PART II

FATALITY ASSESSMENT AND CONTROL EVALUATION (FACE) SUMMARY REPORTS, 1983-1993: CONFINED SPACES

Atmospheric Hazards

Flammable/Explosive

FACE 85-05: Confined Space Incident Kills Two Workers- Company Employee and Rescuing Fireman

INTRODUCTION

On November 15, 1984, one worker died after entering a toluene storage tank. During the rescue attempt, a fireman was killed when the tank exploded.

SYNOPSIS OF EVENTS

The owner of a bulk petroleum storage facility discovered that the toluene storage tank (10 feet in diameter and 20 feet in height) was contaminated and would have to be drained and cleaned. Since the tank's only access portal was located on top of the upright cylindrical tank, the owner decided to have a clean-out access portal installed at the bottom of the tank when emptied. A contractor was called to provide cost estimates for installing the portal. The contractor performed a site survey of the tank and told the owner that the tank must be drained, all sludge removed, and thoroughly ventilated before he would install the portal. The owner directed his maintenance supervisor to get the tank prepared for the contractor.

On the day of the incident the supervisor and an unskilled laborer (a San Salvadorean immigrant on his first day back on the job after working another job for approximately 2 months) drained the tank to its lowest level - leaving 2 to 3 inches of sludge and toluene in the bottom - and prepared for a "dry run" of entry into the tank via the top access portal.

The supervisor rented a self-contained breathing apparatus (SCBA) from a local rental store and instructed the laborer in use of the SCBA and in the procedure they intended to follow. Since a ladder would not fit into the 16-inch diameter access hole, the supervisor secured a knotted, 1/4-inch rope to the vent pipe on top of the tank and lowered the rope into the hole. The 16-inch diameter opening on the top of the tank was not large enough to permit the laborer to enter wearing the SCBA. Therefore, it was decided the SCBA would be loosely strapped to the laborer so it could be held over his head until he cleared the opening. Once entry had been made, the supervisor was to lower the SCBA onto the laborer's back so it could be properly secured.

Immediately prior to the incident, both employees were on top of the tank. The laborer was sitting at the edge of the opening. The supervisor turned to pick up the SCBA. While he was picking up the unit, he heard the laborer in the tank. He turned and looked into the opening and saw the laborer standing at the bottom of the tank. He told the laborer to come out of the tank, but there was no response. The supervisor bumped the rope against the laborer's chest attempting to get his attention. The laborer was mumbling, but was still not responding to his supervisor's commands. At this point, the supervisor pulled the rope out of the tank, tied the SCBA to it and lowered the unit into the tank. Again, he yelled to the laborer in the tank, bumped him with the unit and told him to put the mask on. There was still no response. The laborer fell to his knees, then fell onto his back, and continued to mumble. At this point, the supervisor told the facility manager (who was on the ground) to call the fire department.

The first call went to the police department who relayed it to the fire department. Included in the fire department response was the hazardous materials team, due to the information received about the material in the tank. The fire department (including the rescue and the hazardous materials teams) arrived on the scene approximately 10 minutes after the initial notification. After apprising the situation, fire officials decided to implement a rescue procedure rather than a hazardous materials procedure. Therefore, removal of the disabled person inside the tank was given top priority.

The 16-inch diameter opening at the top of the tank was not large enough to lower a firemen donned in full rescue gear. Therefore, it was decided to cut through the side of the tank to remove the victim. The firemen were aware of the contents of the tank (toluene) and the possibility of an explosion.

The procedure developed by the fire department involved making two 19-inch vertical cuts and a 19-inch horizontal cut with a gasoline-powered disc saw. After the cuts were completed, the steel flap would be pulled down and the victim removed.

While the hazardous materials team was cutting, other firemen were spraying water on the saw from the exterior to quench sparks. Two other firemen were spraying water on the interior cut from the top opening. Three firemen with the hazardous materials team were doing the actual cutting; they were alternately operating the saw because of the effort required to cut through the 1/4-inch thick steel. Sometime during the horizontal cut a decision was made to bring the two firemen off of the top, which meant no water spray on the interior. Simultaneously, the exterior water spray was removed to put out flammable liquid burning on the ground as a result of the shower of sparks from the saw. Thus, at the precise time of the explosion, no water was being sprayed on the saw/cut from exterior or interior. Both vertical cuts were completed and the horizontal cut was 95 percent complete when the explosion occurred.

