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FROM: Minnesota Fatality Assessment and Control Evaluation (MN FACE) Program
Minnesota Department of Health

SUBJECT: MN FACE Investigation 05MN040
Farmer Dies After Being Engulfed In Corn Inside A Steel Grain Bin

SUMMARY

A 47-year-old male farmer (victim) died after he was engulfed in corn inside a steel bin that was nearly full of corn. The bin was equipped with a ventilation fan however it was not turned on at the time of the incident. The bin had one access hatch located near the edge of the roof that was accessible by an exterior ladder attached to the side of the bin. The bin was also equipped with an unloading auger located in the base of the bin.

After the victim and his father positioned a portable auger near the bin, opened the bin's roof hatch and parked a truck beneath the portable auger, they started the electric motors that operated the augers. They opened a sliding control gate for an auger intake located at the center of the bin and corn began to flow from the bin. A few minutes after corn began to flow from the bin, the victim took a grain shovel and climbed the bin ladder mounted to the side of the bin. After climbing the ladder, he entered the bin with the shovel through the roof hatch located near the edge of the bin roof to check the surface of the corn for any signs of crusting.

A few minutes after the victim entered the bin, the victim's father heard a banging sound and immediately stopped both augers. He called his son's name but did not receive a reply. He climbed the exterior bin ladder and looked into the bin through the roof hatch but did not see his son. He climbed down the ladder and called his son's name but again did not get a response. Since he had not been in direct contact with his son for the entire time that the augers had been operating, he thought that maybe his son had climbed down from the bin and walked to a nearby farmhouse. He walked to the farmhouse, entered it and called his son's name but again did not receive a reply.

The victim's father returned to the bin, climbed the exterior bin ladder and again looked into the bin. He saw the scoop of the shovel that his son had taken into the bin protruding vertically above the corn and realized that his son was submerged in the corn. He climbed down the bin ladder and placed a call to emergency rescue personnel and to a nearby farm neighbor. Rescue personnel arrived at the farm shortly after they were called and used power saws to cut holes in the sides of the bin to quickly empty it.

The victim's body was discovered about 20-25 minutes later. Efforts to revive him at the scene were unsuccessful and he was declared dead at the scene. MN FACE investigators concluded

that, in order to reduce the likelihood of similar occurrences, the following guidelines should be followed:

- all equipment used to empty a grain bin should be stopped, and the power source locked out, before workers enter the bin.;
- workers should follow confined space entry procedures when entering grain bins;
- grain bins should be identified as confined spaces and posted with hazard warning signs at all entrances; and
- grain bin ventilation fans should be turned on and operating properly before workers enter bins that are either full or partially full.

INTRODUCTION

On October 17, 2005, MN FACE investigators were notified of a work-related fatality that occurred on September 29, 2005. A site investigation was conducted on January 10, 2006 by a MN FACE investigator. During MN FACE investigations, incident information is obtained from a variety of sources such as law enforcement agencies, county coroners and medical examiners, employers, coworkers and family members.

INVESTIGATION

On the day of the incident, the victim and his father were removing corn from a steel grain bin. The corn was grown and harvested during 2004 and had been placed in the bin during the 2004 harvest season. The corn had been artificially dried in a nearby drying bin and then moved for long term storage into the bin where the incident occurred. The moisture content of the corn was 14 percent and the corn was in good condition at the time of the incident.

The bin was built in 1989, had a diameter of 24 feet and sides that were 18 feet high. It had a storage capacity of 7000 bushels and was full of corn at the time of the incident. The roof of the bin was sloped upward from the sides of the bin and was typical (Figure 1) of the roof on steel storage bins. The inverted cone design of the roof allowed the bin to be filled such that the surface of the corn was higher in the center of the bin than at the outer edges of it. This is commonly done when a bin is filled and results in a limited space between the surface of the stored grain and the inside surface of the bin roof. This limited space between the corn and the bin roof results in a situation where if a worker enters a bin when it is full or nearly full, the worker will not be able to stand upright inside the bin.

The bin was not equipped with a grain drying system however it was equipped with an electric motor driven ventilation fan. The ventilation fan, when operated aerated the grain stored in the bin by forcing outside air into two V channels in the concrete floor of the bin. The V channels were fitted with fine meshed grates that allowed the fan to force air up through the stored grain from the bottom of the bin to the top where it escaped through seams in the bin roof. The ventilation fan was not turned on at the time of the incident.

