

## **Physical Hazards**

### **Engulfment**



## **FACE 86-19: Truck Driver Suffocates in Sawdust Bin in Pennsylvania**

### **INTRODUCTION**

On February 21, 1986, a 22-year-old self-employed truck driver died after entering the top of a 22-foot-high by 15-foot-square sawdust bin. He was suffocated when the sawdust inside the bin collapsed and buried him.

### **BACKGROUND/OVERVIEW OF EMPLOYER'S SAFETY PROGRAM**

The facility at which the fatality occurred has been in operation for the past 115 years and has been under the present ownership for the past 4 years. The facility employs six full-time workers. Fifty percent of the business at the facility involves the manufacturing of wooden gauge (measuring) poles for the local oil industry while the other 50 percent of the business is devoted to surfacing lumber for the local lumber industry. Safety rules exist that cover the work performed in the wood shop. No written safety rules exist that outline precautions to be taken when entering the sawdust bin; however, when the victim began hauling sawdust away from the facility 1 1/2 years ago, the owner and the victim discussed the hazards that might be encountered upon entering the sawdust bin. Both men were aware of the potential hazards. A safety line was present in the sawdust bin, but was not utilized by the victim on the day of the incident.

### **SYNOPSIS OF EVENTS**

The victim had hauled sawdust away from the facility for the past 1 1/2 years. The owner did not receive payment from the victim for the sawdust, nor did the victim bill the owner for hauling the sawdust away from the facility. The only stipulation in the agreement was that the victim would keep the level of sawdust inside the bin at such a level that production would not have to be interrupted. The sawdust bin was located outside and to the rear of the facility. At 10:30 a.m. on the day of the incident, the victim pulled his truck underneath the auger that dispensed the sawdust. This auger was mounted 5 feet above ground level on the side of the sawdust bin at approximately a 45-degree angle from ground level. The control switch was mounted adjacent to the auger. The victim turned the auger on, but very little sawdust came out of the auger. The victim then turned the auger off. It was not unusual for the sawdust to accumulate on the sides of the bin. When this occurred the victim or the owner (the only two workers allowed in the bin) would climb the ladder to the entrance, which was located on the side of the bin 22 feet above ground level. The owner or victim would then utilize a section of pipe to knock sawdust from the sides of the sawdust bin into the auger attachment. Since it was sometimes necessary to enter the sawdust bin to accomplish this task, a safety line was present inside the entrance. The owner stated that he had to remind the victim to use the safety line on several occasions.

At approximately 11 a.m. the victim entered the sawdust bin and was in the process of knocking the sawdust down into the auger attachment when the surface beneath him gave way and he was buried by the sawdust. He had not attached the safety line to himself. To compound the problem, sawdust from the wood planers in the shop continued to be blown into the sawdust bin.

At 11:15 a.m. the owner had to move the victim's truck so that a truck hauling gravel could pass through. The owner was not alarmed when he did not see the victim since it was commonplace for the victim to ride into town with someone to get coffee or something to eat. The owner then left for a doctor's appointment. When the owner returned from his doctor's appointment at 1:15 p.m. he noticed that the victim's truck had not been moved. He climbed the ladder and saw that the sawdust bin was filled to capacity. The owner also saw the end of the pipe protruding from the sawdust in the center of the bin. The owner descended the ladder, entered the facility, and asked the workers if they had seen the victim; they hadn't. The owner ordered all operations to be stopped. He then exited the facility with one of the workers and turned the auger on. The owner and worker then climbed the ladder. The owner entered the sawdust bin without utilizing the safety line and quickly sank into the sawdust up to his chest. The worker was able to rescue the owner. As the level of sawdust in the bin dropped, the victim was uncovered. At approximately 1:30 p.m. the victim was removed from the sawdust bin and was pronounced dead at the scene by the county coroner.

## CAUSE OF DEATH

The county coroner listed asphyxiation as the official caused of death.

## RECOMMENDATIONS/DISCUSSION

***Recommendation #1: All safety equipment provided at a worksite should be utilized.***

Discussion: The owner and the victim in this case both realized the inherent dangers of the unstable material inside the sawdust bin. For this reason a safety line was installed inside the upper entrance of the sawdust bin. Workers should not allow themselves to be lulled into a false sense of security when working in a confined space containing unstable material (i.e., sawdust). Had the victim used the provided safety line in this instance, the likelihood of a fatality occurring would have been greatly reduced.

***Recommendation #2: When work is being performed in a confined space containing unstable material, a standby person must be utilized.***

Discussion: A standby person stationed outside the confined space containing unstable material (i.e., sawdust) should maintain constant communication with the worker inside the area. If visual contact cannot be maintained, the standby person should at least maintain voice contact. The use of a standby person by the victim might have prevented the fatality; the use of a standby person by the owner prevented a rescue attempt fatality.

***Recommendation #3: The feasibility of installing an electrical interlock system in the facility should be examined.***

Discussion: An electrical interlock system could be installed in the facility. This system would disconnect the power to the auger, the blowers, and the planers inside the facility when the entrance to the sawdust bin was opened. This would eliminate the possibility of sawdust being drawn down into the auger causing the surface beneath a worker to collapse, and without the blowers and planers operating, additional sawdust would not be blown into the bin. In addition, this safeguard would alert plant personnel that someone was entering the storage bin.

***Recommendation #4: Facilities whose operations include entrance into a confined space should develop comprehensive policies and procedures for confined space entry and emergencies.***

Discussion: Prior to confined space entry, a hazardous operation should be explained by written procedures that address the hazards associated with entry. Several areas normally addressed by procedures such as this are permit systems (notification of other personnel), standby personnel, and procedures to be followed in an emergency. In this case all of the above areas were not initiated in accordance with generally accepted and established procedures. (The NIOSH Confined Space Document, "Working in Confined Spaces," Publication 80-106, discusses these procedures in detail.)

## **FACE 87-49: Farmer Dies in Indiana**

### **INTRODUCTION**

On May 26, 1987, a farmer suffocated when he was engulfed in shelled corn inside a grain storage bin. The storage bin had a capacity of 12,000 bushels.

### **OVERVIEW OF EMPLOYER'S SAFETY PROGRAM**

The victim was the owner of a 100-acre grain farm. There was no written safety program or safety policy. The farmer was aware of the hazards associated with grain storage bins. He often instructed fellow farmers and family members never to enter a grain storage bin without wearing a harness attached to a lifeline.

