee (management personnel, the safety officer, and employees representing all job responsibilities within the company) meets quarterly and safety meetings are conducted monthly at the various trucking terminals. These monthly safety meetings are used to discuss problems encountered on the job and to reinforce the existing safety program. There is a written safety policy that emphasizes driver safety training and includes some general safety procedures for truck drivers and truck service personnel. New employees receive job-specific training on the job from supervisors and co-workers and complete a three-day job training and safety orientation consisting of formal instruction from professional safety personnel. Truck drivers are also trained on the job by personnel from a chemical manufacturing company concerning loading, handling, transport, and delivery of the chemicals that are hauled by the chemical transport company. General safety rules and a truck driving safety manual are handed out to new drivers. Written confined space policies and procedures were developed and distributed to all truck drivers and truck service personnel after the accident. A signed statement indicating that the employee has read, understands, and agrees to follow safety rules and confined space entry procedures is kept on file by the employer.

[Note: The field evaluation of this incident was delayed for approximately 7 months. During this delay many areas of the safety program were developed or refined.]

SYNOPSIS OF EVENTS

On August 20, 1986, a truck driver (the victim) for a chemical transport company delivered approximately 4,000 gallons of sodium hydrosulfite to a customer. The liquid chemical was being hauled in a 6,500-gallon cargo tanker truck and the space above the liquid in the tank had been filled with nitrogen gas to preserve the quality of the product. As the chemical was off-loaded, the tank was filled completely with nitrogen gas in anticipation of returning to the chemical manufacturing plant to pick up another load of sodium hydrosulfite. This was the standard operating procedure at the trucking terminal which routinely hauls this product.

The victim had hauled sodium hydrosulfite with a nitrogen blanket many times during his 18 months of employment with the company; however, this time on his return trip, he was instructed to pick up a load of clay slurry. In order to haul the clay slurry it was necessary to first rinse out the residual sodium hydrosulfite in the tank. Company-owned truck wash terminals are equipped with mechanical wash/rinse nozzle arms that reach inside cargo tanks, and under normal circumstances, company drivers go to these facilities to clean their cargo tanks. Not being near one of these company facilities, the victim stopped at a nearby truck wash facility owned by another company. This facility does not have a mechanical tank washing device. Instead, a truck wash worker was responsible for washing out tanker trailers manually. The truck wash worker had previously entered cargo tanks on a routine basis (approximately five per month). (According to the compliance officer's report, the truck wash worker did not test or ventilate the atmosphere inside the tanks prior to entry and did not wear a respirator or any personal protective equipment.) The victim was informed by the truck wash manager that the person

responsible for washing out tanker trailers (the truck wash worker) was not there. The victim responded that he would wash out the cargo tank himself, a task which he had not previously attempted. The victim opened a four inch drain valve on the back of the cargo tank, then opened the hatch (20 inches in diameter) on top of the tank, and climbed down inside the tank with a hand spray gun attached to the end of a rubber hose. Pressing the hand valve on the spray gun activated the release of steam and hot water (with or without detergent) from a steam compressor located at the other end of the hose. Approximately 1 minute after the victim entered the tank, the manager noticed that the steam compressor was not running and became concerned. He called to the victim, but received no response. The manager climbed up on top of the tank, looked inside the tank through the top hatch, and noticed the victim lying unconscious at the bottom. The manager attempted to climb down into the tank to rescue the victim, but was too large to fit through the 20-inch diameter tank hatch opening. The manager called the local emergency medical service (EMS) and then the victim's supervisor at the trucking terminal office. (The victim's supervisor told the manager that he should remove the victim from the tank immediately and not wait for the EMS to arrive.) The local EMS and fire department rescue squad arrived on the scene approximately 20 minutes after being notified. Fire department personnel donned self-contained-breathing apparatus, entered the cargo tank through the top hatch, and removed the victim from the tank by a rope around his chest. EMS personnel began cardiopulmonary resuscitation (CPR) at the accident site. The victim was rushed to the nearest hospital where he arrived approximately 1 hour after the accident occurred and was pronounced dead by the attending physician.

CAUSE OF DEATH

The autopsy report lists the cause of death as anoxia due to containment in a nitrogen rich atmosphere.

