



The National Institute for Occupational Safety and Health (NIOSH)

Promoting productive workplaces
through safety and health research



Electroplater and Four Co-workers Die from Asphyxiation in Metal Plating Vat

FACE 8833

INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH), Division of Safety Research (DSR), performs Fatal Accident Circumstances and Epidemiology (FACE) investigations when a participating state reports an occupational fatality and requests technical assistance. The goal of these evaluations is to prevent fatal work injuries in the future by studying: the working environment, the worker, the task the worker was performing, the tools the worker was using, the energy exchange resulting in fatal injury, and the role of management in controlling how these factors interact.

On June 28, 1988, a 25-year-old male electroplater (victim) died after entering a metal plating vat he was cleaning. Four male co-workers also died when they entered the vat in rescue attempts.

CONTACTS/ACTIVITIES

State officials of the Occupational Safety and Health Program notified DSR of the fatal incident and requested technical assistance. On August 3, 1988, a DSR research industrial hygienist conducted a site evaluation, interviewed company officials, and photographed the incident site.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The employer is an electroplating company with 31 employees most of whom are electroplaters. Employees with at least 1 year of experience had attended a one-time training session on chemical hazards from a hazard communication training company. New employees receive a brief orientation on the chemicals used in the plating operation and the location of Material Safety Data Sheets (MSDS), and then take a "chemical awareness test" which is a review of the information received. Electroplaters are required to wear personal protective equipment (boots, gloves, aprons and safety glasses). Acid-mist cartridge-type respirators had been issued to two electroplaters and the wastewater treatment operator, but were available for use by any of the workers.

At the time of the incident the employer had no written safety program, no plant emergency procedures, no on-going safety training, no confined space safe entry procedures, and did not conduct safety meetings with employees.

SYNOPSIS OF EVENTS

The company uses a series of open-top steel tanks to acid treat metal parts and then plate the parts with a metal finish of either zinc, chrome, nickel, brass, copper, or cadmium. Two parallel lines of tanks, separated by a 5-foot-wide removable metal grating walkway, are located in the zinc plating room. Below the walkway is a concrete drainage pit. The only ventilation the zinc plating room receives is from two exhaust fans on the ceiling about 20 feet above the tanks, five open windows (at the time of the incident the windows were closed), and one open door.

The end tank (4' wide x 5' long x 5' deep) on the south side of the zinc plating line is used as a holding tank for excess zinc cyanide that drips from the finished metal parts suspended above the tank. Approximately once a year the tanks are cleaned out by an industrial cleaning and waste hauling company. One day prior to the incident the waste hauling company had completed pumping out the tanks; however, the holding tank still contained about 2 inches of zinc cyanide sludge on the bottom.

During the night shift, the plating company employees were cleaning and rinsing the tanks in preparation for changing from a cyanide process to an acid plating process. Chemicals for the new process were to be added to the tanks and the plating operation was to resume the following morning. During the cleaning process, the metal grating between the two tank lines was removed. This resulted in the top of the end holding tank being 8 feet above the surface of the drainage pit floor. A ladder was used to reach the top of the tank.

In a cleaning procedure that had never been attempted before, the victim manually pumped between 1 and 2 gallons of 1% muriatic acid solution from a 55-gallon drum (which the victim had placed nearby for cleaning and rinsing purposes) into the zinc cyanide holding tank, and then climbed into the tank. The tank had not been tested or ventilated before entry. The victim was not wearing any respiratory protective equipment and the only personal protective equipment (PPE) he was wearing were gloves, boots and an apron. Within a few minutes hydrogen cyanide vapor formed in the tank due to a chemical reaction between the muriatic acid and zinc cyanide. About 4 minutes after he had entered the tank, co-workers observed the victim trying to climb out but then falling back into the tank. Four co-workers entered the tank in an attempt to rescue the victim. They were wearing varying amounts of PPE but no respiratory protective equipment. They all collapsed inside the tank. Other co-workers, seeing these workers collapse, also made varying rescue attempts. By this time, as the chemical reaction continued, most of the co-workers who entered the zinc plating room were unable to even get close to the holding tank because of the hydrogen cyanide vapor. However, one co-worker (without respiratory protection) removed one of the four collapsed co-workers (who was bent over the top of the tank with his head down inside) and administered cardiopulmonary resuscitation.