### **SYNOPSIS OF EVENTS**

The farmer had rented a grain storage bin with 12,000 bushels capacity at a nearby farm. He had stored approximately 8,000 bushels of shelled corn in the storage bin. The temperature of the corn was beginning to rise and the farmer was afraid it was going to spoil. On the day of the incident he was going to load a portion of the grain onto a truck. He was planning to use a grain auger to load the corn onto a truck and to stir the corn remaining in the storage bin. He was doing this in an effort to lower the temperature of the corn. The farmer had diabetes and had recently suffered from "dizzy spells" associated with the disease. He was warned by his daughter as he left the house at noon not to enter the storage bin, and he said he would not.

The farmer drove to the bin and pulled the truck under the loading chute. He then started the auger, using the controls at the base of the storage bin. There were no witnesses to the accident, but it is assumed he climbed the ladder attached to the side of the bin (20 feet) and entered the door at the top. The farmer's son arrived at the storage bin at approximately 2 p.m. He noticed the auger running and only a small amount of corn coming out of the loading chute. Assuming that his father was visiting neighbors, the son opened the chute, but left the auger running and returned home.

At approximately 4:30 p.m., the son was notified by his wife that his father had not returned home. The son and a friend drove to the grain storage bin. The truck had not been moved and the auger was still running. In order to remove the shelled corn, the door on the side of the bin was opened. Cutting torches were used to cut holes at the base of the storage bin. The shelled corn was shoveled away from the storage bin by hand for approximately 2 hours before the farmer's body was found.

### **CAUSE OF DEATH**

The coroner listed "suffocation" as the cause of death.

### **RECOMMENDATIONS/DISCUSSION**

***Recommendation #1: When work is being performed in a confined space containing unstable material, a standby person should be utilized.***

**Discussion:** A standby person stationed outside of confined spaces containing unstable material (i.e. shelled corn) should maintain constant communication with the worker inside the area. If visual contact cannot be maintained, the standby person should at least maintain voice contact. The use of a standby person would have greatly reduced the amount of time before rescue procedures began and may have prevented this fatality.

***Recommendation #2: Confined spaces containing unstable material should be equipped with life lines and harnesses at their entrance point(s).***

**Discussion: Life lines and harnesses should be present at the entrance(s) of confined spaces containing unstable materials and should be utilized by all persons entering the confined space. If these are not provided by the manufacturer they should be installed by the user prior to entry into the confined space. A life line and harness may have prevented this fatality.**

## **FACE 89-33: Grain Elevator Leadman Suffocates After Being Engulfed in Shelled Corn Inside Silo**

### **INTRODUCTION**

On April 5, 1989, a 54-year-old male grain elevator leadman died when he was engulfed in corn stored inside a 76-foot-high, 33-foot-diameter grain silo. The victim was using a pneumatic conveyer to clean the inside of the grain silo.

### **OVERVIEW OF EMPLOYER'S SAFETY PROGRAM**

The victim was employed as an elevator leadman at a grain processing facility that has been in operation for 47 years. The facility employs a total of 80 workers, and has no written safety policy or safety program. Workers receive on-the-job training. Since the incident, the facility has instituted a comprehensive confined space entry program.

### **SYNOPSIS OF EVENTS**

On the afternoon prior to the incident, the victim and a co-worker were assigned the task of removing the remaining grain (shelled corn) from a concrete silo. Most of the grain had been removed by a 16-inch-wide gravity-fed auger-transfer unit incorporated into the floor of the silo. When the grain had reached a level approximately 6 feet above floor level, it would no longer feed into the conveyer. An estimated 10,000 bushels of corn remained in the silo. Until 6 months previous to this incident, procedures called for the remaining grain to be shoveled from the silo by hand. However, the employer purchased a pneumatic conveyer which was powered by the power take-off system of a tractor. Using this device, the remaining grain could be transferred from the silo into a truck by means of a 5-inch diameter suction hose. This pneumatic conveyer had the capacity to transfer between 2,500 and 3,000 bushels of corn per hour.

On the day prior to the incident, the victim and his co-worker positioned the pneumatic conveyer outside the silo. The victim and the facility manager entered the silo by means of a door (16 inches by 18 inches) located on the side of the silo. The bottom of the door was 6 feet above the floor level of the silo. The shelled corn that remained in the silo was level with the bottom of the door. The two men inspected the surface of the grain at that time and felt confident that the surface was not crusted and that no bridging (crusted surface covering a hollow space) was present in the remaining grain. The men then exited the silo. The victim re-entered the silo later with the suction hose of the pneumatic conveyer and began transferring the grain to a truck outside. A co-worker remained outside the silo to operate the tractor and the pneumatic conveyer. After enough corn was removed to determine the machinery was working properly, the two men then shut off the equipment and left it in position for the following day.

The following morning the men resumed the transfer operation. At 10 a.m., the co-worker heard the victim yell from inside the tank to turn the pneumatic conveyer off. After not seeing or hearing from the victim for a few moments, the co-worker looked through the door into the silo. When the co-worker did not see the victim inside the silo, he assumed that the victim had exited the silo and gone inside the office building. Discovering that the victim had not been seen in the area, he called the facility manager. A decision was made to begin cutting holes around the perimeter of the silo in order to remove the grain. In addition, the pneumatic conveyer was restarted and the facility manager entered the silo to operate the suction hose. At 2 p.m., after some of the grain had been removed, the victim was found lying on his back on the floor of the silo. He was removed from the silo by facility personnel and was pronounced dead at the scene by the county coroner.

The rapid removal of the grain by the pneumatic conveyer may have created a quicksand-like effect at the feet of the victim causing him to be engulfed by the shelled corn before he could exit the silo.

## CAUSE OF DEATH

The county coroner ruled suffocation as the cause of death.

## RECOMMENDATIONS/DISCUSSION

***Recommendation #1: Employers should develop a comprehensive safety program that clearly documents procedures for safe entry into confined spaces such as those contained in the NIOSH criteria document on "Working in Confined Spaces" (NIOSH Publication 80-106) and "A Guide to Safety in Confined Spaces" (NIOSH Publication 87-113).***

**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 working in a confined space. These procedures should include, but not be limited to:

1. testing air quality to determine adequate oxygen level and the presence of flammable and/or toxic gas/vapors
2. ventilating the space to remove air contaminants
3. monitoring the space to determine a safe oxygen level is maintained
4. training employees in confined space entry, testing, and use of personal protective equipment, safety harnesses, respirators, clothing, etc.
5. stationing a standby person(s) outside the space for communication and visual monitoring
6. providing for emergency rescue procedures
7. identifying and controlling of the hazards associated with unstable surfaces.