RECOMMENDATIONS/DISCUSSION

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

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

1. Posting of all confined spaces.

2. Air quality testing to determine adequate oxygen supply, adequate ventilation, and the absence of all toxic air contaminants.

3. Monitoring to determine a safe oxygen level is maintained inside the confined space.

4. Employee and supervisory training in confined space entry.

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

6. Emergency rescue procedures.

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

Newly written confined space procedures of the employer do address items #2, #6, and #7 above; however, ventilation procedures are not adequately addressed in item #2 and the other requirements listed above (#1, #3, #4, and #5) are not addressed at all.

Recommendation #2: Employers should insure that employees are properly trained in hazard recognition and safety awareness for all potentially hazardous tasks they are assigned.

Discussion: Although the chemical transport company now has a written safety policy and some safety training, it appears that the victim and his supervisor (and although not employees of the transport company, the truck wash manager and the employee responsible for washing out cargo tanks as well) were not aware of the hazards associated with entry into a confined space with a nitrogen rich atmosphere. When confronted with such potentially hazardous on-the-job tasks, employees should be able to recognize these hazards and take appropriate preventive and corrective actions. The victim's supervisor and the truck wash manager were also not aware of appropriate emergency rescue procedures. The only factor that prevented this accident from resulting in a second fatality was the physical size of the truck wash manager, since the victim's supervisor instructed the truck wash manager to remove the downed employee. If the manager had been able to enter the confined space, without following proper rescue procedures, he probably would have died also.

FACE 88-20: Steelworker Dies in Oxygen-Deficient Confined Space

INTRODUCTION

On March 21, 1988, the 36-year-old male general supervisor for the midnight shift at a steel mill died when he entered the oxygen-deficient service area beneath a 75-ton-capacity, turret-mounted, molten-steel ladle.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The victim was employed by a privately owned steel mill that has been in operation for 19 years. At the time of the incident, the mill employed 700 workers. The mill has a designated manager of safety and health and a comprehensive safety training program. The turret-mounted ladle involved in the incident had been placed into service in February 1988. Confined space entry procedures for the turret service area were being developed at the time of the incident and have since been implemented. All workers at the mill have now been trained in confined space entry procedures. Mill policy at the time of the incident prohibited access to the turret service area to all personnel except workers in the maintenance department who had been trained in confined space entry procedures. During steelmaking operations, no one was allowed in the turret area.

SYNOPSIS OF EVENTS

The mill uses two 75-ton electric arc furnaces to blend components into molten steel. During the process, the molten steel is transferred to and from a turret-mounted ladle that travels between the two furnaces. Electrodes in the ladle maintain the temperature of the molten steel during the refining process until any required alloys are added. Argon is piped into the ladle to create turbulence to mix the alloys. An enclosed, 8-foot-high by 14-foot-diameter dome shaped service area, located beneath the turret, houses the gears and motor that drive the turret. The argon is piped through this service area into the ladle. The service area is accessed by any one of three, 24-inch by 36-inch service doors located on one side of the service area.

On March 21, 1988, the victim and his crew worked the 11 p.m. to 7 a.m. shift. They were scheduled to work 2 overtime hours (from 7 a.m. to 9 a.m.) to prepare the plant for a tour of 500 international steelmakers. During the regular shift, one of the crew members informed the victim that a gauge indicated an abnormal consumption of argon. The victim acknowledged this fact, but made no mention of searching for the leak. At 9 a.m. the crew was relieved. Later, one member stated that he had seen the victim in the locker room and presumed he was leaving the plant. At approximately 11 a.m., the victim's wife contacted the mill concerning her husband's whereabouts and was told he had left the mill. Shortly after lunch a worker noticed the victim's truck still in the parking lot. A search was initiated and the victim was found in the service area. Fire department personnel were summoned, and removed the victim from the service area at 1:15 p.m. He was pronounced dead at the scene by the coroner.

The victim did not alert anyone that he was going to enter the service area. Although no one saw the victim enter the service area, it was assumed that he attempted to locate the argon leak in the piping after he and his crew were relieved, entered the oxygen-deficient atmosphere of the service area, and lost consciousness.

During the installation of the turret in January 1988, the victim and two members of his crew entered the service area, lost consciousness, and were rescued. As a result of the January incident, the employer established the policy that only maintenance workers trained in confined space entry procedures were to enter the service area. Since the fatal incident, the piping for the argon has been routed outside the service area and <u>all</u> workers have been trained in confined space entry procedures.

