



## Hazards of Flowing Grain

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**F**armers work with many tasks that present a wide range of hazards. Working with flowing grain is one of these tasks. This task does not seem to demand much attention to safety until an incident occurs. Flowing grain has many hazards that may go unnoticed.

### Flowing Grain Hazards in Agriculture

Nationally, an average of 12 grain entrapments are reported each year. Three-quarters of these entrapments resulted with a fatality, and two-thirds of the fatalities were in grain bins. Three-quarters of the entrapments occurred when grain was being unloaded. Out of condition corn was cited as the major factor in the entrapments. Nearly one-quarter of the entrapments involved children.

Pennsylvania has averaged one reported grain entrapment case each year over the past 20 years. One-half of these entrapments have been fatal, have occurred in grain bins, and involved children.

Entrapment is the most often identified hazard and cause of injury when working with flowing grain. However, there are several other hazards associated with grain handling systems. For example, respiratory problems, fires, and noise are major concerns when storing and handling grain. Electrical hazards exist with over-head power lines, portable augers and electric motors. Mechanical hazards are found on augers, dryers, stirrers and other associated equipment. The potential for falls from ladders and other structures is also present.

Nevertheless, this fact sheet will focus mainly on grain entrapment hazards. Entrapments in grain most often occur when a storage bin or transport vehicle is being loaded or unloaded.

### Grain Bin Entrapment

There are many types of structures where grain in various conditions can be stored. One of the most common types in Pennsylvania is the grain bin. Grain bins are designed to store low moisture grains until they are needed. Most grain bins are designed to unload from the bottom center of the bin.

High moisture grains are often stored in tall, small diameter silos which present their own hazards. Some of the same hazards that are found in grain bins are also present in grain storage silos. For example, high moisture grain will have the same flowing grain hazard as low moisture grain. The following information relating to grain bins can also be applied to silos used to store grain.

There are three common types of grain bin entrapment: entrapment of a worker by flowing grain, the collapse of a grain bridge, or the avalanche of a grain wall.

**Flowing Grain:** An auger is used to move the grain from the bottom center to the outer edge of the bin and into a vehicle or different storage. When the auger is running, grain flows out of the bin from directly over the outlet to the unloading auger in the center of the bin floor. This creates a funnel shape flow on the top of the grain with the grain flowing in a column below the surface, similar to the spout of a funnel (Figure 1).

With a large auger, a worker inside the bin can be pulled knee deep into the column of grain within a few seconds. Once a worker's knees are covered by grain, it is almost impossible to free himself without the assistance of others. If the knees are covered, and the grain is still flowing, the flowing grain is similar to quicksand and can completely engulf a person and result in suffocation. Figure 2 illustrates how a victim can become engulfed in flowing grain. Figure 3 illus-



Figure 1. Normal flow from a grain bin.

trates how quickly a person will sink into flowing grain as a 10 inch unloading auger moves 85 cubic feet of grain per minute (about 68 bu. per minute). As shown, a 6-foot person will sink into the grain past the knees and become helpless in less than five seconds, and can be completely engulfed in about 25 seconds.

**Collapsing Grain Bridge:** A grain bridge can be the most inconspicuous entrapment hazard. Poorly conditioned grain can become moldy and harden into a crust-like mass. This can occur on the surface and anywhere in the grain. Cavities or pockets are created when dry or loose grain is unloaded by the auger and hardened or crusted grain does not move. This crust and the cavity below it is commonly referred to as a grain bridge. This crust or grain bridge can give way if walked on while trying to break the crust. Breaking through the crust will cause the worker to fall and become entrapped in the grain (Figure 4, page 3). It can be difficult to locate the victim when this type of entrapment occurs because a large amount of grain can suddenly flow and completely engulf the victim in an instant. It is much safer to dislodge a grain bridge by using a long pole through an access hole from outside the bin.



Figure 2. Entrapment in flowing grain.

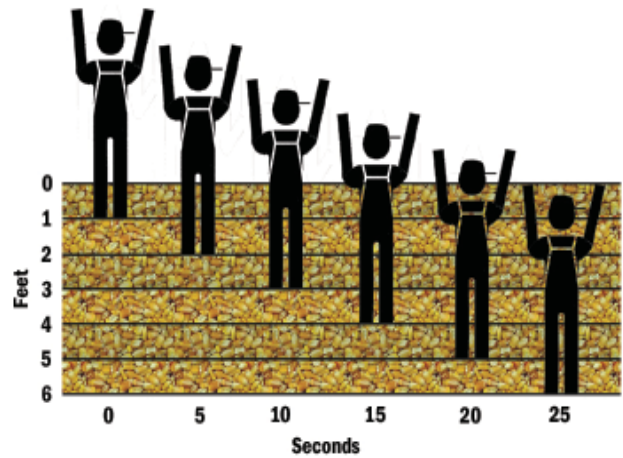


Figure 3. Depth vs. Time

**Grain Wall Avalanche:** In some cases, moldy grain will be found sticking to the walls of the bin. After removing the loose grain, the worker may be faced with a wall of crusted grain that must be broken free before it can be unloaded. If the wall of grain is higher than the height of the worker when the worker stands on the grain bin floor, an avalanche may occur as the worker tries to break up the crusted wall of grain. This avalanche could completely engulf the worker leading to injury and possible death (Figure 5). One foot of grain over an entire individual would weigh approximately 300 pounds. This is normally too much weight for the individual to break free.