Since the incident the employer has implemented a comprehensive confined space entry program.

***Recommendation #2: Confined spaces containing unstable material should be equipped with life lines and harnesses at their entrance point(s), and workers should be trained in their usage.***

**Discussion:** Life lines and harnesses should be present at the entrance(s) of confined spaces containing unstable materials and should be utilized by all persons entering the confined spaces. If these are not incorporated into the design of the silo by the manufacturer, they should be installed by the user prior to worker entry into the confined space. Workers should then be trained in the proper use of this equipment.

***Recommendation #3: When work is being performed in a confined space containing unstable material, a standby person should be utilized in a manner such that constant communication with the worker inside the confined space can be maintained.***

**Discussion:** A standby person, e.g., stationed outside of confined spaces containing unstable material (i.e., shelled corn), should maintain constant communication with the worker inside the area. If visual contact cannot be maintained, the standby person should at least maintain constant voice contact. In this instance, although there was a person outside the silo, he was not a designated standby person and did not maintain constant contact with the person inside. The co-worker outside the silo was operating noisy machinery that made it difficult to hear a worker inside the silo. Although the co-worker heard the victim yell to turn the pneumatic conveyor off, he may not have heard other calls from the victim. If a designated standby person had been stationed at the door of the silo, quicker action may have been taken that may have prevented the fatality.



***Recommendation #4: Employers should perform a hazard analysis on each new piece of equipment or machinery and associated tasks to determine if potential hazards exist.***

Discussion: A proper hazard analysis involves three distinct steps:

- (1) outline each step of a task or activity that involves the equipment or machinery
- (2) identify all potential hazards presented by the equipment or machinery during each step
- (3) develop measures for controlling each hazard.

Had such an analysis been performed, the employer may have identified the danger associated with rapidly transferring unstable material when someone is standing on the surface of that material.

***Recommendation #5: Employers should instruct workers to enter confined spaces only when absolutely necessary and to strictly adhere to established confined space entry procedures.***

Discussion: In this instance it was not absolutely necessary for the worker to enter the silo when the job began. A significant amount of the corn could have been removed while a worker maneuvered the 5-inch flexible hose from outside the silo. Enough corn could have been transferred in this manner to allow the victim to stand on the floor of the silo to complete the job. This would have eliminated the hazard of performing work while standing on an unstable surface.

***Recommendation #6: Employers should not allow workers to stand on or work from the surface of loose, granular materials, even when the surface appears to be stable.***

Discussion: Employers should not only prohibit workers from standing on unstable surfaces while performing their assigned tasks, but should also require employees to wear safety harnesses or safety belts attached to lifelines when working in the vicinity of unstable surfaces. Workers should be made aware of the hazards, such as engulfment, bridging, and crusting, associated with unstable surfaces. Workers should be instructed in the identification of these hazards and appropriate methods needed to avoid them.

***Recommendation #7: Equipment manufacturers should recognize potential hazards inherent in the operation of their products, and provide appropriate warnings and safety information in product advertising and packaging.***

Discussion: At the time of the investigation, advertising literature for two manufacturers of pneumatic conveyor systems was obtained. Neither pamphlet contained any warning of the hazards associated with entering confined spaces or the hazards associated with unstable surfaces such as stored grain. A photograph in one pamphlet actually shows a worker inside a silo standing on shelled corn while performing his task. No safety devices or stand-by persons are visible in the photograph.

Both manufacturers were apprised of the situation and alerted to the hazard presented by standing on grain while using the pneumatic conveyor system. The manufacturers are considering including a warning in the advertising literature that addresses the hazards associated with confined spaces and unstable surfaces. Additionally, copies of NIOSH publications 87-113 (A Guide to Safety in Confined Spaces) and 88-102 (Preventing Entrapment and Suffocation Caused by the Unstable Surfaces of Stored Grain and Other Materials) were sent to the manufacturers for consideration as supplementary information to be included with advertising literature. Responsible advertising could contribute to the prevention of these fatalities.

## FACE 91-04: Maintenance Worker Suffocates From Engulfment After Falling Into Sawdust Silo

### SUMMARY

A maintenance worker (victim) for a furniture manufacturing company fell headfirst into a sawdust storage silo and suffocated. The silo is 17 feet in diameter, 36 feet high, and has a 24-inch diameter manhole on top near the edge. Although there were no witnesses, evidence suggests that the victim did the following: a) climbed to the top of the silo to check the sawdust level inside, b) removed the manhole cover, c) stuck his head inside the manhole and noted that the silo was nearly full of sawdust, d) reached inside the manhole with a hoe-like tool to "rake down" the sawdust pile, e) slipped from this position, and f) fell headfirst into the sawdust 7 feet below. The upper half of the victim's torso became submerged in the sawdust and the victim suffocated in an upside down position. NIOSH investigators concluded that, in order to prevent future similar occurrences, employers should:

- *provide appropriate fall protection equipment to all workers who may be exposed to a fall hazard*
- *develop and implement safe work procedures for employees who work in, or near, confined spaces containing unstable materials*
- *develop and implement a comprehensive confined space safety program*
- *consider retrofitting silos and similar storage facilities with mechanical leveling/raking devices, or other means to minimize the need for workers to climb and enter silos.*

### INTRODUCTION

On September 21, 1990, a 52-year-old male maintenance worker died after falling headfirst into a sawdust silo. On September 25, 1990, officials of the Virginia Occupational Safety and Health Administration notified the Division of Safety Research (DSR) of the death, and requested technical assistance. On November 15, 1990, a research industrial hygienist from DSR traveled to the incident site and conducted an investigation. The DSR investigator reviewed the incident with company representatives and employees, the medical examiner, and the Virginia OSHA compliance officer assigned to this case. Photographs of the incident site were obtained during the investigation.

The employer in this incident is a furniture manufacturer that has been in business for 60 years. Most of the work performed by the company involves machining hardwood and the assembly of furniture components. The company employs 275 full-time employees, including 6 maintenance workers. The victim had been employed by the company for 8 years as a maintenance worker. The company has a written safety program consisting of hazard communication, lockout/tagout, respiratory protection, and confined space entry components. A safety committee composed of supervising laborers and management is responsible for the safety program. New employees receive on-the-job safety training from supervisors and co-workers.