CAUSE OF DEATH

The coroner listed the cause of death as anoxia due to a presumed excessive argon gas exposure in a confined space.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Employers should ensure that restricted areas can be accessed only by authorized personnel.

Discussion: Mill policy allowed only plant maintenance personnel, trained in confined space entry procedures, to enter the turret service area. The victim apparently made a conscientious effort to guarantee proper mill operations for the tour of international steelmakers by entering the service area to locate and correct the argon leak.

The victim knew and understood mill policy. Additionally, he had been exposed to and overcome by argon less than two months prior to his fatal exposure. In this instance, knowledge of the existence of a hazard was not a strong enough deterrent. To ensure that unauthorized personnel do not enter restricted areas, all entrances to such areas should be locked. Only authorized persons should be provided with the means to enter.

FACE 89-44: Two Farm Laborers Die in Oxygen-Deficient Manure Pit

INTRODUCTION

On June 26, 1989, a 31-year-old male dairy farm laborer entered a manure pit to clear a pipe, lost consciousness, and collapsed at the bottom. In a rescue attempt, his 33-year-old brother, also a farm laborer, entered the pit, lost consciousness, and collapsed. Both workers (hereinafter referred to as initial victim and rescuer victim) were pronounced dead at the scene.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The employer is a family-owned farm operated by the father and five sons. The farm consists of a 60-cow dairy herd with 80 acres of wheat, corn, hay, and pasture. The two victims, who had both worked on the farm since the age of 12, were in charge of the dairy operation. The family has owned the farm for 42 years and maintained a dairy herd for the past 28 years. Discussions with the farm owner indicated that the family members were aware of some of the hazards associated with tractors and other machinery, and oxygen-limiting silos. This hazard awareness was mostly due to farm machine manufacturer information.

SYNOPSIS OF EVENTS

The dairy operation has a barn with 60 stalls where the cows are milked twice a day. The barn has a built-in manure removal system consisting of a 2-foot-wide, 1-foot-deep trough (recessed into the concrete floor), which runs the length of the barn under each stall. Inside the trough is an electric-powered, chain-driven paddle conveyer which is turned on once a day to remove the manure. The conveyor discharges the waste into an underground open-top concrete pit adjoining the end of the barn. The 12-foot-square pit is 4 1/2 feet deep. The pit is housed in a small insulated, unventilated room to protect it from freezing. Animal waste at the bottom of the pit is pulled into a 6-inch-diameter steel pipe by a pump powered by a 25-horsepower electric motor mounted 6 inches above the top of the pit. A grinder inside the pipe/pump apparatus breaks up large solids. From here the waste pipe runs underground to a 200,000-gallon, open-top waste storage tank 10 feet away from the barn. The waste pump, grinder and storage tank had been installed 10 years before the incident. During this time, the piping, pump, and grinder inside the pit had corroded. The pipe developed several holes as a result of corrosion. Straw and other solid material moving through the pipe would often lodge in these holes causing blockages. In order to clear such blockages the victims would routinely enter the pit (without first testing the atmosphere and ventilating), disconnect the pipe at a joint, and manually clear the pipe.

On the day of the incident, the two victims went to the barn to milk the cows. Although the incident was not witnessed, evidence suggests the following sequence of events.

When the victims arrived at the barn, the pit contained about 3 feet of waste. The victims turned on the waste pump, but it did not remove any of the waste. Realizing that the suction line inside the pit was blocked, they decided to enter the pit to clear it. The initial victim put on rubber chest waders, entered the pit with a pipe wrench, disconnected the end pipe section and manually removed the blockage. The rescuer victim stood on the edge of the pit providing assistance to the initial victim as he worked in the pit. The victim soon collapsed inside the pit due to the lack of oxygen. [It is presumed that a high concentration of gases (hydrogen sulfide, carbon dioxide, methane, etc.) produced by the decomposition of the waste material, displaced the oxygen in the air inside the waste pit.] In a rescue attempt, the rescuer victim entered the pit and collapsed on top of the initial victim.