One fireman was killed instantly from the explosion and several were injured. The man inside the tank was presumed to be already dead at the time of the explosion.

CONCLUSIONS/RECOMMENDATIONS

The conclusions and recommendations are presented in two parts: Part I - the confined space entry; and Part II - the rescue effort.

Part I - Confined Space Entry:

The following factors may have contributed to the confined space fatality:

The company had no confined space entry procedures.

The supervisor was not qualified to direct confined space entry.

The laborer was inadequately trained for confined space entry — possible language barrier.

Appropriate protective clothing and equipment were not provided.

The only access portal required vertical entry.

The access portal was small.

It was the laborer's first day back on the job. (He may have felt obligated to perform any task assigned.)

RECOMMENDATIONS

Written confined space entry procedures should be developed and used. Procedures should contain the following: permit system, testing and monitoring of the atmosphere, training of employees, safety equipment/clothing, safe work practices, rescue procedures, standby person requirements, and use of respiratory protection.

Selection of proper respiratory protection — whether it be a self-contained breathing apparatus (SCBA) or supplied air system — is essential. Selection should be determined by the physical limitations, equipment available, and work procedures.

Confined space testing and evaluation by a qualified person before entry and implementation of safety measures will help reduce risk-taking by employees.

Vertical access from the top of a 20-foot tank by a rope was found to be physically impossible while wearing respiratory protection and protective clothing. An additional access port on the side near ground level would eliminate this problem. The port should be of adequate size to permit entry of a worker wearing full protective clothing.

Workers must be properly trained (in English, Spanish, or the prevailing language) in confined space entry procedures and use of personal protective equipment. Also, the tank contents and known potential hazards should be discussed.

A prior accident should have alerted someone that additional protection was needed. If entry procedures are being followed and an accident occurs, it is necessary to re-evaluate the procedures and make necessary corrections for employee safety.

Part II - The Rescue Effort:

The following factors may have contributed to the rescue effort fatality and injuries:

The condition of the person down inside the tank was not known.

The location and size of the only access portal on the tank precluded entry by a rescuer wearing full protective clothing and equipment.

The fire department's confined space entry procedures precluded entry into a confined space containing hazardous materials without full protective clothing and equipment.

The choice of methods to open the tank for rescue entry introduced an ignition source to an atmosphere which was known to be potentially explosive (see tank calculations).

The use of water sprays to prevent ignition of a flammable/explosive atmosphere in a confined space may not be effective under certain conditions.

There were combustible materials on the ground surrounding the tank which ignited prior to the explosion and necessitated removal of exterior water spray away from saw/cut.

The fire department chain of command possibly created confusion when orders were given without full knowledge of the situation.

The number of fire department personnel in the immediate area may have been excessive.

The victim (fire fighter) was directly in front of the cut during the cutting procedure and when the explosion occurred.

RECOMMENDATIONS

While cutting the tank and assisting fellow firemen who were cutting, one fire fighter stood directly in front of the opening, rather than to the side. This maximized the impact the victim received from the explosion. It is recommended that procedures be outlined that minimize such risk by firemen.

When hazardous tasks are performed only essential personnel should be in the immediate area, regardless of perceived risk by fire fighters. Nonessential personnel should be permitted only after the hazardous task(s) has been completed.

More extensive departmental procedures for efforts involving responses to explosive environments and hazardous materials are needed. Procedures should include command responsibilities, determinations of and distinctions between rescue and recovery efforts, uses of potential sources of ignition, methods to minimize risks of ignition, etc.

City fire departments should establish a registry of confined spaces and toxic/explosive substances for specific companies within the area in which they serve. Such a registry should provide not only the name of the substance, but should also provide sufficient information so that emergency response personnel will have one comprehensive source that provides information sufficient to safely effect a rescue effort.

Research is needed to determine the best methods (if any) to gain entry in such circumstances. Cutting may be too hazardous, even with the use of water sprays.