The city police, state police, and fire department were notified. Personnel from these departments arrived within approximately 15 minutes and began removing the workers from the zinc cyanide holding tank. Firefighters were wearing full turnout gear (standard PPE for firefighters) with self-contained breathing apparatus (SCBA). Police officers were not wearing any respiratory protective equipment or PPE.

The rescue effort was hampered because police and fire department personnel were initially unaware that hydrogen cyanide vapor was involved. During the rescue effort they became suspicious that hydrogen cyanide vapor might be involved after learning from plant employees that zinc cyanide and acids were used at the plant. The hydrogen cyanide vapor permeated the exposed skin and the leather protective "turnout gear" when they removed the victims from the tank. As a result, 17 police officers and firefighters received toxic exposures, and the turnout gear became contaminated. A further complication was the uncertainty between responding agencies as to who should take command of the rescue effort, including administering emergency medical care and securing the contaminated area from unauthorized entry. This disorganization continued for nearly 2 hours before the premises were finally sealed off.

The county coroner pronounced the electroplater (victim) and three of the co-workers attempting rescue dead at the scene. The fourth co-worker was taken to the local hospital where he died 2 days later. In addition to the 5 fatalities, 30 individuals received medical treatment for toxic exposure to hydrogen cyanide vapor:

2 company workers hospitalized

10 company workers treated and released

1 police officer hospitalized

3 police officers treated and released

13 firefighters treated and released

1 medical examiner treated and released

TOTAL 30

Seven hours after the incident began, a private environmental and hazardous waste consulting firm (contracted by the employer) collected air samples at the plant for analysis of toxic air contaminants. Concentrations of hydrogen cyanide vapor measured 1.0 milligram per cubic meter (mg/m³) immediately outside the plant door, and 6.0 mg/m³ immediately outside the zinc cyanide holding tank. Analyses for other toxic air contaminants were negative. Sample collectors were unable to obtain air samples from inside the holding tank at that time.

After collecting these samples the consulting firm added a chemical to neutralize the chemical reaction inside the holding tank and then ventilated the building using portable blowers. The following day the consulting firm analyzed the air inside the holding tank; hydrogen cyanide vapor was present at a concentration of 2.0 mg/m³.

It is assumed that the concentration of hydrogen cyanide vapor inside the holding tank was at least 60.0 mg/m³ (the level immediately dangerous to life) at the time of the incident. This is based on the acute effect of the vapor on the workers.

CAUSE OF DEATH

The county coroner listed the cause of death for all five electroplaters as asphyxiation due to overexposure to hydrogen cyanide vapor.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: The company should develop and implement a written safety and training program. This program should include the recognition of hazards and safe work methods.

Discussion: The company had no written safety program or policy. Any training at the plant was on-the-job, with little emphasis on safety and health. The victim (age 25) was an electroplater with 3-1/2 years experience. All four co-workers who died (ages 19, 21, 29, and 29) were electroplaters with less than 8 months experience. Using muriatic acid to clean out the zinc cyanide holding tank had never been attempted before and it is unlikely the employees involved understood that hydrogen cyanide vapor would be produced by adding muriatic acid to zinc cyanide. (In fact, two active chemicals such as zinc cyanide and muriatic acid should never even be kept in the same area.) Additionally, entry into the tank without adequate ventilation, PPE, and respiratory protection implied the employees generally did not recognize the hazards involved and that the tank was a confined space. A training program should focus on educating employees on hazards associated with the plant operation, the use of Material Safety Data Sheets (MSDS), the reactivity and toxicity of chemicals, methods of working safely, plant emergency procedures, and the proper use of PPE, including respiratory protection.