### INVESTIGATION

Wood scraps and sawdust from the plant production areas are removed by a system of mechanical conveyors and suction ducts. The sawdust is stored in one of two steel silos, then burned in the plant boiler. The sawdust is drawn into each silo through an 8-inch diameter duct at the top center of the structure. The larger silo, measuring 25 feet in diameter and 55 feet high, operates about 80 percent of the time. When it is full or being emptied, sawdust is diverted to a smaller silo (measuring 17 feet in diameter and 36 feet high). The smaller silo will fill up in about 5 days when the plant is in full operation.

The victim was responsible for keeping the scrap wood conveyers, sawdust removal ducts, and the two silos operating. Whenever the smaller silo was in operation, the victim would visually check the sawdust level inside the silo twice a day. The victim would climb a staircase attached to the side of the silo, remove

the cover to a 24-inch-diameter manhole located at the top near the edge, and peer inside. If the tip of the sawdust pile or cone was close to the inlet duct, the victim would “rake it down.” This was done by reaching inside the manhole with a tool resembling a garden hoe with a 10-foot-long aluminum handle. The victim kept this tool on top of the silo near the manhole.

The smaller silo was in operation on the day of the incident. At 1:15 p.m., the victim entered the boiler room and informed the maintenance supervisor that he believed the smaller silo was nearly full, and that he was going to check the sawdust level. Although there were no eyewitnesses to the incident, based on the circumstances and evidence, it is presumed that the following sequence of events occurred:

- the victim climbed the stairs to the top of the small silo and opened the manhole cover
- the victim crouched, or laid down, stuck his head inside the manhole and noted that the silo was nearly full of sawdust
- the victim reached inside the manhole with the hoe to rake down the sawdust pile
- the victim slipped from his position and fell 7 feet, headfirst into the sawdust
- the upper half of the victim’s torso became submerged in the sawdust and the victim suffocated in an upside-down position.

About 30 minutes later, a co-worker entered the boiler room and asked the maintenance supervisor if he had seen the victim. The maintenance supervisor told the co-worker that the victim had gone to check on the sawdust level in the smaller silo. The co-worker climbed to the top of the silo and peered inside the manhole. He saw the victim’s legs sticking out of the sawdust, and the hoe lying on top of the sawdust. The co-worker yelled to the victim, but there was no response.

The co-worker ran back to the boiler room and told the maintenance supervisor what had happened. The maintenance supervisor radioed the plant superintendent, who called the emergency medical service (EMS). The plant superintendent, maintenance supervisor, co-worker and several other workers ran up the stairs to the top of the silo. The superintendent tied a rope around his waist, the other workers lowered him into the silo through the manhole, and he tied a rope around the victim’s waist. The workers pulled the victim out while the superintendent assisted from inside the silo. After the superintendent was pulled out of the silo, he carried the victim down the stairs to the ground. By this time, EMS personnel had arrived at the scene (about 10 minutes after the emergency call was received). EMS personnel administered cardiopulmonary resuscitation to the victim at the scene and in route to the local hospital. The victim was pronounced dead on arrival by the attending physician.

## **CAUSE OF DEATH**

The medical examiner listed the cause of death as suffocation due to submersion in sawdust.

## **RECOMMENDATIONS/DISCUSSION**

***Recommendation #1: Employers should provide appropriate fall protection equipment for all workers who may be exposed to a fall hazard.***

**Discussion:** Employers should provide appropriate fall protection equipment for all workers exposed to fall hazards, and should provide worker training in the proper use of this equipment. Once this training is provided, employers should initiate measures to ensure the use of this fall protection equipment. A safety belt and lanyard, suitably anchored, would be appropriate fall protection equipment for use on top of sawdust silos. This type of fall protection equipment has an additional life-saving benefit. When properly installed, such fall protection equipment will prevent workers from being engulfed if they fall into a silo or other confined space containing unstable materials.

***Recommendation #2: Employers should develop and implement safe work procedures for employees who work in, or near, confined spaces containing unstable materials.***

Discussion: OSHA construction safety standard 29 CFR 1926.250(b)(2), General Requirements for Storage, requires workers to use safety belts while working on stored materials in silos, bins, or other similar storage areas. The Mine Safety and Health Administration (MSHA) has requirements for storage of materials in the mining industry (39 CFR 56). These requirements address the storage of loose, unconsolidated materials, safe access, and the use of safety belts and lines. In the absence of general industry standards covering such work, these requirements are appropriate for application to similar situations in general industry. Life lines and harnesses should be present at the entrances of confined spaces containing unstable materials, and should be used by all workers (including rescuers) entering confined spaces. Optimally, lifelines and harnesses should be incorporated into the design of the silo by the manufacturer. Silos without this design feature should be provided with appropriate safety equipment, by the employer, and use should be mandatory. Workers should be trained in the proper use of this equipment. Some lifelines, harnesses, and human hoisting devices designed for confined space entry are also rated for fall protection (Recommendation #1). A NIOSH Alert entitled "Request for Assistance in Preventing Entrapment and Suffocation Caused by the Unstable Surfaces of Stored Grain and Other Materials" provides additional recommendations pertaining to work on or around silos.

***Recommendation #3: Employers should develop and implement a confined space safety program.***

Discussion: Employers should ensure that 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. adequate ventilation to remove air contaminants
3. monitoring the space to determine that a safe atmosphere is continuously maintained
4. training 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. emergency rescue procedures
7. identifying and controlling the hazards associated with unstable surfaces.

***Recommendation #4: Employers and manufacturers should consider retrofitting silos and other similar storage facilities with mechanical leveling/raking devices, or other means to minimize the need for workers to climb or enter silos.***

Discussion: Silos, bins, hoppers, tanks, transport vehicles, and surge piles where loose materials are stored, handled, or transferred should be equipped with mechanical leveling/raking devices or other means for remotely handling materials. Such devices would minimize the need for workers to climb or enter such storage facilities. Usually cone shaped piles of loose material can be leveled, and bridging of material prevented, by mechanical agitation or vibration of stored materials.

