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OREGON FATALITY ASSESSMENT AND CONTROL EVALUATION
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Center for Research on Occupational & Environmental Toxicology
OHSU OREGON HEALTH & SCIENCE UNIVERSITY
Fatality Investigation Report
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Mechanic dies from lack of oxygen in transport tank

SUMMARY

On February 4, 2004, a 23-year-old tank mechanic died when he entered a permit-required confined space. The mechanic was assigned to prepare a shipping container used to transport silicon tetrachloride for an inspection. The tank had been purged with an inert nitrogen atmosphere. While waiting for the inspector to arrive, the mechanic entered the tank for an unknown reason, apparently without first testing the atmosphere, and died of asphyxiation. When the victim was discovered about an hour later, a coworker jumped into the tank, again without testing the atmosphere first, and lifted the victim up to others standing on top of the tank. Testing by fire department responders showed the atmosphere at the bottom of the tank to be about 12% oxygen, below the minimum safe level of 19.5% oxygen.

A mechanic entered this chemical transport tank while it was in the shop for routine inspection.

CAUSE OF DEATH: Asphyxiation

RECOMMENDATIONS

- **Employers must evaluate confined spaces in the workplace. A permit-required confined space requires written entry procedures, including posted documentation of test results by an authorized person.**
- **Never enter a confined space without first testing the atmosphere with an appropriate air-monitoring instrument.**
- **Never enter a confined space without appropriate personal protective equipment for safe entry.**
- **A trained attendant must monitor workers in a confined space and be prepared for an emergency response that does not involve direct entry of the space.**

INTRODUCTION

On February 4, 2004, a 23-year-old tank mechanic died from lack of oxygen after entering a chemical transport tank prior to a scheduled inspection. OR-FACE received notification of the incident the next day. An OR-FACE investigator was invited onsite by the employer. Local fire and emergency medical responders were at the scene. This report is based on information from the onsite investigation, and reports from Oregon OSHA, law enforcement, and the medical examiner.

The employer was a longtime Oregon company, based in Portland, specializing in the manufacture and maintenance of transportation tanks. At the time, the firm had 5 factories and 11 sales branches in several western states, employing over 550 workers, with about one-third in Oregon. On the day of the incident, at least two management and three coworkers were present in the vicinity of the tank department where the incident occurred.

The firm had a written confined-space entry policy, which stated, "No tank entry is permitted until the tank passes the Confined Space Pre-entry Atmospheric Check and the reclassification Confined Space Form is completed." The OSHA investigation found that documentation was not always completed, however, and employee interviews indicated that atmospheric testing was not always performed. In late 2003, the employer trained a designated person to perform atmospheric testing on all tanks prior to entry. The individual was transferred 2 weeks prior to this incident and the duties were not reassigned.

The tank mechanic had worked for the employer since 1999, with duties that included inspecting and repairing tanks. He completed a 45-minute hazardous materials training course and test certificate in his first year, and was promoted to journeyman in 2001. Interviews by OSHA and the Medical Examiner indicated that he had been given positive performance appraisals, had never been known to bypass safety measures, and reportedly had completed "hundreds" of tank inspections similar to the one in this incident.

INVESTIGATION

On the day of the incident, the tank mechanic arrived at work at 6:30 a.m., and was told to prepare a container for dual inspection with an industry shipping inspector. About 7:45 a.m., the foreman helped the mechanic back the chemical transport truck into a bay of the tank shop. The mechanic was last seen about 45 minutes later, and was not missed until the industry inspector arrived shortly before 10 a.m.

The tank due for inspection that day was designated for the transport of silicon tetrachloride. Chemical transport tanks go through two inspections: an annual visual inspection, and a 2.5 year visual and pressure check as in this case. The visual and pressure check requires work inside the tank to verify structural integrity, and possible welding.

The tank had been purged with inert nitrogen. A dated memo posted on the outside of the tank by the owner stated: "… this container has been washed, and is free of any hazardous materials …

This container has a breathable atmosphere only when proper tank entry is followed (fresh air moved through the container and use of oxygen monitor before entering)."

The tank mechanic had placed a ladder next to the tank, opened the top manhole cover, and lowered a drop light inside. Without testing the atmosphere, he then entered the tank for an unknown reason and collapsed at the bottom of the ladder from lack of oxygen. His footprints did not extend beyond the base of the ladder.

A man-hole cover at the top of the transport tank provided access into the interior.

When the inspector arrived, a coworker went looking for the tank mechanic and discovered him lying face down inside the tank. He called for help, then took a deep breath and entered the tank to retrieve the victim, without testing the atmosphere. The rescuer ran out of breath while trying to lift the victim up to others at the top of the tank, and was only able to take very shallow breaths. He emerged from the tank unharmed.

Resuscitation efforts failed, and the victim was pronounced dead by emergency responders shortly afterward. There were no injuries to indicate the victim had fallen into the tank rather than descending on his own.