A preliminary hazard analysis of the entire operation should identify hazardous areas (physical, chemical, environmental, etc.), conditions, and tasks that are performed. This is especially important when a new work task is initiated. In this case, a new cleaning procedure was attempted without identifying potential hazards. Based upon the hazard analysis, safety procedures can be developed and implemented. For example, the method of plating metal parts and cleaning out the zinc cyanide holding tank should be evaluated to determine if either process could be changed to minimize or eliminate exposure to cyanide or the need to enter the tanks. Less hazardous chemicals should be substituted where possible. Tank entry was considered necessary to clean the sludge build-up inside the zinc cyanide holding tank after the level became too low to

pump. If removal methods were mechanically incorporated inside the tank, sludge build-up would not occur and manual cleaning of the tank would not be necessary. Other methods should be used for the removal of sludge and liquid waste from the tank before exposing workers to this hazard.

Environmental monitoring and control should be established. The facility did not have an effective ventilation system and during the tank cleaning process only two ceiling fans were used to provide air circulation. Ventilation rates should meet industrial hygiene standards for areas where workers are exposed to potentially hazardous chemicals. Ventilation should be maintained close to maximum efficiency and the adequacy of the system should be evaluated by monitoring of the work environment.

Recommendation #2: The employer should develop and 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. These procedures should minimally include the following:

1. Posting confined space warning signs on all tanks in the plant
2. Air quality testing to determine adequate oxygen supply, adequate ventilation, and the absence of all toxic and flammable air contaminants
3. Monitoring to ensure 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. Identification of chemicals, possible chemical reactions, and chemical exposures
7. Hazard communication of potentially hazardous chemicals and chemical reactions
8. Development of site specific work plans and procedures that address the task being performed, emergency access, and egress
9. Training for proper selection of personal protective clothing, based on exposures.
10. Emergency rescue procedures
11. Availability, storage, and maintenance of emergency rescue equipment

The air was not monitored for toxic air contaminants and oxygen level before the workers entered the zinc cyanide holding tank. Specific recommendations regarding safe work practices in confined spaces can be found in NIOSH publications 80-106, "Working in Confined Spaces" and 87-113, "A Guide to Safety in Confined Spaces".

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

Discussion: The employer did not have any SCBA's or supplied air respirators in the plant. The employer did provide acid-mist cartridge-type respirators; however, employees were not trained on their use and limitations. Employees were also not given physical examinations to determine if they were capable of wearing a respirator. The cartridge-type air-purifying respirator used by some of the workers in this incident was not the proper respirator for entering and cleaning a tank. A positive pressure SCBA or supplied-air respirator with auxiliary, escape-only SCBA should have been used. Adequate respirator selection should be according to criteria in the NIOSH Respirator Decision Logic (NIOSH publication #87-108) for assigning respirators in the plating operation; following these criteria will prevent workers from wearing inappropriate respirators for the task assigned.

Recommendation #4: Firefighters, police personnel and others responsible for emergency rescue should be trained in confined space rescue and hazardous material emergencies.

Discussion: Fire and police department rescuers in this incident were not adequately trained in confined space rescue procedures. Many were also unaware of the hazards of hydrogen cyanide vapor. A “level A” totally encapsulated protective suit should have been worn in the rescue effort. Additionally, adequate means of exit from the confined space (such as life lines, harnesses, or man lifts) were not incorporated into the rescue attempts. Emergency rescue teams should be cognizant of all hazards associated with confined spaces, including rescue problems, and should wear proper PPE and devices for emergency egress. The conventional leather turnout gear worn by the firefighters did not give adequate protection against hydrogen cyanide vapor.

City and county 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 also sufficient information so that emergency response personnel will have sufficient information to plan a safe rescue. The development of a chemical hazard emergency plan should be coordinated with other involved agencies so that combined rescue efforts are organized and effective.

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