The bin had one access hatch located near the edge of the roof that was accessible by an exterior ladder attached to the side of the bin. The bin also had a center cover at the peak of the bin roof. The access hatch cover and the cover at the bin of the roof were opened before the victim and his father started to remove corn from the bin. Both covers were opened to allow dust that was generated inside the bin while it was emptied to escape through the roof openings. If bin access hatch and roof covers are left closed while bins are emptied, grain dust may accumulate inside a bin and possibly create a very hazardous environment inside the bin due to the explosive nature of airborne grain dust.



Figure1. Typical Steel Bin Roof with Access Hatch and Center Opening Cover

The bin had a side access opening that was approximately 3 feet wide by 4 feet high. The access opening was fitted with a hinged exterior door that opened outward and with a hinged interior door that opened inward. The hinged interior door on steel bins is designed to open inward so that when a bin is full of grain, the pressure of the grain in the bin acts to keep the door closed.

The bin was equipped with an unloading auger that was six inches in diameter and was installed several inches below the surface of the concrete base of the bin. It extended from one side of the bin to the center of the bin floor where a square auger intake opening was located. The intake opening was approximately 12 inches square and was fitted with a steel grate. The steel grate acted as a shield or guard when the bin was empty or nearly empty and prevented workers from being directly exposed to the auger if they were in the bin when it was empty or nearly empty. There was also a second auger intake near the outer edge of the bin. Both auger intakes were fitted with sliding control gates that could be independently controlled from outside the bin. At the time of the incident, only the control gate for the center auger intake had been opened to allow corn to enter the auger at the center of the bin.

A portable auger powered by an electric motor was positioned near the bin such that the intake of the portable auger was directly below the discharge opening of the unloading auger located in the floor of the bin. A truck was parked under the discharge opening of the portable auger. The two augers enabled corn to be removed from the bin by the unloading auger and then transferred into the truck parked under the elevated end of the portable auger.

After positioning the portable auger near the bin, opening the bin's roof hatch and the cover at the center of the bin roof and parking a truck beneath the portable auger, the victim and his father started the two electric motors that operated the augers. They opened the sliding control gate for the auger intake located at the center of the bin and corn began to flow from the bin. The victim's father estimated that corn was flowing from the bin at a rate of between 4-5 bushels per minute. A few minutes after the corn began to flow from the bin, the victim took a grain shovel and climbed the bin ladder mounted to the side of the bin. After climbing the ladder, he entered the bin with the shovel through the roof hatch located near the edge of the roof to check the surface of the corn for any signs of crusting.

Shortly after the victim entered the bin, the victim's father heard a banging sound. He thought that there was a problem with one of the augers so he immediately stopped the motors operating both augers. He then called his son's name but did not receive a reply. He climbed the exterior bin ladder and looked into the bin through the roof hatch but did not see his son inside the bin. He climbed down the ladder and called his son's name but again did not get a response. Since he had not been in direct contact with his son for the entire time that the augers had been operating, he thought that maybe his son had climbed down from the bin and walked to the farmhouse that was only a short distance from the bin. He walked to the farmhouse, entered it and called his son's name but again did not receive a response.

The victim's father returned to the bin, climbed the ladder fastened to the side of the bin and looked through the roof hatch into the bin. He now saw the scoop of the grain shovel that his son had taken into the bin protruding vertically a short distance above the surface of the corn and realized that his son was submerged in the corn. He climbed down the bin ladder and immediately placed a call to emergency rescue personnel and to a nearby farm neighbor. Rescue personnel arrived at the farm shortly after they were called along with the neighbor who had been called. Rescue personnel used power saws to cut holes in the sides of the bin to allow corn to quickly spill from the bin.

The victim's body was discovered a short time after rescue personnel had cut holes in the bin. It was estimated that he had been submerged in the corn for 20-25 minutes before he was removed from the bin. Efforts to revive him at the scene were unsuccessful and he was declared dead at the scene a short time after he was removed from the bin.

As indicated earlier in this report, the design of the bin roof allowed the bin to be filled such that the surface of the corn was higher in the center of the bin than at the outer edges of it. This resulted in a limited space between the surface of the corn and the inside surface of the bin roof. This limited space created in a situation where the victim would not have been able to stand upright inside the bin. After entering the bin, the victim probably was in a crawl position with his head toward the center of the bin. This may have resulted in him being pulled under the grain with his head below the rest of his body, a position in which he would have almost immediately become unable to do anything to prevent himself from becoming completely submerged including making a call for help.