## REFERENCES

1. Office of the Federal Register, Code of Federal Regulations, Labor, 29 CFR 1926.250(b)(2), U.S. Department of Labor, Occupational Safety and Health Administration, Washington, D.C., July 1989.
2. Office of the Federal Register, Code of Federal Regulations, Labor, 39 CFR 56.16002, 39 CFR 56.11001, and 39 CFR 56.15005, U.S. Department of Labor, Mine Safety and Health Administration, Washington, D.C., July 1989.
3. National Institute for Occupational Safety and Health, Request for Assistance in Preventing Entrapment and Suffocation Caused by the Unstable Surfaces of Stored Grain and Other Materials, DHHS (NIOSH) Publication Number 88-102, December 1987.
4. National Institute for Occupational Safety and Health, Criteria for a Recommended Standard... Working in Confined Spaces, DHHS (NIOSH) Publication Number 80-106, December 1979.
5. National Institute for Occupational Safety and Health, A Guide to Safety in Confined Spaces, DHHS (NIOSH) Publication Number 87-113, July 1987.

## **FACE 91-12: Truck Driver Suffocates After Being Engulfed in Shelled Corn Inside Grain Storage Bin in Ohio**

### **SUMMARY**

A truck driver (victim) was engulfed in shelled corn inside a grain storage bin and suffocated while trying to clear an obstructed grain auger. The grain bin was 32 feet in diameter, 20 feet high, and contained approximately 8,000 bushels of corn at the time of the incident. The bin had a 36-inch by 20-inch hatch at the top near the edge, another hatch on the side, 2 feet above the bin floor, and steel access ladders anchored to the exterior and interior of the bin wall. The victim and two farm laborers were transferring corn from the bin to a truck, using two augers. One auger, placed horizontally in the bottom of the bin, pushed the corn through a pipe into a small hopper outside the bin. The second auger lifted the corn from the hopper to the truck. When each truck was loaded, the corn was hauled to a commercial grain storage silo. When the third truckload had been loaded, the corn stopped flowing into the hopper. The victim and one of the laborers entered the grain bin through the top hatch and tried to get the grain flowing again. The victim stood on the surface of the corn in the middle of the bin, and probed the corn with a 15-foot-long section of 1-inch-diameter galvanized pipe. The laborer stood on the corn near the ladder at the side of the bin. When the corn began to flow, the victim was quickly engulfed, sank to the bottom of the bin, and suffocated. The laborer hung onto the ladder and escaped injury. NIOSH investigators concluded that, in order to prevent future similar occurrences, employers should:

- *develop and implement safe work procedures and training for employees who work in, or near, confined spaces containing unstable materials*
- *provide lifelines and harnesses, and ensure that workers wear them before entering confined spaces containing unstable materials*
- *consider retrofitting grain storage bins and other similar storage facilities with mechanical leveling/raking devices, or other means to minimize the need for worker entry.*

### **INTRODUCTION**

On January 24, 1991, a 43-year-old male truck driver (victim) died after being engulfed in shelled corn inside a grain storage bin. On February 26, 1991, officials of the Ohio State University Agricultural Department notified the Division of Safety Research (DSR) of the death, and requested technical assistance. On March 26, 1991, a research industrial hygienist from DSR traveled to the incident site and conducted an investigation. The DSR investigator reviewed the incident with the company owner, the medical examiner, the property owner, the investigating police officer, the county agriculture extension agent, and a representative from the Ohio State University Agriculture Department. Photographs of the incident site were obtained during the investigation.

The employer in this incident, a commercial trucking company, had been in business for 23 years. Most of the work performed by the company had involved hauling agricultural products. At the time of the incident, the company owner employed only one truck driver (the victim), who had worked for the owner for 23 years. The owner had employed as many as four truck drivers at one time. The company did not have a written safety policy, safety program or established safe work procedures. Employees did not receive any type of safety training.

### **INVESTIGATION**

On the day before the incident, the company owner contacted the victim and asked him to haul approximately 12,000 bushels of shelled corn from a grain bin on a local farm to a nearby commercial grain storage silo.

The grain bin on the farm was 32 feet in diameter, 20 feet high, and was constructed of corrugated galvanized steel. The bin had two access hatches. One hatch was on the side, 2 feet above the bin floor,

and measured 30 inches wide by 60 inches high. The other hatch was located on the top near the edge, and had an elliptical shape measuring 36 inches by 20 inches across the center. Posted on the inside of the top hatch door was a 20-inch by 12-inch hazard warning sign in red and black lettering. It stated, "DANGER ... YOU CAN SUFFOCATE UNDER GRAIN IN THIS BIN ... DO NOT ENTER WHEN THIS BIN IS BEING LOADED OR UNLOADED." Also included on the warning sign were safety instructions, and diagrams depicting potential hazards of being engulfed and suffocating in grain. Access to the top of the bin was provided by a galvanized steel ladder anchored to the outside of the bin. A second ladder was anchored to the inside of the grain bin, and extended from the top hatch to the bin floor. Installed within the concrete floor of the bin was a channel with an auger shaft. The auger was connected to a horizontal, 4-inch-diameter grain discharge pipe which extended to the outside of the grain bin. When the grain was loaded from the bin to a truck for commercial transport, a portable electric motor was mounted to the discharge pipe outside the bin. A drive belt on the electric motor turned the shaft of the horizontal auger, and the grain was drawn from the bottom of the bin, through the discharge pipe, and into a small plastic hopper outside the bin. A mobile grain auger, driven by a tractor power-take-off (PTO) unit lifted the grain from the hopper to the truck.

The victim arrived at the site in the afternoon on the day before the incident. With the help of two farm laborers employed by the property owner, the victim transferred nearly 3,000 bushels of corn from the bin to the truck. When the second truckload was nearly loaded, the victim and farm laborers noticed that some of the corn appeared to be "out of condition," i.e., to have a high moisture content. This caused the grain to agglutinate, and obstructed its flow. Since it was late in the afternoon, the victim decided to transport the second load, and complete loading and transporting the rest of the corn the following day.

On the day of the incident, the victim returned to the site at 1 p.m., and worked with the farm laborers to fill the third truckload. When the truck was nearly full, the corn stopped flowing out of the bin discharge pipe. The victim transported that load, and returned at approximately 5 p.m. The victim told the farm laborers that he would enter the grain bin and probe the corn with a pole or rod to get the corn flowing again. He found a 15-foot-long, 1-inch-diameter section of galvanized pipe to use for this purpose. He climbed the ladder to the top of the grain bin, and one of the laborers (first laborer) handed him the pipe. The victim opened the top hatch, inserted the pipe, and entered the bin with the grain bin auger still running. There was approximately 12 feet of corn remaining inside the bin. The first laborer entered the bin and stood on the corn near the ladder to help the victim probe the corn. The victim stood on the corn near the center of the bin and pushed the pipe to the bottom of the bin in several places, but the corn still would not flow.