### Grain Transport Vehicle Entrapments

While most entrapments occur in grain bins, they can also occur in grain transport vehicles.

Grain transport vehicles come in many shapes and sizes, but their main purpose is to transport grain from one point to another. These include gravity wagons and large bulk material semi-trailers.



Figure 4. Collapsing grain bridge.

As with grain bins, entrapments in grain transport vehicles occur when they are being loaded or unloaded, with most entrapments occurring during unloading. When grain transport vehicles are being unloaded the grain flows similar to grain in a bin. The outlets of grain transport vehicles are normally located on the bottom or side of the container, but similar flow patterns form and the grain flows out through the center of its mass. Again, the flowing grain is similar to quicksand and can quickly engulf a person and result in entrapment and suffocation.

Most on-farm grain transport vehicle engulfment incidents involve gravity flow wagons and young children, with some victims as young as two years old. Normally, these children are not actively working, have a short attention span, and are unable to understand the hazards of flowing grain. These children should be in a safe play area and not in this hazardous work zone.

Victims trapped in large bulk material semi trailers are usually either drivers checking to dislodge grain or mill workers sampling grain.

## Entrapment Prevention

It takes less than five seconds to become helplessly trapped in flowing grain and less than 30 seconds to become fully engulfed. Keep the following items in mind before you enter a grain bin.

- ï Most people can not pull another person out of a grain bin with a rope even if standing next to the entrapped person. Once a person becomes entrapped, it takes much more force than you expect to pull someone out of the grain. Figure 6 illustrates the amount of force it takes to pull a 165 pound adult out of grain at different depths.
- ï Make sure you are not alone. This means that someone must be aware of your presence in the bin. If you have problems, you will want someone on the outside who can come to your rescue.
- ï Ensure the power has been turned off and the auger is not running. Power to the augers should be turned off, locked and tagged so that no one else can start the auger while you are inside or an automatic timer doesn't start the auger. Use a lockout and tag out system to ensure your safety.



Figure 5. Avalanche of a grain wall.

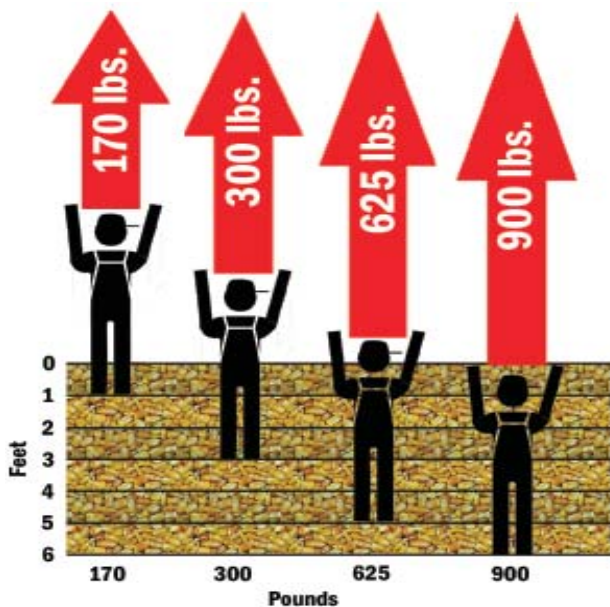


Figure 6. Depth vs. Force for a 165 lb. adult.

i Damp, wet grain can cause a bridge to form. Grain bridges should be broken from outside the bin with a long pole. If you must enter a bin: 1) use a body harness, 2) tie yourself off to a sturdy point, and 3) have at least two other people present in case you need emergency assistance.

## Summary

The following steps can reduce the risk of grain bin entrapment. While some of the following steps may seem simple or trivial, they can save your life.

- Place entrapment warning decals on grain bins and grain transport vehicles.
- Prevent unauthorized entry to grain bins and grain transport vehicles, especially by children.
- Make sure all workers and children are aware of entrapment hazards.
- Keep grain in proper condition. This may include the use of mechanical stirrers to prevent the grain from molding. Remember, out of condition grain was cited as the leading cause of adult entrapments.

- Use inspection holes or grain bin level markers instead of entering a grain bin.
- Enter a grain bin or grain transport vehicle only if it is absolutely necessary. Use a body harness secured to the outside of the bin or vehicle.
- Use a pole to break up possible grain bridges from outside the bin.
- Lockout/Tag-out all auger controls before entering a bin.
- Have at least two observers present during grain bin entry.
- Establish a form of nonverbal communication with observers (Hand Signals).
- Work from top to bottom when cleaning grain bin walls.

## References

Kingman, D.M., W.E. Field and D.E. Maier. 2001. Summary of Fatal Entrapments in On-farm Grain Storage Bins, 1966-1998. *Journal of Agricultural Safety and Health*. 7(3): 169-184. St. Joseph:MI, ASAE

Penn State Agricultural Injury Database, 1980-2000. Department of Agricultural and Biological Engineering, The Pennsylvania State University, University Park, PA. [www.abe.psu.edu/extension/agsafety](http://www.abe.psu.edu/extension/agsafety)

Schwab, C.V., I.J. Ross, L.R. Piercy and B.A. McKenzie. 1985. Vertical Pull and Immersion Velocity of Mannequins Trapped in Enveloping Grain Flow. *Transactions of the ASAE*. 28(6): 1997-2002. St. Joseph, MI: ASAE

PSU

1st Edition 8/03

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