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G90-990 Explosion Venting and Suppression of Bucket Elevator Legs

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NebGuide

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Explosion Venting and Suppression of Bucket Elevator Legs

Explosion vents and explosion suppression devices limit the danger and damage associated with grain dust explosions. This NebGuide discusses these devices and design guidelines for application on bucket elevator legs.

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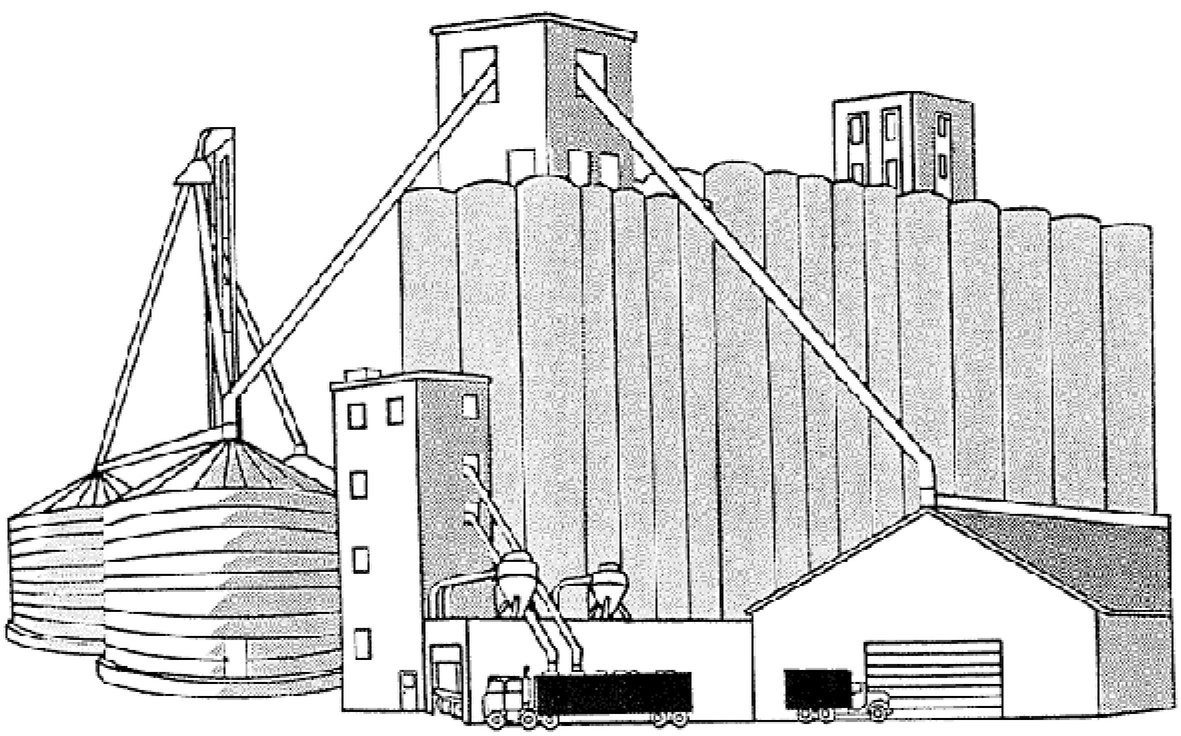
The bucket elevator leg has been identified as a major source of grain dust explosions. As a bucket elevator leg conveys grain, the elements necessary for a grain dust explosion are possible. Fuel (grain dust in suspension above the minimum explosive concentration), oxygen and confinement are inherent inside a functioning bucket elevator leg. Introduction of an ignition source will initiate a grain dust explosion.



Any bucket elevator leg conveying grain is susceptible to grain dust explosions. The more grain conveyed with a particular leg, the greater the likelihood of a grain dust explosion. The possibility of a grain dust explosion exists in small on-farm legs, but it is much greater in larger commercial legs conveying millions of bushels of grain each year.

Grain Dust Explosions

A grain dust explosion is actually a series of explosions consisting of a primary explosion followed by multiple secondary explosions. The primary explosion is usually a small over-pressure propagating a pressure front of approximately 2 pounds per square inch (psi). The pressure front expands from the point of ignition at an approximate velocity of 1000 feet per second. The pressure front may expand throughout a facility and aerate layered dust in its path. The subsequent fire front may serve as an ignition source for the newly formed dust clouds. In this way multiple secondary explosions can occur throughout a grain handling facility.

Secondary grain dust explosions are by far the most devastating. These explosions propagate a pressure front of approximately 80 psi moving at more 1000 feet per second. No conventional grain handling structure can withstand this magnitude of internal pressure.

The state-of-the-art in bucket elevator design is to locate the bucket elevator leg outside the facility, thereby eliminating the headhouse and decreasing the potential for catastrophic damage. Additional technologies, such as explosion venting and explosion suppression devices, will further decrease the potential for catastrophic damage.