Suddenly, the corn began to flow, pulling the victim down with it. Almost instantly the victim was buried up to his knees, and continued to sink into the corn. The victim immediately yelled to the first laborer, "Turn off the auger!" The first laborer hurriedly climbed up the ladder, stuck his head out the top hatch, and shouted to the laborer who was on the ground near the hopper (second laborer) to turn off the grain bin auger. The second laborer immediately pulled the electric power cord to the auger motor, and the first laborer climbed back down into the bin in an attempt to rescue the victim. The first laborer could not see very well because of the dust in the air, so he yelled the victim's name several times, but could not hear any response. The first laborer climbed back up the ladder inside the bin, and told the second laborer to "Get help!"

After calling the emergency medical service (EMS) from a phone at a nearby residence, the second laborer climbed to the top of the grain bin, and the two laborers entered the bin to look for the victim. The grain had stopped flowing but the dust in the air restricted the laborers' visibility to only a few feet. The laborers searched for the victim for approximately 10 minutes. They walked across the surface of the corn several times, thrusting their hands into the corn in various places, and calling out the victim's name. However, they were unsuccessful in locating the victim, and did not hear any response from him.

Two police officers, followed by several local volunteer fire fighters, arrived at the scene approximately 10 to 15 minutes after receiving the emergency call. They opened the side hatch on the bin, and began shoveling corn away from the bin. Fire fighters cut several openings in the side of the bin with the bucket on a front end loader and a metal-cutting power saw. Other emergency responders shoveled corn away

from all the openings in the bin. The victim was found on the bottom of the bin after having been engulfed for approximately 90 minutes. The victim received cardiopulmonary resuscitation (CPR) at the scene and in route to a local hospital where the attending physician pronounced him dead on arrival.

#### **CAUSE OF DEATH:**

The medical examiner listed the cause of death as mechanical asphyxiation due to inhumation in corn.

#### **RECOMMENDATIONS/DISCUSSION**

***Recommendation #1: Employers should develop and implement safe work procedures and training for employees who work in, or near confined spaces containing unstable materials.***

**Discussion:** Farm workers, truck drivers, and other employees who work with agricultural products are regularly exposed to confined space hazards. Employers should ensure that they and their workers are familiar with the hazards of grain bins, silos, manure pits, and other farm-related confined spaces. Additionally, they should be aware of possible emergencies, and specific procedures to follow, prior to working in confined spaces. Grain storage bins, by their design, meet the NIOSH criteria for the definition of a confined space. Entrance into these bins should be in accordance with the guidelines in NIOSH Publication 80-106 ("Criteria for a Recommended Standard ... Working in Confined Spaces"). Four other publications, designed to increase worker awareness of confined space hazards, and to provide specific recommendations for safe work procedures are available: (1) A grain bin hazard alert, developed and published by the Ohio State University Cooperative Extension Service, "Suffocation Hazards in Grain Bins," (2) NIOSH Publication 88-102 (NIOSH Alert, "Request for Assistance in Preventing Entrapment and Suffocation Caused by the Unstable Surfaces of Stored Grain and Other Materials"), (3) NIOSH Publication 86-110 ("Request for Assistance in Preventing Occupational Fatalities in Confined Spaces"), and (4) NIOSH Publication 87-113 ("A Guide to Safety in Confined Spaces"). During the on-site investigation, the NIOSH/DSR investigator gave a copy of each NIOSH publication to the employer, the farm owner, and the agriculture extension agent. The publications do not address all safety concerns and recommendations for every situation. However, they do provide useful information in developing safety training and safe work procedures specific to the engulfment hazards associated with storing and transporting grain. Some of these issues which should be addressed are included in the appendix of this report.

***Recommendation #2: Employers should provide lifelines and harnesses, and ensure that workers wear them before entering confined spaces containing unstable materials.***

**Discussion:** OSHA construction safety standard 29 CFR 1926.250(b)(2), General Requirements for Storage, requires workers to use safety belts while working on stored materials in silos, grain bins, or other similar storage areas. The Mine Safety and Health Administration (MSHA) has requirements for storage of materials in the mining industry (30 CFR 56). These requirements address the storage of loose, unconsolidated materials, safe access, and the use of safety belts and lines. Although OSHA and MSHA have no jurisdiction in this incident, their standards serve as appropriate guidelines in this instance. Life lines and harnesses should be present at the entrances of confined spaces containing unstable materials, and should be used by all workers (including rescuers) entering confined spaces. A standby person should tend the lifeline when silos, bins, tanks, or other confined spaces are entered. If the manufacturer does not incorporate lifelines and harnesses into the design of the storage bin or silo, then the employer should provide the equipment. The use of this equipment should be mandatory, and workers should be properly trained in how to use it. Some lifelines, harnesses, and human hoisting devices designed for confined space entry are also rated for fall protection (Appendix item #1).

***Recommendation #3: Employers should consider retrofitting grain storage bins and other similar storage facilities with mechanical leveling/raking devices, or other means to minimize the need for workers to enter grain storage bins.***



Discussion: Grain bins, silos, hoppers, tanks, transport vehicles, and surge piles where loose materials are stored, handled, or transferred should be equipped with mechanical leveling/raking devices or other means for remotely handling materials. Such devices would minimize the need for workers to enter such storage facilities. Usually cone-shaped piles of loose material can be leveled, and bridging of material prevented, by mechanical agitation or vibration of stored materials.

## REFERENCES

1. National Institute for Occupational Safety and Health, Criteria for a Recommended Standard ... Working in Confined Spaces, DHHS (NIOSH) Publication Number 80-106, December 1979.
2. Ohio State University Cooperative Extension Service, Suffocation Hazards in Grain Bins, August 1975.
3. National Institute for Occupational Safety and Health, Request for Assistance in Preventing Entrapment and Suffocation Caused by the Unstable Surfaces of Stored Grain and Other Materials, DHHS (NIOSH) Publication Number 88-102, December 1987.
4. National Institute for Occupational Safety and Health, Request for Assistance in Preventing Occupational Fatalities in Confined Spaces, DHHS (NIOSH) Publication Number 86-110, January 1986.
5. National Institute for Occupational Safety and Health, A Guide to Safety in Confined Spaces, DHHS (NIOSH) Publication Number 87-113, July 1987.
6. National Institute for Occupational Safety and Health, Guidelines for Controlling Hazardous Energy During Maintenance and Servicing, DHHS (NIOSH) Publication Number 83-125, September 1983.
7. Office of the Federal Register, Code of Federal Regulations, Labor, 29 CFR 1926.250(b)(2), U.S. Department of Labor, Occupational Safety and Health Administration, Washington, D.C., July 1989.
8. Office of the Federal Register, Code of Federal Regulations, Labor, 39 CFR 56.16002, 39 CFR 56.11001, and 39 CFR 56.15005, U.S. Department of Labor, Mine Safety and Health Administration, Washington, D.C., July 1989.