FACE 87-33: Digester Explosion Kills Two Workers at Wastewater Treatment Plant in Pennsylvania

INTRODUCTION

On February 6, 1987, two workers at a wastewater treatment plant were draining a sewage digester when an explosion lifted the 30-ton floating cover, killing both workers instantly.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The employer in this incident was a small borough within the Commonwealth. The victims worked for the wastewater treatment plant which is under the public works department. The public works department has a total of 10 employees (2 in the wastewater treatment section and 8, including a public works supervisor, in the street maintenance section).

New employees are given a brief orientation on benefits and policies and receive on-the-job training that addresses their assigned duties. Additionally, employees are sent to any pertinent seminars that would be of value in their training. No safety training or safety meetings are conducted at the wastewater treatment plant. Employees are not trained in confined space hazards or safe entry procedures. The only confined space procedures are four basic recommendations that are posted on the bulletin board at the wastewater treatment plant.

SYNOPSIS OF EVENTS

On February 6, 1987, the two operators (a father and son) of the wastewater treatment plant were in the final stages of drainage a digester (30 feet deep by 27 feet in diameter) that had been taken out of service for routine cleaning. The heavy sludge remaining in the bottom of the digester was approximately 8 feet deep. Two tank pumper trucks were brought in to remove the heavy sludge; however, the sludge was not pumping well. The operator of the wastewater treatment plant told the driver of the pumper truck that he would go up on top of the digester and spray water into the sludge to make it pump easier. The driver of the pumper truck reversed his pump to blow air up through the sludge to help loosen the heavy mass. The two plant operators climbed up onto the floating cover of the digester and using a 1-inch garden type hose, they began spraying water into the bottom of the digester to loosen up the heavy sludge. The operators lowered a 200-watt light bulb on an extension cord into the digester through a 22-inch diameter manhole on top of the floating cover to view the sludge level. The light and cord were not designed or approved for use in hazardous (classified) locations. Apparently the light bulb either struck the concrete and broke, or the cold water spray made contact with the hot glass light bulb, causing it to break. The broken light provided a source of ignition for the combustible gas(es) in the digester, probably methane.

The truck driver who remained on the ground stated he heard a "whoomp" but the sound didn't appear to be an explosion. However, his truck and pump were running at the time of the explosion, increasing the ambient noise level. After a few minutes the driver went up the ladder to the top of the digester and saw that the 30-ton floating cover was wedged in the digester on a 45-degree angle. Neither of the workmen was visible.

The rescue squad was called and arrived within a few minutes. However, to remove the victims, a large crane was brought in to tip the wedged cover enough to send in a driver to retrieve the victims. It took approximately 4 hours before the victims were removed from the digester. They were both pronounced dead at the scene by the local coroner.

NOTE: When agitating the sludge, i.e., blowing air up through the heavy sludge, it is possible to release trapped gases such as methane and hydrogen sulfide.

CAUSE OF DEATH

The coroner's report listed the cause of death of both men as cervical fracture.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: The employer should develop proper work procedures and should train employees concerning safe maintenance procedures.

Discussion: The municipality did not provide safe operating/maintenance procedures or training in hazard recognition. This training should include recognition of potential hazards associated with digester cleaning operations and proper tools and equipment to be used in a combustible atmosphere. The workers had used this light and extension cord in the past and assumed it was safe. The light and cord were not designed or approved for use in hazardous (classified) locations and should not have been used.

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 in developing procedure for confined spaces. 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 and supervisors been trained in selection and use of approved equipment and tools for use in a confined space?

   - Electric tools approved in accordance with 29 CFR Part 1910, Sub Par 5.
   - Lighting explosion proof design where necessary. Intrinsically safe for the atmosphere involved.
   - Electric lines, junctions approved in accordance with the National Electric Code and National Fire Code.

7. Have employees been trained for confined space entry?

8. Is ventilation equipment available and/or used?

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

FACE 87-50: Tractor-Trailer Repairman Dies While Welding Interior Wall of a Tanker in Indiana

INTRODUCTION

On June 9, 1987, a tractor-trailer repairman (the victim) for a trailer repair company entered an 8500-gallon cargo tank to weld a leak on the interior wall of the tanker. When the victim began welding, an explosion occurred killing him.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The employer in this incident is a trailer service company that has nine employees: six trailer repairmen and three secretarial staff members. The company is family-operated and has one shop. The company has a written safety program, with the majority of the safety procedures given as part of on-the-job training. Specific safety regulations for confined spaces were in place at the time of the incident that, if followed, would have prevented the accident. As a result of this incident, the company has decided to stop servicing tanker-trailers.