When the victims failed to return to their homes 4 hours after they were last seen, other family members began a search for them. An hour later they found the victims submerged in the waste pit. The local volunteer fire department and the emergency medical service (EMS) were notified by family members and arrived at the scene in 10 minutes. Fire fighters put on self-contained breathing apparatus (SCBA), entered the waste pit, and removed the victims.

Efforts to resuscitate the victims were unsuccessful and they were pronounced dead at the scene by the county coroner.

CAUSE OF DEATH

The coroner listed the cause of death for both victims as drowning.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Farm owners should become familiar with the hazards of confined spaces and adopt safe procedures specific for each type of confined space.

Discussion: Manure waste pits, by their design, meet the NIOSH criteria for the definition of a confined space. Entrance into these pits should be governed by NIOSH guidelines for working in confined spaces (NIOSH Publication 80-106). The following items have been outlined in NIOSH Publication 87-113, "A Guide to Safety in Confined Spaces." Not all of these issues can be addressed practically on a family farm. However, they do provide some guidance to farm owners who are adopting their own safe work practices for work in confined spaces.

1. Is entry necessary? Can the assigned task be completed from the outside (such as clearing the blockage through a clean-out pipe outside the pit)? Components of manure waste pits should be designed and installed in a manner that would allow maintenance to be performed on all serviceable parts from outside the pits.

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

3. Are confined spaces tested before entry and continuously monitored while work is being performed, especially when agitation of manure has not occurred recently, thus allowing the buildup of fermentation gases?

4. Is ventilation equipment of explosion-proof design (or silo fans that can be positioned outside of the building that houses the manure pit) available and used before and during entry?

5. Do workers know how and when to use the following:

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

6. Can workers recognize confined spaces (pits, tanks, silos, grain bins, etc.) and are they aware of their hazards?

7. Are confined space safe work practices discussed before attempting entry?

8. Is there a confined space safe rescue plan and do workers know how to safely respond in an emergency?

Recommendation #2: Manure pumping equipment should be constructed of materials that are corrosion resistant.

Discussion: Manufacturers of manure pumping equipment should be encouraged to use corrosion-resistant materials such as heavy plastic or stainless steel in pump parts. In this incident the high acid level of the animal waste severely corroded the pump parts. Since its installation 10 years before this incident, the waste pump and piping, which were constructed of steel and cast iron, had been repaired many times due to corrosion. This required workers to enter the pit frequently to clear blocked pipes and to perform pump maintenance. Pump parts constructed of a corrosion-resistant material would require less frequent entry for maintenance.

Recommendation #3: Farm owners and workers need task-specific worker safety guides through improved dissemination efforts.

Discussion: The farm owners in this incident received little if any useful farm safety literature on the operation and maintenance of farm machinery, and no information on the hazards of farm-related confined spaces. Worker safety guides specific to each type of farm machine and confined space should be developed. Dissemination of this material through agricultural extension agents, farm bureaus, and other agricultural associations should be improved. In this way farm workers and owners will receive useful information that will heighten their awareness of farm machine and confined space hazards.

FACE 89-46: Five Family Members Die After Entering Manure Waste Pit on Dairy Farm

INTRODUCTION

On July 26, 1989, a 65-year-old male dairy farmer, his two sons (37 years old and 28 years old, respectively) a 15-year-old grandson, and a 62-year-old nephew died when they entered a manure waste pit with an oxygen-deficient atmosphere.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The farmer owned and operated a dairy farm with his family. The nephew owned and operated a welding repair shop but was at the farm on the day of the incident. The 1,800-acre farm, 800 acres of which is leased for pasture for their 800 head of cattle, has been in the family for 100 years.

The farm has no written safety policy or safety program. Grain silos located on the farm are recognized as potential confined space hazards and are equipped with exhaust fans. The manure pit, which was installed 18 years ago, was not regarded as a confined space hazard. Many times in the past, workers had entered the manure pit to perform maintenance operations without incident.