Explosion Venting

Explosion venting is the process of providing escape routes for high pressure gases within a bucket elevator leg. Explosion vents replace a portion of the leg casing and are designed to rupture or release at relatively low pressures. Atmospheric vents should not be confused with explosion vents. Most atmospheric vents are not big enough to sufficiently exhaust the high pressure gases. When an explosion occurs, explosion vents are ruptured, relieving the internal pressure and maintaining the structural integrity of the bucket elevator leg casing. Venting exterior legs is simple. Venting interior legs is more difficult and often impractical.

Table I. Ratio of explosion vent area to vented volume

Section	Vent Area per 100 ft^3 of Vented Volume
head	5 ft^2
trunk	8 ft^2
boot	5 ft^2

Explosion vents are sized as a ratio of vent area to vented volume. In the trunk, or mid-section of the leg, the minimum vent ratio is 8 square feet of vent space per 100 cubic feet of vented volume. In the head section the minimum vent ratio is 5 square feet of vent area per 100 cubic feet of vented volume. Given the compact and cramped nature of the boot section of the leg, venting is generally not practical.

However, if venting of the boot is required, the minimum vent ratio is 5 square feet of vent area per 100 cubic feet of vented volume. A summary of the required vent area to vented volume is shown in *Table I*.

Vent panels should be on the side of the leg housing. When looking into the leg through the vent panel, the edge of the belt should be visible as shown in *Figure 1*. Another design parameter is that the total vent area should be approximately 60% of the leg cross-sectional area. Vents along the mid-section of the leg should be spaced 15 feet apart along the entire height of the trunk. *Figure 1* illustrates the placement and configuration of the explosion vents. The boot section should be treated as an interior leg if it is below grade.

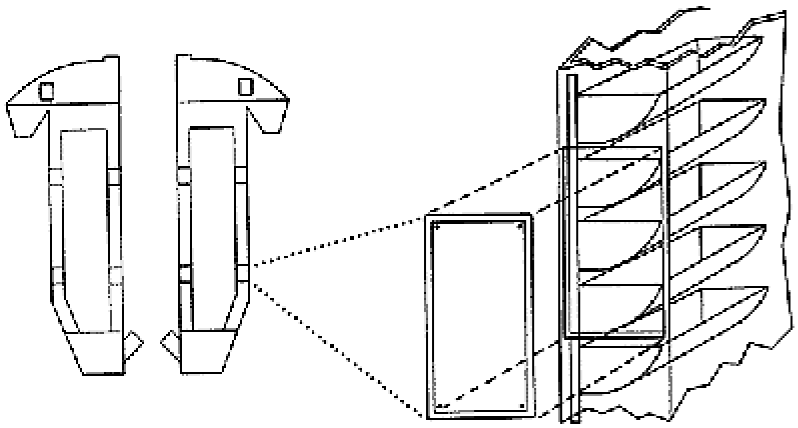


Figure 1. Location of explosion vents. Inset shows how the edge of the belt should be visible through an open vent panel.

Venting interior legs is not easy. Although the same design parameters are used, consideration must be given to the space where the pressure will be exhausted. Little is accomplished if the explosion is vented into a basement, gallery or work area. Ducting is needed to exhaust the pressure outside. The ducting should have at least the same cross-sectional area as the vent. The ducting should be no longer than 10 feet and have no bends or elbows.

The material used for vent panels is also important. The vent material should have a rupture strength of no more than 1 psi, preferably less. The material may vary from aluminum to polyvinyl-chloride. Heavier material can be used if the bolts attaching the vent to the leg casing are designed to fail under less than 1 psi of pressure.

Depending on the design of the vent panels, they may become dislodged from the leg casing during an explosion. The vent panels should be secured to the leg with a chain or cable so they will not fall to the ground.

Explosion vents can be used in other applications. Galleries, bins, basements and loadout bins also can be vented. Consult an experienced engineer or a qualified manufacturer or distributor for further information on venting these locations.

Explosion Suppression

Explosion suppression is accomplished by detecting a grain dust explosion early and flooding the confinement with an extinguishing agent. Research has shown that this technology can effectively suppress grain dust explosions in bucket elevator legs.

A grain dust explosion can be detected by optical, thermal, or pressure sensors, or a combination of sensors. Optical sensors react to ultraviolet radiation from a spark or flame. Dust concentrations inside the leg can impede optical sensors. Thermal sensors compare the air temperature at the leg outlet to the air temperature at the leg inlet. If this temperature difference exceeds a prescribed threshold, a signal is initiated.

Pressure sensors are most commonly used for detecting grain dust explosions. Pressure sensors use a diaphragm-type device which responds to the initial pressure front of an explosion by quickly closing electrical contacts. As the explosion develops, both a pressure front and a flame front propagate from the point of ignition. The pressure front travels approximately 10 times faster than the flame front. The pressure sensor detects the pressure front and sends a signal through a control unit to a high-rate discharge extinguisher. This process is illustrated in *Figure 2*.