SYNOPSIS OF EVENTS

On June 9, 1987, a 34-year-old welder (the victim) and an assistant began preparing a tanker-trailer for repairs. The victim was the shop foreman and had been performing tanker repairs for approximately 15 years (7 years with this company). The tanker was a multi-compartment type with four compartments of different sizes (see Figure 1) with a leak in an interior wall that required welding. A small baffle area is located between the compartments to prevent chemicals from mixing together if a leak in an interior wall occurs.

The tanker compartments were steam cleaned for 1 to 1-1/2 hours to remove trapped chemicals and vapors from the tanker. The chemical in this instance was lacquer-thinner. Drain plugs were opened the entire time steaming was conducted to allow proper drainage of the compartments and baffles. Opening the drain holes is a standard safety procedure for the company when doing tanker repairs. The victim and his assistant left the tanker to do other tasks while the steam cleaning progressed. Because of this, they were not aware that the drain hole in the second baffle area had clogged (See B, Figure 1).

The victim and the assistant returned after allowing sufficient time for the steaming operation to clean the compartments and baffles. They discovered the clogged drain and cleaned it, which allowed the trapped liquid to drain from the baffle. At that time, the victim decided not to re-steam the baffle, despite the strong fumes. Instead, the tanker was moved into the shop area and the victim instructed the assistant to shoot compressed air into the baffle drain hole to dissipate the vapors. This was done for approximately ten minutes.

After air-blowing the baffle, the victim and assistant entered the tanker compartment to do pre-treatment work to the leak (See A, Figure 1) before welding. The assistant remarked about the "strong fumes" in the compartment; however, the victim decided to continue the repair operations. When the pre-treatment was completed, the victim instructed the assistant to leave the compartment, pass in the welding equipment and to stay on top of the tanker to attach the lids to the other compartments. Upon leaving the compartment, the assistant again mentioned the "strong fumes." The written company safety policy required that an explosion meter was to be used at this point. The explosion meter was available and was in working condition. However, the victim did not follow the safety policy and requested the assistant to pass in the welding equipment. After passing in the equipment, the assistant began replacing the compartment lids as instructed. An explosion, which apparently occurred as the victim began welding the leak, broke the weld of the compartment wall along approximately six feet of the seam line.

The assistant was the first to reach the compartment and saw the victim against the compartment wall opposite the leak (See C, Figure 1). The owner of the company immediately notified the local fire department and emergency medical service. The fire department responded after 10 to 12 minutes, by

which time the victim had been removed from the tanker by co-workers. The emergency medical team began CPR at the scene and continued CPR while in route to the hospital. The victim was rushed to a nearby hospital, approximately 10 minutes away, where he was pronounced dead by the attending physician. The time between the incident and arrival at the hospital was approximately thirty minutes.

CAUSE OF DEATH

The autopsy report lists the cause of death as "multiple blunt force injuries."

RECOMMENDATIONS/DISCUSSION

Recommendation #1: The employer should initiate a comprehensive enforcement and safety review program for confined space entry procedures.

Discussion: All employees who repair tankers should be aware of the importance of stated company safety procedures, including confined entry policies. The employer should reinforce employee awareness of the potential hazards associated with confined spaces. The employer did have a written policy that was sufficient to prevent the incident if it had been followed; however, this policy should be communicated and enforced. This should include:

1. Posting of confined space procedures;

2. Regularly scheduled safety policy meetings (bi-weekly or monthly) to re-enforce company safety codes;

3. Review process for allowing employees to make recommendations or for improving written company safety codes;

4. Employer monitoring of tasks assigned to employees to assure the implementation of safety policies;

5. Emergency rescue procedures;

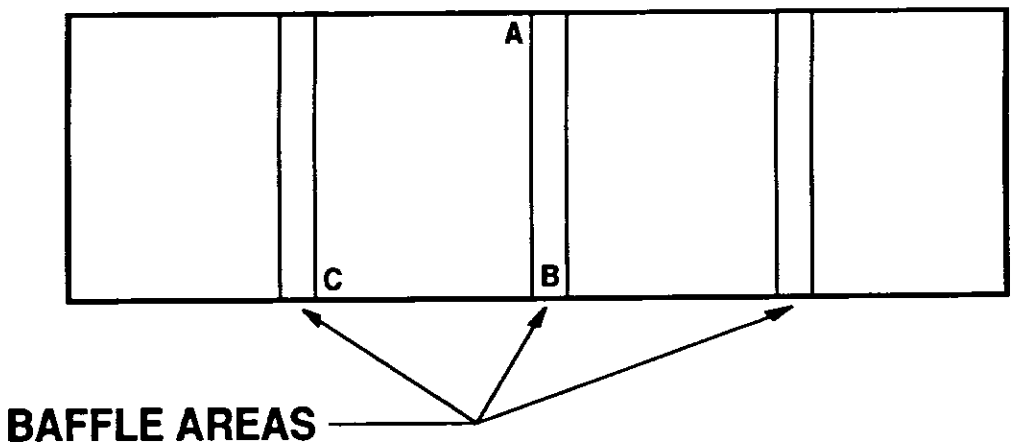
6. Availability, storage and maintenance of emergency rescue equipment.

Recommendation #2: The employer should expand confined space policies to address hazards due to oxygen deficient, flammable/explosive, or toxic environments.

Discussion: This incident emphasized the need to address all of the potential hazards in confined spaces. Locating the clogged baffle drain before entering the tanker compartment allowed the baffle to be drained of trapped chemicals. However, if the clogged drain had not been located, the concentration of chemical vapors in the tanker compartment may have been sufficient to place both the victim and the assistant in an oxygen deficient or toxic environment. The need to inform employees about the hazards of confined spaces in all respects should be a priority of the employer. Information concerning confined space entry procedures is available from various NIOSH documents including:

1. "Criteria for a Recommended Standard...Working in Confined Spaces" - DHEW (NIOSH) Publication No. 80-106

2. "A Guide to Safety in Confined Spaces" - DHHS (NIOSH) Publication No. 87-113.



A. Location of leak.

B. Baffle area with clogged drain.

C. Location of victim after explosion.

Figure 1 (87-50). Lateral view of the tanker-trailer in which fatality occurred.

FACE 88-30: Laborer Dies in Explosion

INTRODUCTION

On July 14, 1988, an 18-year-old male laborer died as a result of an explosion which occurred while he was making repairs on the interior of a tanker truck compartment.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The victim was one of seven employees of a truck and trailer repair shop. The shop had no written safety policy or safety program. All employees received on-the-job training. The victim had been employed full-time at the facility for 45 days.

SYNOPSIS OF EVENTS

A tanker truck's aluminum cargo tank had developed a crack in an interior compartment wall. The cargo tank was 16 feet long, divided into 4 interior compartments, and had a total tank capacity of 3,000 gallons. The interior compartments were of double wall construction with a dead air space between the walls. This configuration prevented liquid in one compartment from flowing into another should a single wall fail. Each compartment had an individual hatchway located on top of the tank. Each also had its own drain and shut-off valve connected by a manifold pipe to one common outlet.

The crack had developed in a weld in Compartment 3 on the wall located between compartments 3 and 4. Planned repairs involved welding a 20-inch-long piece of 3-inch structural aluminum angle over the crack.

On the morning of the incident, the truck was brought into the garage to have the compartment repaired. Compartment 3 was steam-cleaned while the other three compartments were left sealed. The compartment atmosphere was not tested for toxicity or explosibility prior to entrance. The victim entered Compartment 3 and used an electric grinder to prepare the crack for welding. When the victim finished preparing the weld site, he left the facility to pick up the piece of aluminum angle to be used for the patch. When the victim returned, he and the supervisor ate lunch together but did not discuss the job. After lunch, the victim re-entered the compartment and began welding the patch over the crack.

The supervisor stated that at 2:10 p.m. the victim was using the grinder once again when an explosion occurred in Compartment 2. The top sections of both walls separating compartments 2 and 3 were blown into Compartment 3. The double wall wrapped around the victim's head, crushing his skull. The volunteer fire department was summoned. Firemen used an electric winch to pull the double wall away from the victim. Approximately 40 minutes after the explosion, the victim was removed from the tanker and pronounced dead at the scene by the county coroner.