SYNOPSIS OF EVENTS

The cattle-holding barn at the farm is equipped with a conveyor system to remove the manure. The system runs throughout the barn and conveys the manure to a waste-holding pit which is 24 feet long by 20 feet wide by 10 feet 8 inches deep. The pit is accessed by a 4-foot-square opening located inside a 17-foot by 35-foot service shed attached to the holding barn. A second entrance in the concrete top of the pit is located outside the barn. This entrance measures 3 feet 6 inches by 6 feet and is usually covered by a sheet of plywood. When the pit becomes full, the waste is pumped into a holding pond outside the barn. This slurry system is powered by a 20-horsepower pump located at floor level at the entrance of the pit. The pit contains an agitator to break up large clumps of manure so that it can be pumped out. Although the agitator shaft extends from above floor level down into the pit, the shear pin for the agitator shaft is located approximately 1 foot below floor level inside the pit. The pit had been entered in the past whenever this shear pin needed to be replaced. A 12-foot wooden ladder was used by workers to descend into the pit.

On the day of the incident, it is believed that the farmer's 28-year-old son entered the pit to replace the shear pin on the agitator shaft. One farmhand interviewed stated that the pump had not been operating for several days before the incident. The farmer's 15-year-old grandson was with his uncle. The grandson's 8-year-old brother was outside the barn door. The 8-year-old heard his brother yell for him to get help because their uncle had fallen into the pit. The 8-year-old ran to the farmhouse for help. While the farmer's 37-year-old son and nephew ran to the pit, the wife of the first victim called the fire department, the sheriff's department, and the owner of a farm equipment business located a mile from the farm. The owner of the farm equipment business stated that the call was received at 9 a.m., and that he and two of his workers left immediately for the farm. Apparently, the 15-year-old grandson, the farmer, his 37-year-old son, and his nephew all entered the pit to attempt rescue. A carpet installer working at the farmhouse went to the pit and saw all five men unconscious inside the pit. He entered the pit and was overcome, but did not lose consciousness. He was assisted from the pit by his helper. The farm equipment business owner instructed one of his workers to get a rope from their truck. His worker returned with a rope which had a hook on one end. The worker held his breath, entered the pit, and looped the rope around the waist of one of the victims and hooked it. After the worker exited the pit, he, his co-worker, and their boss lifted the victim out of the pit. All five victims were removed in this manner. The younger son was removed first, then the farmer, the nephew, the elder son, and the grandson. The business owner stated that the last victim was removed from the pit at 9:20 a.m. By this time, EMS personnel had arrived at the scene and begun to administer cardiopulmonary resuscitation along with fire department personnel. The nephew was pronounced dead at the scene by EMS personnel. Four victims were transported to the emergency room. The farmer and the younger son were pronounced dead upon arrival. Although the elder son and grandson were breathing, the elder son died 1 hour later in the

emergency room. The grandson was transferred by helicopter to a major trauma center and was pronounced dead upon arrival 6 hours after being removed from the pit.

Gas readings taken the day after the incident by the State Department of Labor investigator showed a methane level of 2 percent and a hydrogen sulfide (H_2S) reading of 18 ppm. This H_2S reading is well below the NIOSH Immediately Dangerous to Life and Health (IDLH) limit (300 ppm), but exceeds the OSHA Permissible Exposure Limit (PEL) of 10 ppm. Readings taken by the DSR team 12 days after the incident showed a methane level of 3.5 percent, an oxygen level of 20.2 percent, and a hydrogen sulfide level of 7 ppm. It should be noted that the temperature and humidity for the 3 days preceding the incident were in the mid 90^{o} F range and the barometric reading at the time of the incident was 30.17 and there was no wind. These conditions would have been favorable for a buildup of methane and/or hydrogen sulfide inside the tank. A thunderstorm occurred later in the morning of the incident that significantly reduced the temperature. While taking gas readings at the inside entrance to the manure pit during their investigation, the DSR investigators removed the plywood cover on the outside opening. The gas levels (H_2S and methane) dissipated almost immediately. On the day of the DSR investigation, the temperature was 55^{o} F and conditions were windy.

CAUSE OF DEATH

The medical examiners listed the cause of death for all of the victims as asphyxiation due to methane gas exposure.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Manure waste pits should be identified as confined spaces.