CAUSE OF DEATH

The cause of death listed on the death certificate was asphyxiation under corn in a grain bin.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: All equipment used to empty a grain bin should be stopped, and the power source locked out, before workers enter the bin.

Discussion: Workers are exposed to various hazards if they enter or work inside a grain bin while it is being emptied. When grain is flowing from a bin, a worker inside the bin may be quickly engulfed and buried by the flowing grain. Flowing grain acts similarly to quicksand and may create forces so great that once a worker is waist deep in the grain, he or she will be unable to escape even with the aid of a safety rope. Typical auger unloading rates are high enough that a worker may be pulled below the surface of the grain in as little as 10-15 seconds. Because of these hazards, workers should “never” enter or work inside any grain structure when unloading equipment is operating and the structure is being emptied. In addition, all power sources should be locked out to ensure that unloading equipment cannot start accidentally or be started inadvertently by someone else. This may require locking out all electrical circuits that operate electric motors, removing ignition keys from tractors or removing spark plug wires from gasoline engines.

Recommendation #2: Workers should follow established confined space entry procedures when entering grain bins.

Discussion: If entrance into a grain bin is necessary, workers should follow established confined space entry procedures such as those described in NIOSH Publication No. 80-106. Anyone entering a bin should wear a safety belt or harness and a lifeline that is attached to a fixed external anchor point in a manner that ensures they will remain above the surface of the stored material. In addition, a standby person should be stationed outside the bin whenever a worker enters a bin. Visual contact and/or audible communication should be maintained between the worker in the bin and the standby person at all times. Details of a rescue must be discussed and understood by the worker and the standby person before entry into a bin occurs.

Recommendation #3: Grain bins should be identified as confined spaces and posted with hazard warning signs at all entrances.

Discussion: Grain bins meet the NIOSH definition of a confined space. A space is considered “confined” if it has any one of the following characteristics: (1) limited openings for entry and exit; (2) unfavorable natural ventilation; or (3) is not designed for continuous worker occupancy. Entrance into confined spaces are addressed in NIOSH Publication No. 80-106 (Working in Confined Spaces). Warning signs to alert farm workers of the hazards associated with grain bins should be posted at all entrances. In some areas, signs should be printed in more than one language for workers who might not be able to read and understand English. In addition, workers should do whatever possible to reduce the effects of unfavorable natural ventilation inside a steel grain bin by opening bin covers and roof hatches while a bin is being emptied. If a

bin is equipped with a ventilation fan, the fan should be turned on while the bin is being emptied to also increase the circulation of air within the bin. The combination of opening bin hatches and bin covers along with operating ventilation fans while a bin is being emptied can aid in the dissipation of potentially hazardous environments due to the explosive nature of airborne grain dust when it is confined within a poorly ventilated enclosed air space.

Recommendation #4: Grain bin ventilation fans should be turned on and operating properly before workers enter bins that are either full or partially full.

Discussion: Older grain bins typically were not equipped with ventilation fans but many grain bins built in recent years are equipped with electric ventilation fans. These fans are used primarily to circulate outside air through the stored grain. Ventilation fans typically force outside air into a space between the concrete bin foundation and a raised steel floor containing small holes. In this case, the ventilation fan when turned on forced air into two V-channels in the concrete base of the bin. Ventilation fans force air upward through the grain and it escapes through seams in the bin roof. When ventilation fans are operating, they are capable of providing a small flow of air through the stored grain. Although this flow of air is small, it may prevent a buried worker from suffocating if the worker is located within a short time after being buried in the grain. The presence and use of ventilation fans does not lessen or eliminate the confined space hazards of steel bins nor does their use reduce the need for workers to follow the guidelines provided in Recommendations 1, 2, and 3 above. However, grain bin ventilation fans should be turned on and operating properly before workers enter bins which are either full or partially full. In addition to provide a small flow of air through the grain, the flow of air helps to clear dust from the bin as the air flows through open hatches and covers in the roof of the bin.

REFERENCES

1. NIOSH (1979). Criteria For a Recommended Standard: Working in Confined Spaces. Morgantown, WV: U.S. Department of Health, Education, and Welfare, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 80-106.

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