The petroleum company's manifest was reviewed during the investigation. Immediately before the truck was brought in for service, compartments 1 and 2 had contained gasoline. It is assumed that a small quantity of gasoline was still present in compartments 1 and 2 and in the drainage system. The drains on all four compartments were open which may have allowed explosive vapors to accumulate in the drain lines.

The facts suggest at least two possible explanations for the explosion:

1. while the victim was dressing (preparing) the weld with the grinder, a piece of hot metal fell into the drain causing the gas vapors to ignite, or

2. explosive vapors entered the compartment through the drain opening and ignited. If ignition occurred in Compartment 3, the source was either the grinder motor or electrical arcs created by electrical flow between bare conductors on the grinder power cord and the metal compartment.

In either case, the ignition spread through the drainage system to Compartment 2, where an explosive concentration of vapors was enclosed.

CAUSE OF DEATH

The coroner listed the cause of death as blunt force trauma to the head.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: The employer should initiate a program of safe work practices and ensure that employees understand and follow specific prerequisites for entering a confined space. These should minimally include the following:

1. ***recognition of confined spaces and associated hazards***
2. ***air quality testing to ensure adequate oxygen supply, adequate ventilation, and permissible levels of toxic and explosive contaminants***
3. ***monitoring of the space to determine that safe atmospheres are being maintained***
4. ***employee and supervisory training in confined space entry, in the selection and usage of required respiratory protection, and emergency rescue procedures***
5. ***availability, storage, and maintenance of emergency rescue equipment.***

Discussion: The air quality was not determined before the worker entered the compartment and ventilation was not maintained. The air quality was not monitored for toxic air contaminants and oxygen level. If the atmosphere in the compartment had been tested prior to the beginning of work, it may have alerted the victim that a problem existed.

Recommendation #2: All containers, such as the truck compartments in this case, which have recently been used for storage, transport or dispensing of flammable liquids, should be emptied, thoroughly cleaned, and purged before initiating repairs to the container. The atmosphere within the compartment should be tested to determine that it is below the lower explosive limits if repairs involve potential ignition sources.

Discussion: Although two other compartments had contained gasoline, only the compartment in which work was to be performed was steam-cleaned. This created a dangerous situation since the drains leading to a common outlet were open in all four compartments. The possibility of an explosion would have been greatly reduced had all four compartments been steam-cleaned and the drains thoroughly flushed.

Recommendation #3: Employers should maintain portable hand tools in safe operating condition.

Discussion: The power cord on the portable grinder had visible bare conductors. This created a condition which could have resulted in an arcing effect due to current flow from the conductor to the metal compartment, thereby producing an ignition source for the explosive atmosphere. Additionally, this hazardous condition exposed users of the grinder to potential contact with electrical energy which could result in injury or death.

FACE 89-38: Painter Dies from Burns Received from Explosion Inside Tank

INTRODUCTION

On May 16, 1989, a 41-year-old male painter (the victim) suffered burn injuries from an explosion which occurred while he was painting the inside of a 1,300-gallon tank. He died 5 days later. A 32-year-old male painter (co-worker) stationed outside the tank suffered burns and a broken arm.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The employer is a sheet metal fabrication company with 30 employees. The company manufactures steel tanks and has been in business for 20 years. Most of the employees are sheet metal workers, welders and painters. The victim had been with the company as a painter for 3 1/2 years. The co-worker had been a painter with the company for 4 years. The company has a management level employee who serves as the safety officer on a collateral-duty basis. The safety officer conducts safety meetings once a month. New employees receive a safety orientation which consists of a brief discussion of company requirements for workers to wear steel toe boots, hearing and eye protection. New employees are given handouts which they are expected to read covering safety requirements. The company has no written safety program and does not have any written confined space entry procedures. Confined space entry procedures regarding ventilation of tanks during welding is discussed at monthly safety meetings.

SYNOPSIS OF EVENTS

The victim and co-worker had been assigned to paint the inside of a recently fabricated 1,300-gallon steel tank. The tank measured 68 inches high, 75 inches in diameter, and stood vertically with a 22-inch diameter manway opening on the top.