## APPENDIX

### Confined Space Safety Checklist for Grain Storage Bins:

1. Is entry necessary? Can the assigned task be accomplished from the outside? Under certain conditions, a worker could use a non-conductive pole (such as fiberglass or wood) of sufficient length to probe the grain in a bin from immediately above the top hatch, without entering. However, to prevent electrical injury, workers should first verify that there are no overhead electric powerlines near the grain bin that a pole might contact. Also, for fall protection, workers should wear a harness with a lifeline tied off to a secure anchorage point on top of the bin.

Employers should address the following items (beginning with #2) only if entry into a grain bin has been determined necessary:

2. Are grain bins and other confined spaces posted with warning signs where workers will notice them? In this incident, a warning sign was posted on the top hatch where the victim entered.
3. Has the grain bin auger been de-energized and locked out/tagged out prior to entry?
4. Has consideration been given to testing the air quality to determine an adequate oxygen level and the presence of flammable and/or toxic dust, gas, or vapor?

5. Is ventilation equipment of explosion-proof design available and used before and during entry? Some grain storage bins, like the one in this incident, have an electric fan built into the side of the bin at the bottom. The fan can be operated to pull air from the top of the bin and out the bottom. In this incident, the fan was not used.
6. Do workers know how and when to use the following personal protective equipment?:
  - Respirators (air-supplying and air-purifying)
  - Lifelines/harnesses
  - Emergency rescue equipment (SCBA, human hoist, etc.)
  - Protective clothing
  - Eye protection
  - Hard hats
  - Gloves
7. Can workers recognize confined spaces (grain bins, tanks, silos, etc.), and are they aware of their hazards?
8. Do workers discuss confined space safe work practices with employers and co-workers before attempting entry?
9. Is there a confined space rescue plan, and do workers know how to respond safely in an emergency?

## **FACE 92-34: Mill Worker Dies in Feed Storage Bin**

### **SUMMARY**

On August 31, 1992, a 56-year-old male millworker (the victim) died of suffocation after becoming engulfed in soybean hulls in a grain mill storage bin. The victim and two co-workers were unloading the soybean hulls from an open-topped indoor storage bin compartment when the material became lodged in the compartment. The victim positioned himself on the upper level of the multilevel feedmill building to attempt to dislodge the material with a flexible sewer tape. After load out operations had been completed, the co-workers could not locate the victim. He was later found dead inside the bin compartment, engulfed in the soybean hulls. The victim either entered or fell into the open-topped storage compartment and was engulfed when the bridged material collapsed during load out operations.

NIOSH investigators concluded that, to prevent future similar incidents, employers should:

- *develop, implement, and enforce a written safety program which includes confined space entry and rescue procedures and training to ensure that workers assume that all stored materials are bridged and that the potential for entrapment and suffocation associated with stored grain and other loose materials is constant*
- *ensure that workers are protected from the engulfment hazards of open-topped bins by installing bin covers to prohibit entry*
- *consider installation of devices which will prevent stored granular materials from lodging on the inside of bins*
- *install standard railings with toeboards and intermediate rails around all openings where persons may be exposed to hazards of falls*
- *ensure that workers entering storage areas wear safety belts or harnesses equipped with properly fastened life lines*
- *ensure that safety signs are posted to warn workers of the hazards of working with stored grains and other loose materials.*

### **INTRODUCTION**

On August 31, 1992, a 56-year-old male millworker (the victim) died of suffocation after becoming engulfed in soybean hulls. On September 14, 1992, the Virginia Occupational Safety and Health Administration (VAOSHA) notified the Division of Safety Research (DSR) of the incident and requested technical assistance. On September 23, 1992, a DSR safety engineer traveled to the site and conducted an investigation of the incident. The investigator interviewed the general manager of the feedmill, a co-worker, and the VAOSHA compliance officer assigned to the case. Measurements and photographs of the site were obtained as well as copies of the death certificate and medical examiner's report.

The employer was a regional farm bureau established in 1913, employing a total of 40 employees at various locations through-out the region, 5 of whom were millworkers employed at the feed-mill where the incident took place. According to the general manager, the facility had been in existence in various capacities for about 80 years. Safety issues were the responsibility of the general manager, who reported to a board of directors. The employer did not have a written safety program; however, safety policies were communicated verbally from the general manager to employees. There was no formal training program and specific job duties were learned on the job. The victim had been employed as a millworker for 10 years, all at the incident site. This was the first fatality experienced by the farm bureau since its inception.

## INVESTIGATION

The incident occurred in a 10-compartment open-topped storage bin, which was approximately 47 feet long, 20 feet wide, and 18 feet deep. The top of the bin was accessed by a 27-inch-wide walkway around two sides and one end. The compartments were arranged in two rows of five, with an auger-type conveyor centrally located along the top of the bin. The conveyor loaded material into each compartment through individual discharge chutes dropping from the side of the conveyor trough. Load out was accomplished by another auger-type conveyor system located under the compartment hoppers. At the time of the incident, a nonstandard railing had been installed around one side of the bin, 36-inches above the walkway.

On the day of the incident, the victim and co-workers started work at the normal 7 a.m. start time. Throughout the morning the victim and his co-workers had been engaged in loading trucks with material from the bin compartments. At about 11 a.m. they began loading a truck with soybean hulls. They had almost completed loading the truck when the compartment was emptied.