Discussion: Manure waste pits, by their design, meet the criteria established by NIOSH to define confined spaces. A space is considered "confined" if it: 1) has limited openings for entry and exit; 2) has unfavorable natural ventilation which could contain or produce dangerous air contaminants; and 3) is not intended for continuous employee occupancy. Entrance into such pits should be governed by NIOSH guidelines for working in confined spaces (NIOSH Publication No. 80-103). Ideally, a manure pit should be ventilated, and the atmosphere within the pit tested prior to entry and monitored while work is being performed. Self-contained breathing apparatus should be utilized by those entering the pit if an oxygen-deficient and/or toxic atmosphere is found to exist. Although such specialized equipment and training in the use of this equipment may not be readily available to many farm workers, these workers must, at a minimum be made aware of potential hazards associated with manure waste pits, such as oxygen-deficient or toxic atmospheres. NIOSH is preparing an alert detailing the hazards associated with manure waste pits. Additionally, NIOSH requests the assistance of agricultural extension agents, farm journals, agricultural associations, and farm equipment manufacturers in alerting farm workers to the hazards associated with manure waste pits.

Recommendation #2: Manure waste systems should be constructed in a manner that would allow maintenance to be performed on all serviceable components from outside the pits.

Discussion: Components of manure waste systems should be installed in a manner that allows maintenance to be performed from outside the pits, or provide for the easy retraction of serviceable parts for maintenance. Typically, these waste systems are not purchased as a single unit; however, it may be possible to install waste pit components that would eliminate the need to enter the pits to perform maintenance. Had the shear pin for the agitator shaft been located outside the pit, it is likely that this tragedy would have been prevented.

Recommendation #3: Manure waste systems should be equipped with some type of powered ventilation system.

Discussion: Waste systems should be equipped with some type of powered ventilation system. Ideally, these systems should be equipped with both supply and exhaust ventilation to eliminate the accumulation

of gases. In the case of explosive gases such as methane, the system should be of sufficient size to prevent the gas from reaching its explosive limits and should be of explosion-proof design as defined in the National Electrical Code. The system might be composed of portable fans, but must be of sufficient size to ensure constant circulation of fresh air throughout the waste system, and be of explosion-proof design.

Recommendation #4: Manure waste systems should never be entered unless absolutely necessary.

Discussion: Because dangerous gases may be present, a waste system pit should never be entered unless absolutely necessary. If entrance into the pit is necessary, a standby person(s) with the capability to remove the person from the pit, if necessary, must be stationed outside the pit and must maintain visual or vocal contact with the person in the pit. If the standby person(s) is not physically capable of removing the person from the pit, some sort of mechanical lifting device (a winch, hoist, etc.) should be in position over the pit. Anyone entering the pit to perform any work must wear a safety belt or harness and have a lifeline attached to a substantial anchor point outside the pit. This would enable a standby person(s) to remove someone from the pit without entering the pit. Details of a rescue plan must be resolved before entry. Should an emergency develop, a short delay caused by lack of preparation could be fatal.

Recommendation #5: Entrances to waste pits should be covered by a grate-like cover.

Discussion: All entrances to waste pits should be covered with a properly secured grate-like cover to prevent someone from accidentally falling into the pit and to aid ventilation.

Recommendation #6: Farm employees must be instructed never to enter a manure pit, or any other confined space to attempt a rescue operation, without proper consideration for their own safety.

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

Recommendation #7: Manufacturers of equipment designed for manure waste pit systems should include warnings on the hazards associated with these systems.

Discussion: Manufacturers of equipment designed for animal waste pit systems should include information concerning the hazards of these pits to all purchasers of their equipment, and should provide information (diagrams, etc.,) on how to install their equipment so that it can be serviced without requiring workers to enter the pit.

FACE 91-14: Furnace Operator Dies After Being Overcome by Argon Gas in Pressure Vessel in South Carolina

SUMMARY

A 43-year-old male furnace operator (victim) died after being overcome by argon gas in a 7.5-foot deep pressure vessel with a 24-inch inside diameter. The victim was summoned by the vessel tender to enter the vessel to retrieve three tungsten carbide steel objects that had dropped into the vessel during the unloading process. The victim was lowered into the vessel by holding onto the hook of the overhead crane used to unload the vessel. The victim retrieved one object and handed it out to the tender. The victim then squatted down to reach under the vessel's internal heating element to retrieve the second object and was overcome by argon gas that was present at the bottom of the vessel. NIOSH investigators concluded that, to prevent future similar occurrences, employers should:

- *develop and implement a confined space safety program*
- *alert workers of all hazards that might be encountered during the performance of their duties*
- *continually stress the importance of adherence to established standard operating procedures*
- *develop an extraction tool that would eliminate the need to enter a confined space (pressure vessel)*
- *evaluate the design of the pressure vessel to determine if it could be modified to allow for the extraction of objects from outside the vessel.*

INTRODUCTION

On May 9, 1991, a 43-year-old furnace operator died after being overcome by argon gas in a 7.5-foot deep pressure vessel. On May 13, 1991, officials of the South Carolina Occupational Safety and Health Administration notified the Division of Safety Research (DSR) of the death, and requested technical assistance. On May 30, 1991, two DSR safety and health specialists and a safety engineer traveled to the incident site to conduct an investigation. The incident was reviewed with employer representatives, the county sheriff's office, and the county coroner. Photographs of the incident site were taken.

The employer in this incident is a tungsten carbide steel fabrication plant that has been in operation for 41 years and employs 150 workers, including 9 furnace operators. The plant engineer manages the safety program on a collateral duty basis. There are no written safety rules or safety policy. The workers are provided with classroom, manual, and on-the-job safety training. Workers seen committing unsafe acts are disciplined with 3-days suspensions for the first offense and dismissal for the second offense. The victim worked for this employer for 2.3 years prior to this incident.

INVESTIGATION

The employer fabricates more than 20,000 tungsten carbide items. Two production shifts are run at the facility from 5:30 a.m. until 2 p.m. and from 3:30 p.m. until midnight. The fabricated items are placed on three sections of stacked trays and lowered into a pressure vessel (installed in 1975) using an overhead crane. A cylindrical stainless steel insulating hood is placed over the trays. The insulating hood is 24 inches in diameter and 7.5 feet high and serves as the inner liner of the vessel. The vessel is 7.5 feet deep. It has an inner diameter of 24 inches and an outer diameter of 42 inches. A 9-inch water cooling jacket surrounds the inner wall. Argon gas is piped into the vessel to pressurize it at 15,000 psi and the vessel is heated to a temperature of 1,500 degrees centigrade by an internal heating element. Four and a half hours are required for the vessel to reach peak temperature and pressure. This peak is held for 1 1/2 hours, then the vessel cools for 5 hours. This process assures the quality of the tungsten carbide product. The tender on the following shift reclaims the argon gas to de-pressurize the vessel. The hydraulically sealed

lid is removed and the insulating hood and three sections of stacked trays are lifted out of the vessel by the overhead crane. Any argon gas remaining in the vessel is allowed to naturally escape into the atmosphere. The vessel is surrounded by a service pit that is equipped with an oxygen monitoring device. This device does not monitor the oxygen inside the vessel.

The vessel had been shut down and the argon gas had been reclaimed at 11 p.m. the night before the incident; however, the vessel lid had not been removed. When the vessel tender began his shift at 5:30 a.m., he removed the lid and insulating hood then began to remove the three sections of stacked trays. At some point during this removal process, three objects (2 inches in diameter and 3 inches long) fell from the trays into the vessel. The tender called the maintenance foreman to see if it was possible to reload the vessel and continue the operation with the fallen objects still inside. The tender was instructed by the maintenance foreman that if the objects did not interfere with the placement of the insulating hood that the operation could continue. The tender determined that the objects would have to be removed since at least one of the objects would interfere with the placement of the insulating hood.

The tender tried for 15 minutes to remove the objects with a thong-like extraction tool, but was unsuccessful. The tender did not contact the maintenance department, though maintenance was responsible for removing objects from the vessel and had established procedures for this task. Instead, the tender summoned the victim from another area of the facility, to enter the vessel and retrieve the objects, possibly because of the size of the victim. The victim was 5 feet, 6 inches tall and weighed 120 pounds.

The victim arrived at the scene and tried unsuccessfully to remove the objects with the extraction tool. When it was determined that entry would be necessary for the retrieval of the objects, the tender lowered the victim into the vessel using the overhead crane. The victim held on to the crane hook to be lowered into the vessel. He was not tied off to the crane hook. The victim released the crane hook and retrieved one of the objects and handed it out to the tender. As he squatted down to reach under the internal heating element to retrieve the second object, he was overcome by the argon gas that still remained in the bottom of the vessel.