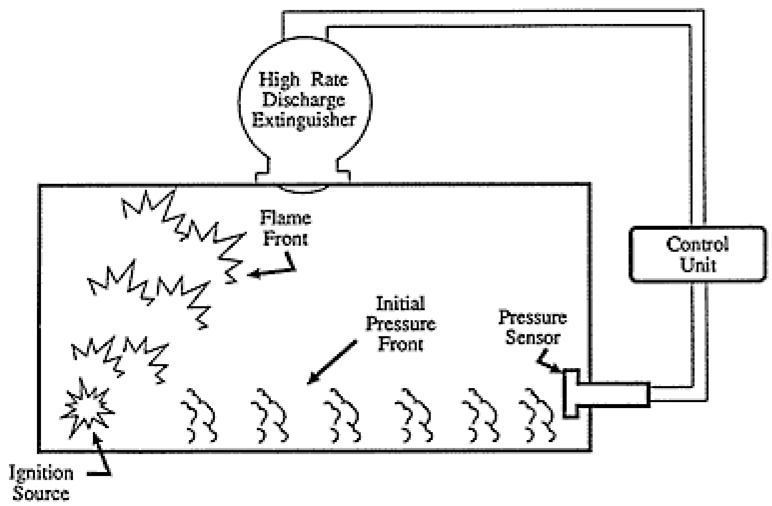


Figure 2. Operation of explosion suppression device.

The control unit electronically controls the detector and extinguisher and may provide inter-locking to the leg and other equipment. It may be battery powered to provide protection during a power failure.

High-rate discharge extinguishers are pressurized, rechargeable spherical containers. The extinguishers are activated by a signal from the control unit. The extinguisher valve can be completely opened in 5 milliseconds to provide rapid flooding of the confinement with discharge velocities that can exceed 100 feet per second. The extinguishers are filled with a suppression agent, generally dry chemical powders or halon gases.

Dry chemical powders commonly used are mono-ammonium phosphate or sodium bicarbonate. Sodium bicarbonate is generally preferred over mono-ammonium phosphate for grain handling systems because it is compatible with food and is water soluble. Sodium bicarbonate is stable under long-term storage conditions and is nontoxic and noncorrosive. When a dry powder is used, the extinguisher is pressurized with carbon dioxide or nitrogen.

Halon gases have an advantage over dry chemical powders in that they completely dissipate after each discharge. This eliminates the messy cleanup after an accidental discharge of dry chemicals. However, high concentrations of halon gas are toxic to humans and should never be used where workers are present. This problem is minimized, however, when halon gas is discharged inside a bucket elevator leg and dissipated below potentially harmful concentrations.

Explosion suppression systems are best for interior legs where explosion venting is impractical. Injecting the suppressing agent at several locations within the leg more effectively suppresses the flame front than a single or dual point application. Suppression systems generally consist of eight to 10 units mounted on the head, boot and trunk sections of the leg. *Figure 3* illustrates a typical arrangement of explosion suppression devices.

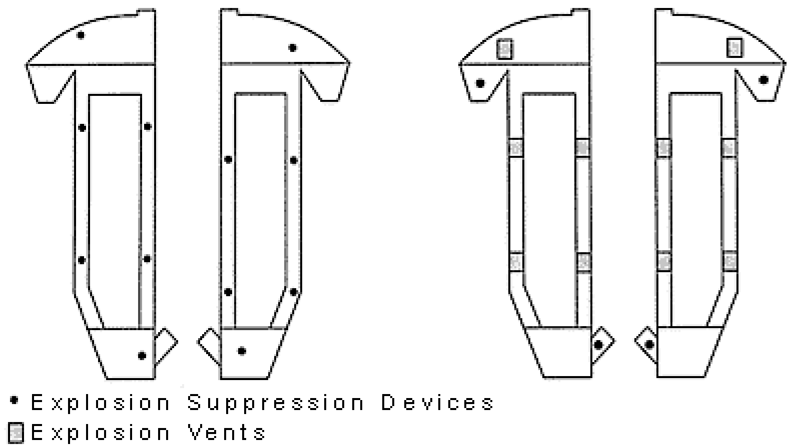


Figure 3 (left). Location of explosion suppression devices on bucket elevator legs.

Figure 4 (right). Location of explosion vents and suppression devices when used together on bucket elevator legs.

The explosion suppression devices on the trunk section of the elevator leg prevent the flame front from moving through the leg. Explosion suppression devices also are recommended for the inlet and outlet of the elevator leg. They create a chemical barrier to prevent the flame front from spreading to other parts of the facility such as tunnels or galleries.

The exact number of devices and their arrangement will depend on the manufacturer's specifications and the configuration of the particular leg. Most explosion suppression devices can be installed directly on the elevator leg casing with minor structural changes.

In certain situations, explosion suppression devices can be used with explosion venting. An exterior leg equipped with both explosion vents and explosion suppression devices (located at the inlet and outlet of elevator leg) can vent any explosions which might occur and prevent propagation of the flame front to adjacent equipment as shown in *Figure 4*.

Summary

Explosion venting and suppression of elevator legs can significantly decrease the probability of a devastating secondary grain dust explosion. These techniques will not eliminate primary explosions, but can help control them by preventing secondary explosions.

Before installing explosion vents or suppression devices, discuss your alternatives with an engineer experienced with this technology. Also, visit other grain handling facilities that use these devices or talk with your insurance company for more information about these.

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