Fire department personnel tested the atmosphere in the tank and found about 12% oxygen at the bottom of the tank, 15% in the middle, and 17% at the top, all below the minimum safe level of 19.5% oxygen. The manhole cover had been open by then for over an hour, and ambient air raised the oxygen level at the top of the tank. Investigators found the employer's atmospheric monitor was missing the necessary strap to reach the bottom of the tank, indicating that even had the victim tested the atmosphere with available equipment, he would have been at risk as he descended into the confined vessel.

RECOMMENDATIONS/DISCUSSION

Recommendation #1. Employers must evaluate confined spaces in the workplace. A permit-required confined space requires written entry procedures, including posted documentation of test results by an authorized person.

A confined space is defined as a space with (a) a restricted opening that makes entry and exit difficult, (b) is large enough for a person to enter completely, and (c) is not designed to be occupied. Such spaces include pits, wells, vats, ship compartments, silos, pipes, tunnels, tanks, sewers, and so on.

The evaluation of a confined space should involve testing the atmosphere, and also an assessment of structural security, including the threat of collapse or engulfment, and the isolation of hazardous mechanical or electrical energy. Occupational safety regulations (29 CFR

1910.146) require a written entry permit for confined spaces with a potentially hazardous atmosphere or other conditions that could entrap or harm a worker.

Employers must establish written entry procedures for permit-required confined space. The procedures can be summarized in five basic steps.

- *Evaluate.* An employer must identify hazardous confined spaces in the workplace where workers may be expected to enter, and post warning signs.

- *Test.* An employer must provide appropriate equipment to test the atmosphere prior to entry. Tests must be performed by a trained, authorized person. Testing equipment should be periodically checked against known atmospheres to ensure reliability.

- *Inform.* Hazards identified in test results must be documented in a written entry permit and posted outside the space. A worker entering a confined space must be trained in entry procedures, and must be allowed the opportunity to observe testing. Training and participation increases awareness of the invisible dangers in a confined space.

- *Control.* The employer must implement measures to prevent unauthorized entry. Prior to entry, a safe atmosphere must be assured, usually involving continuous forced-air ventilation.

- *Monitor.* Atmospheric conditions in a confined space can change rapidly. Testing should be repeated prior to entry. The area in the confined space where work is performed must be continuously monitored. A worker inside should always be accompanied by an attendant outside the space to maintain communication, and implement a rescue plan if necessary. Entry must be authorized by an entry supervisor.

Recommendation #2. Never enter a confined space without first testing the atmosphere with an appropriate air-monitoring instrument.

Never trust your senses to determine if the air in a confined space is safe. The level of oxygen cannot be determined without a calibrated instrument, and many toxic gases and vapors are odorless or overwhelm the sense of smell.

Prior to entry, always test the air from outside the confined space to detect oxygen levels and toxic or flammable atmospheres. Even brief exposure to a toxic or oxygen-deficient atmosphere can cause immediate collapse. In some instances, workers putting their head inside a vat or descending a ladder into a confined space have lost consciousness.

All compartments must be tested where workers will be present, including the bottom, middle, and top of the space workers must pass through. Gases may stratify based on density and OSHA recommends testing depths at 4 ft intervals.

Recommendation #3. Never enter a confined space without appropriate personal protective equipment for safe entry.

Use appropriate personal protective equipment when working in a confined space. The required equipment depends on conditions. Examples include physical protection (hardhat, goggles, gloves), respiratory protection (air-purifying or air-supplied respirators), ventilation fans to control atmospheric hazards, and fall protection (safety harness, lifeline). Equipment that is adequate for some conditions may be insufficient for others. If no air is available, for example, a filter mask will not help. Prior evaluation and preparation of the work area is critical.

Recommendation #4. A trained attendant must monitor workers in a confined space and be prepared for an emergency response that does not involve direct entry of the space.

Work in a confined space must always be performed with a minimum of two persons. A trained attendant must always remain outside the space and stay in communication with the workers inside. In case of emergency, the function of the attendant is not to personally attempt a rescue, but to summon rescue and emergency services, and prevent unauthorized persons from attempting a rescue. An attendant may only perform a rescue if relieved by another attendant, and when provided with necessary training and equipment.

Over half of the workers who die in a confined space are would-be rescuers. The danger to an impulsive rescuer emphasizes the need for a prearranged plan, training, and proper equipment readily available to implement an emergency response. Equipment should include an atmospheric monitor, personal protective equipment, and retrieval devices.

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CROET at OHSU performs OR-FACE investigations through a cooperative agreement with the National Institute for Occupational Safety and Health (NIOSH), Division of Safety Research. The goal of these evaluations is to prevent fatal work injuries in the future by studying the work environment, the worker, the task, the tools, the fatal energy exchange, and the role of management in controlling how these factors interact.

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