The National Institute for Occupational Safety and Health (NIOSH)

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Furnace Operator Dies After Being Overcome by Argon Gas in Pressure Vessel in South Carolina

FACE 9114

SUMMARY

A 43-year-old male furnace operator (victim) died after being overcome by argon gas in a pressure vessel measuring 3 feet 6 inches in diameter by 7 feet 6 inches deep. The victim was summoned by the vessel tender to enter the vessel and retrieve three tungsten carbide steel objects that had been dropped 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, squatted down to reach under the vessel's internal heating element and retrieve the second object, and was overcome by residual argon gas at the bottom of the vessel. NIOSH investigators concluded that, in order to prevent future similar occurrences, employers should:

- develop, implement, and enforce a written safety policy and safe work procedures
- 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
- evaluate the design of the pressure vessel and its internal components to determine if it could be modified to allow for the extraction of objects from outside the vessel
- develop an extraction tool that would eliminate the need to enter a confined space (pressure vessel).

INTRODUCTION

On May 9, 1991, a 43-year-old furnace operator died after being overcome by argon gas at the bottom of a pressure vessel measuring 3 feet 6 inches in diameter by 7 feet 6 inches deep. 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 was a tungsten-carbide steel fabrication plant that had been in operation for 41 years and employed 150 workers, including 9 furnace operators. The plant engineer managed the safety program as a collateral duty. There were no written safety rules or safety policy. The workers were provided with classroom, manual, and on-the-job safety training. A worker seen committing an unsafe act was disciplined with a three days suspension for the first offense and dismissal for the second offense. The victim worked for this employer for 2 years and 3 months 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 2:00 p.m. and from 3:30 p.m. until midnight. The annealing process associated with this incident involved placing items on three sections of stacked trays and lowering them into a pressure vessel (installed in 1975) using an overhead crane (Figure). A cylindrical stainless steel insulating hood is placed over the trays. The insulating hood is 24 inches in diameter and 7 feet 6 inches high and serves as the inner liner of the vessel. The vessel is 7 feet 6 inches deep. It has an inner diameter of 2 feet and an outer diameter of 3 feet 6 inches. A 9-inch water cooling jacket surrounds the inner wall. Argon gas is piped into the vessel to pressurize it to 15,000 psi and the vessel is heated by an internal element to a temperature of 1500 degrees Celsius. 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 pumps out or “reclaims” the argon gas to de-pressurize the vessel. The hydraulically-sealed lid is removed and the insulating hood and stacked trays are lifted out of the vessel by the overhead crane. Any argon gas remaining in the vessel is allowed to escape into the atmosphere. The vessel is surrounded by a service pit 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 11:00 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 trays. At some point during this 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. Since at least one of the objects would interfere with the placement of the insulating hood, the tender decided that they would have to be removed.

He tried to remove them with a thong-like extraction tool, but could not secure them. He 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 for assistance. Because the victim was small-statured–5 feet 6 inches tall and 120 pounds–the tender may have thought the victim could more easily enter the pressure vessel than he could.

The victim arrived at the scene and tried to remove the objects with the extraction tool. He was unsuccessful. When it became apparent that entry would be necessary, the tender positioned the overhead crane over the vessel, the victim grasped the crane hook, and the tender lowered him into the vessel. He was not tied off or secured to the crane hook. When the victim reached the vessel floor, he released the crane hook, retrieved one of the objects and handed it out to the tender. As he squatted down to reach under the heating element to retrieve the second object, he was overcome by the residual argon gas in the bottom of the vessel, and collapsed.

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 a co-worker lowered him into the vessel. The co-worker saw the tender slump over and 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. Upon his arrival, he examined the victim and pronounced him 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, implement, and enforce a written safety policy and safe work procedures designed to help workers recognize, understand, and control hazards.

OSHA Standard 29 CFR 1926.21 (b)(2) states, “The employer shall instruct each employee in the recognition and avoidance of unsafe conditions and the regulations applicable to his work environment to control or eliminate any hazards or other exposure to illness or injury.” Companies should evaluate the tasks performed by workers, identify potential hazards, develop and implement a safety program addressing these hazards, and provide worker training in safe work procedures.

Recommendation #2: 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. ventilating the space 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. developing, and training employees in, emergency rescue procedures
7. identifying and controlling the hazards associated with the confined space involved.

Recommendation #3: 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.

Recommendation #4: 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. These procedures controlled the argon gas hazard.

Recommendation #5: The employer should evaluate the design of the pressure vessel and its internal components 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. Additionally, the employer should 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 during the 11-hour annealing process.

Recommendation #6: 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-designed 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.

REFERENCES

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

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

29 CFR 1926.20. Code of Federal Regulations, Washington, D.C.: U.S. Government Printing Office, Office of the Federal Register.

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