The tender called the plant office, told them to summon the emergency medical squad (EMS) and returned to the vessel with a co-worker. The tender tied himself off to the crane hook and the co-worker lowered him into the vessel. When the co-worker noticed the tender slump over he immediately raised him out of the vessel and laid him on the ground. The tender was unconscious but breathing, and regained consciousness within a minute. When the EMS arrived one of the EMS crew members tied himself off to the hook, held his breath, and was lowered into the vessel where he tied a rope around the victim's chest. The victim was then raised out of the vessel, 35 minutes after he was overcome. EMS personnel immediately initiated CPR. The coroner was summoned, and when he arrived, pronounced the victim dead at the scene.

CAUSE OF DEATH

The coroner attributed the cause of death to an oxygen deficient atmosphere.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Employers should develop and implement a confined space safety program.

Discussion: The maintenance department had existing procedures for entry into the vessel which included:

1. placing an exhaust fan over the top of the vessel for a period of time
2. flooding the interior of the vessel with compressed air

3. using the overhead crane to lower a man in full body harness into the vessel to retrieve the object.

Although maintenance personnel realized the hazard created by the presence of argon gas in the bottom of the vessel (argon is heavier than air and would accumulate at the bottom of the vessel), it is evident workers in other areas of the plant were unaware of the potential hazard. Employers should ensure that all employees are aware of the potential hazards, possible emergencies, and specific procedures to be followed prior to working in, or around, a confined space. At a minimum, as discussed in NIOSH publications 80-106, "Working in Confined Spaces," and 87-113, "A Guide to Safety in Confined Spaces," the following items should be addressed:

1. testing the air quality to determine adequate oxygen level and the presence of combustible and toxic air contaminants

2. adequate ventilation to remove air contaminants

3. monitoring the space to determine that a safe atmosphere is maintained

4. training the employees in confined space entry, testing, and the use of personal protective equipment, safety harnesses, respirators, clothing, etc.

5. stationing a standby attendant outside the space for communication and visual monitoring

6. emergency rescue procedures

7. identifying and controlling the hazards associated with the confined space involved.

Recommendation #2: Employers should alert all workers of all hazards associated with operations that might be encountered during the performance of their daily duties.

Discussion: Employers should alert all workers within a facility of all hazards associated with the operations within the facility that might be encountered during the performance of their daily duties. The incident site in this instance was not the victim's usual work area. The victim was not familiar with the hazards associated with the argon gas in the pressure vessel. Had he been made aware of the hazards associated with entrance into the vessel, this fatality might have been prevented.

Recommendation #3: Employers should continually stress the importance of adherence to established standard operating procedures.

Discussion: In this instance, standard operating procedures called for the tender to contact the maintenance department to remove the objects from inside the pressure vessel. The maintenance department had established safe work procedures for entry into the pressure vessel that controlled the argon gas hazard. If standard operating procedures had been followed in this instance, the fatality would have been prevented.

Recommendation #4: Employers should develop an extraction tool or system that would eliminate the need for entry into the pressure vessel.

Discussion: The employer should evaluate the design of the extraction tool now being used to remove fallen objects from the pressure vessel. If possible, the tool should be re-tooled to improve its effectiveness. Because 20,000 different items are treated in the pressure vessel, it would be difficult to develop a tool that would be compatible with all items. Possibly, a tool could be developed with interchangeable ends for retrieving items with different sizes and shapes.

Recommendation #5: The employer should evaluate the design of the pressure vessel to determine if it could be modified to allow for the extraction of objects from outside the vessel.

Discussion: The feasibility of incorporating some type of catch basket into the interior design of the insulation hood should be evaluated. If this was possible, the objects could be removed once the insulation hood was removed from the pressure vessel. The employer should also evaluate the design of the trays to determine if they could be modified in such a way that the potential for fallen objects could be eliminated. Possibly, a top and bottom lip could be incorporated into design of the tray or, if possible, and if clearance allowed, a protective sleeve could be placed over the stacked-tray sections to catch any objects dislodged from the trays.

References:

1. National Institute for Occupational Safety and Health, Criteria for a Recommended Standard...Working in Confined Spaces, DHHS (NIOSH) Publication Number 80-106, December 1979.

2. National Institute for Occupational Safety and Health, A Guide to Safety in Confined Spaces, DHHS (NIOSH) Publication Number 87-113, July 1987.