They then switched load out to the end compartment, which had been filled 3 weeks earlier with 18.6 tons (37,220 lbs.) of soybean hulls. The victim and his two co-workers attempted to unload the compartment by opening the slide gate under the compartment hopper and pounding on the hopper sides to dislodge the hulls. When this failed, the victim ascended the stairs to the walkway around the top of the bin, and attempted to dislodge the bridged material by dropping the weighted end of a flexible sewer tape into the soybean hulls. Shortly after the victim left, the co-workers observed the hulls begin to flow out of the compartment. They proceeded to load out the material into 300 pound capacity wheeled boxes, to be transferred into the waiting truck. After four boxes had been loaded, the truck was full and the co-workers shut down the conveyor system. Thinking that the victim would know that the truck was loaded when he heard the conveyor machinery shutdown, they proceeded to eat lunch. After a short period, they decided to look for the victim, since he had not joined them for lunch. The area around the bin was searched without success and one of the co-workers expressed concern that the victim may have fallen into the bin. They then decided to load out the contents of the bin compartment to see if the victim was inside. The conveyor machinery was started and the contents were loaded out into boxes, exposing the victim lying on two rod braces approximately 8 feet below the top of the compartment. One of the co-workers notified the local emergency medical service, (EMS) which responded in about 10 minutes. The victim was removed from the compartment by EMS personnel, transported to a local hospital and pronounced dead at 1:15 p.m.

## CAUSE OF DEATH

The medical examiner determined the cause of death as suffocation.

## RECOMMENDATIONS\DISCUSSION

***Recommendation #1: Employers should develop, implement, and enforce a written safety program which includes confined space entry and rescue procedures and training to ensure that workers assume that all stored materials are bridged and that the potential for entrapment and suffocation associated with stored grain and other loose materials is constant.***

**Discussion:** The co-worker interviewed during this investigation indicated that, when the compartment had been filled 3 weeks prior to the incident, it was necessary for the millworkers to trim the top of the load to prevent material from spilling over into adjacent compartments. This had been done with shovels while the millworkers were standing on top of the material in the bin compartment. There had been no problems with this procedure at the time of loading. While it is not known whether or not the victim entered the bin compartment of his own volition, past experience of the workers with this particular material, soybean hulls, indicated to them that standing on top of the material in the compartment was an acceptable practice. NIOSH has prepared an Alert detailing the hazards associated with the storage of grain and other loose granular materials (NIOSH Publication No. 88-102). NIOSH has published

other materials which can also serve as the basis for developing a comprehensive confined space entry program (NIOSH Publication Nos. 80-106, 86-116, and 87-113.) The physical properties of granular materials in bins are such that workers may easily develop a false sense of security while on top of the material, because the exact set of conditions necessary for bridging and subsequent collapse of the bridged material may only occur infrequently. Bridging occurs in storage bins that contain loose materials such as soybean hulls; it is caused by the material clinging to the sides of the bin. As the bin is emptied from the bottom, the material clinging to the bin sides lodges there, forming a bridge over the void previously occupied by the withdrawn material. The bridge may collapse without warning, entrapping workers who are standing on the bridge and who may be unaware that the surface is unstable. Workers may not be aware that the potential for engulfment is constantly present. Safety programs should prohibit entry into bins unless absolutely necessary; when entry is necessary, workers should be adequately protected from the hazards of confined spaces, such as engulfment. Workers may be protected by using properly secured safety harnesses and lanyards and by stationing standby persons outside of the bin.

***Recommendation #2: Employers should ensure that workers are protected from the engulfment hazards of open-topped bins by installing bin covers to prohibit entry.***

Discussion: The bin compartment in this incident was open at the top and guarded by a 36-inch-high railing. It is conceivable that the victim fell over the top or slipped under the railing while trying to dislodge material with the sewer tape. After the incident, the tape was found routed under the railing, with the weighted end in the compartment and the other end on the walkway. Bins can be covered with solid sheeting, or if necessary, a grating could be installed, to allow access for tools while prohibiting intentional or inadvertent entry by workers.

***Recommendation #3: Employers should consider installation of devices which will prevent stored granular materials from lodging on the inside of bins.***

Discussion: Devices are available which, when installed in a bin, can prevent material from bridging or can dislodge bridged material without the need for workers to be exposed to the hazards of confined spaces or unstable materials. These devices range in complexity from a simple chain hung down the center of the bin, to mechanical vibrators. In this incident, one of the compartments of the bin had been equipped with a chain attached to the ceiling of the building and hung down inside the compartment near its center. This compartment normally stored soybean meal, a material which readily bridges. Ambient vibration present when machinery is operated inside the building causes the chain to oscillate, thereby minimizing lodging of the surrounding material. A similar arrangement could be applied to other compartments containing granular materials.

***Recommendation #4: Employers should install standard railings with toeboards and intermediate rails around all openings where persons may be exposed to hazards of falls.***

Discussion: In this incident, a 36-inch-high railing had been installed around the edge of the bin compartments and the walkway. Standard 42-inch-high railings as specified in 29 CFR, 1910.23(e) should be installed around all floor openings where persons are exposed to fall hazards. Such railings should be equipped with toeboards and intermediate railings, as well as a top rail. Although this incident was unobserved, evidence suggests that the victim may have fallen through or over the railing and into the bin compartment during unloading operations. Additionally, railings could provide an anchor point for safety lines and lanyards worn by workers when working over the bin compartment.

***Recommendation #5: Employers should ensure that workers entering storage areas wear safety belts or harnesses equipped with properly fastened life lines.***

Discussion: Although it is not known whether the victim intentionally entered the bin compartment during the incident or fell into it, workers at this facility had entered prior to the incident without the protection of properly secured safety belts or harnesses. When entering areas where granular materials

are stored, the potential for engulfment is always present. If the storage space absolutely must be entered, safety belts or harnesses secured to life lines can protect the workers by arresting their fall when bridged material collapses, and by providing a means for rescue retrieval.

***Recommendation #6: Employers should ensure that safety signs are posted to warn workers of the hazards of working with stored grains and other loose materials.***

**Discussion:** Although a nonstandard railing had been erected around the accessible sides of the open-topped bin compartment, there were no warning signs posted to alert workers to the hazard of potential entrapment and suffocation present if the compartment was entered. Employers should treat all grain bins, silos and other areas where grain is stored as confined spaces. Posting readily observable warning signs where workers may be exposed to the hazards of confined spaces can reinforce worker training and serve as a constant reminder of the hazards associated with the storage of granular materials.

## **REFERENCES**

NIOSH Criteria for a Recommended Standard ... Working in Confined Spaces, December 1987, U.S. Department of Health, Education and Welfare, Publication No. 80-106.

NIOSH Alert, Request for Assistance in Preventing Occupational Fatalities in Confined Spaces. January 1986, U.S. Department of Health and Human Services, Publication No. 86-110.

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