The victim entered the tank by stepping on the mixing blades that had been built into the inside of the tank. He was wearing a supplied air respirator (without an auxiliary escape Self Contained Breathing Apparatus (SCBA)), welder's cap, coveralls, rubber gloves, and steel toe boots. To provide lighting for the victim, the co-worker positioned a 500-watt, non-explosion-proof halogen lamp over the manway opening. The co-worker then sat on top of the tank next to the manway to observe the victim. He (the co-worker) was wearing a dust/mist respirator. Using an airless spray gun, the victim began spray painting the inside of the tank with an epoxy-base paint. The victim had completed painting the bottom and sides of the tank, and he was painting the top when the spray gun nozzle hit the lamp, breaking the sealed beam. This ignited the epoxy vapor which caused a flash fire explosion. The victim was able to climb out of the tank unassisted. He then removed the respirator mask and both the victim and co-worker walked approximately 300 feet to the office. There they explained to office personnel what had happened. Office personnel notified the local Emergency Medical Service (EMS). Police officers who were in the area heard an emergency call concerning the explosion and arrived at the scene in 3 minutes. A rescue squad ambulance arrived 10 minutes after being notified and transported the victim to a local hospital emergency room. The co-worker was taken to the same hospital in another worker's car. Both workers were fully conscious and able to converse while being transported to the hospital and while medical care was being administered in the emergency room. The victim suffered second and third degree burns on 40 percent of his body (thighs, hands, arms and chest). The co-worker suffered first and second degree burns on 12 percent of his body (face and neck), and suffered a broken arm from falling off the top of the tank after the explosion. The two workers were transported the same day to a nearby burn center where they were hospitalized. The co-worker recovered sufficiently to be released from the hospital 8 days after the incident. The victim died from burn complications 5 days after the incident.

CAUSE OF DEATH

The attending physician listed the immediate cause of death as respiratory failure. This was due to respiratory complications as a consequence of thermal burns affecting 40 percent of the victim's body.

RECOMMENDATIONS/DISCUSSION

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

Discussion: The company did not have a formal safety program established. A logical first step in developing a safety program is to identify all potential hazards. One way is by analyzing the sequential steps in routine operations to identify potential hazards, and attempting to develop procedures or other control measures which effectively eliminate or reduce the hazards. This type of analysis is known as job hazard analysis. Additionally, each specific job involves hazards particular to that job or the working environment. For example, in the steel tank painting process there were two hazards which should have been identified: 1) The flammable epoxy paint being sprayed inside the tank, and 2) the non-explosion-proof floodlight being used to illuminate the spraying process. An evaluation of these hazards should have led to control measures such as changing to an explosion-proof light and/or substituting the epoxy paint for an acrylic base or other non-flammable paint. NIOSH Publication Number 78-100, "Health and Safety Guide for the Fabricated Structural Metal Products Industry" should be used as a guide in developing the safety program.

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

Discussion: Although the company had verbal confined space procedures for entering and working in tanks, the procedures were unsafe and inadequate. The company should therefore immediately develop and implement a comprehensive confined space entry program as outlined in NIOSH Publications Number 80-106, "Working in Confined Spaces," and Number 87-113, "A Guide to Safety in Confined Spaces." At a minimum, the following items should be addressed:

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

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

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

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

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

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

   - protective clothing
   - respiratory protection
   - hard hats
   - eye protection
   - gloves
   - lifelines and
   - emergency rescue equipment?

6. Have employees been trained for confined space entry?

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

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

9. Is ventilation equipment available and/or used?

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

In addition to the above items, the following should be specifically incorporated into the confined space procedures for work performed inside tanks:

1. The use of explosion-proof lighting and fixtures in and near flammable atmospheres, as required by National Electric Code (NEC) Article 501-9(a)(1) and 501-9(b)(1) and the National Fire Protection Association (NFPA) Standard 33.

2. The use of non-flammable paints (if at all possible) for coating the inside of tanks.

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

Discussion: Employees were not trained in the use of respirators. Although the victim wore a supplied air respirator, it was not equipped with an auxiliary, escape SCBA. Respirators should be selected according to criteria in the "NIOSH Respirator Decision Logic" (DHHS [NIOSH] Publication No. 87-108). Additional information on the characteristics and use of respirators is available in the "NIOSH Guide to Industrial Respiratory Protection" (DHHS [NIOSH] Publication No. 87-116