The National Institute for Occupational Safety and Health (NIOSH)

Promoting productive workplaces through safety and health research

Confined Space Incident Kills Two Workers – Company Employee and Rescuing Fireman

Death in the Line of Duty...A summary of a NIOSH fire fighter fatality investigation

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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.

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FACE: 85-05
DATE: January 6, 1985
CAUSE: Confined Space (Poisoning, Fire)
SUBJECT: Confined Space Incident Kills Two Workers -- Company Employee and Rescuing Fireman

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

A toluene storage tank (10 feet in diameter and 20 feet high) had to be drained and cleaned. While the tank was empty, the company planned to install a clean-out portal at the bottom of the tank. On the 15th, a supervisor and an unskilled laborer drained the tank to its lowest level, leaving 2 to 3 inches of toluene and sludge at the bottom. The only entry into the tank at this time was a 16-inch diameter opening at the top. The supervisor and the worker (an immigrant who may have lacked fluency in English) planned a "dry run" entry into the tank from the top. The worker was provided with a SCBA, but the top opening was not wide enough to enter while wearing the apparatus, and so the worker was to enter while the SCBA was loosely strapped, and put it on when inside. Also, the available ladder did not fit through the opening and so the supervisor tied a knotted rope to a vent pipe and lowered it into the tank. While picking up the SCBA, the supervisor heard the worker in the tank, turned, and saw the worker standing on the bottom of the tank. The supervisor attempted to lower the SCBA to the worker, but the worker was mumbling and unresponsive. The worker then fell down, and the supervisor left for help.

The Fire Department rescue and hazardous materials teams arrived 10 minutes after notification. The firefighters were unable to pass a firefighter in full rescue gear through the top opening, and decided to cut through the side of the tank. They were aware of the possibility of explosion. The cut was made with a gasoline-powered disk saw. The cutting area was sprayed with water inside and outside the tank to quench sparks. At some point, firefighters stopped spraying the inside of the tank. The outside spray was interrupted temporarily to put out a fire in flammable liquid residue on the ground next to the tank. The tank then exploded. Additional factors contributing to the confined space part of the incident include: The company had no confined space entry procedures, and the supervisor and worker had no training. Additional factors contributing to the explosion include: possible confusion in the Fire Department chain of command, and the position of the firefighters making the cuts. Note that with a tank of these dimensions, only 56 ounces of toluene are needed to create a flammable atmosphere -- toluene that would cover the bottom of the tank to a depth of 0.01 inch. Recommendations:

- Written confined-entry procedures should be developed and used. Respiratory protection is essential. Confined spaces should be evaluated by a qualified person before entry. Workers need proper training. A prior accident should have alerted the company that procedures needed to be reevaluated. A ground access port (as was planned) would have prevented the incident.

- The Fire Department needs more extensive procedures for responses to

explosive and hazardous materials. Departments should establish registries of confined spaces and toxic/explosive substances. Research is needed on the best way to enter tanks such as this one. When hazardous tasks are performed, only essential personnel should be in the immediate area. Workers cutting into a tank such as this one should avoid standing immediately in front of the opening.