FOCUS ARTICLE

Troublesome Trends in the Agricultural and Food Industry: How NFPA 61 Can Help You Manage the Risk of Fires and Explosions

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Fire and explosion incidents in the agricultural and food processing industry, reported during the last three years by dustsafetyscience.com indicate that the number of incidents is trending upward. The percentage of reported fire and explosion incidents has also increased from an average of about 32% of the total incidents reported in 2016 and 2017, to an average of over 44% in the last three years. The lion's share of these fires and explosions have occurred in the grain industry, although the food industry reports significant numbers, as well. This article will address these trends and the factors that are driving them. The 2020 revision of NFPA 61, The Standard for Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities, has added some important requirements and has made some changes that should serve to help in the reduction in the numbers of these incidents. Practical measures to reduce the risk of fires and explosions in grain dryers, product storage bins and silos, as well as bucket elevators will also be addressed.

FIRES AND THE EXPLOSION INCIDENTS

Table 1 shows data from 2017 through 2020. Data in this table indicates that the agricultural and food processing industry experienced increasing number of incidents from 2017 until 2019. In 2020, this number decreased; however, the overall numbers have been trending upward. Where the equipment involved in the incident was specifically identified, the highest percentage of incidents have occurred in grain elevators (mechanical conveying systems, including bucket elevators), grain dryers and storage bins/silos. Combined, these three pieces of equipment were involved in over 80% of the total incidents. The ratio of fires to explosions is fairly high and typically four or five to one. Explosions can occur in all three of these types of equipment; however, fires are more predominant, particularly in grain dryers.

Year	Number of Incidents	% of Total Incidents	Fatalities	Injuries	Number of Fires	Number of Explosions	Equipment Number Of Incidents - (% Of Incidents)			
							Unknown/ No details	Bucket Elevators	Grain Dryers	Silos/ Bins
2017	53	32.3	5	14	45	8	12 (22.6)	14 (26.4)	4 (7.5)	19 (35.8)
2018	86	44.3	0	14	69	17	8 (9.3)	13(15.1)	30 (34.9)	22 (25.6)
2019	98	46.2	1	12	83	15	12 (12.2)	10 (10.2)	34 (34.7)	32 (32.7)
2020	77	54.2	0	18	60	17	8 (10.4)	16 (20.8)	13 (16.9)	23 (29.9)

Table 1: Fires and Explosions in the Agricultural and Food Processing Industry for a Four-Year Period

FIRE AND EXPLOSION MITIGATING STRATEGIES

Since the majority of incidents involve grain elevators, grain dryers and silos/bins, both engineering and administrative controls are recommended to prevent or mitigate the consequences of fires and explosions for this type of equipment.

Bucket Elevators (legs)

Bucket elevators are frequently involved in fires and explosions experienced in the agricultural and food industry. Inside of a bucket elevator transporting grain or other food products, a combustible dust cloud may be produced at the inlet and discharge points. The likelihood of this will be predicated upon the particle size of the material being charged into the elevator. If a credible ignition source exists within the dust cloud, flash fire or explosion can occur. To prevent an explosion hazard from existing, systems must be in place to control either the fuel or ignition sources. Installing local exhaust ventilation at the inlet and discharge of the bucket elevator is good practice and can serve to prevent dense dust clouds from being formed. Even in the absence of a dense dust cloud, at the inlet and discharge points, fine dust can build up on the inside walls and the outsides of the buckets of these elevators. An accumulation of as little as 0.0005 inch can present a secondary explosion hazard inside of a bucket elevator. Fires can also occur if head, tail or knee pulley bearings overheat or belt misalignment occurs. In these cases, accumulated material inside the bucket elevator, or some cases the belts, can ignite and burn.

The OSHA safety standard for grain elevators **(29 CFR Part 1910.272)** requires that bucket elevators be equipped with specific ignition control features including:

> A motion detection device which will shut down the bucket elevator when the belt speed is reduced by no more than 20% of the normal operating speed;
> Bearings mounted externally to the leg casing or a design which includes bearing vibration or temperature monitoring, or other means to monitor the condition of those bearings mounted inside or partially inside the leg casing; and
> A belt-alignment monitoring device which will initiate an alarm to employees when the belt is not tracking properly, be installed or a means to keep the belt tracking properly.

These requirements do not apply if the bucket elevators are either equipped with an operational fire and explosion suppression system capable of protecting at least the head and boot section of the bucket elevator; or if equipped with pneumatic or other dust control systems or methods that keep the dust concentration inside the bucket elevator to at least 25% below the lower explosive limit all times during operations. The latter exception may be problematic, to design and implement.

NFPA 61 provides similar requirements **(Section 9.3.14)** for bucket elevators and includes additional requirements as follows:

> Lagging installed on the head pulley to minimize slippage;
> A requirement that the belts and lagging be fire-resistant and oil-resistant;
> High bearing temperature or vibration detection at the head, tail and the pulley bearings for inside legs;
> Head, tail and knee-pulley alignment systems; and
> Explosion protection for all inside legs and newly installed outside legs.

DEKRA has conducted dust hazard analyses (DHAs) in many industrial agriculture and food processing facilities throughout the country and, in many cases, has found that motion detection devices are installed but are programmed to shut down the leg only if zero speed is indicated. Experience has shown that a belt slipping on the tail pulley can produce friction which can initiate fires. It is important that the speed switches be programmed to alarm, and shut down the belt if the belt speed is reduced to less than 80% of normal.

In addition, DEKRA has investigated explosions in bucket elevators where misaligned belts or heated bearings have signaled an alarm that was either not heard, or where subsequent remedial actions were not taken. Even though not required by the standard, it is good engineering practice to interlock these alarms to stop feed to the leg and shut it down.

With regard to explosion protection, it is DEKRA's experience that a deflagration event inside of a bucket elevator installed in a grain-handling facility, where there typically is no isolation either up or downstream of the elevator, will often propagate in both directions resulting in a spread of fires and explosions to connecting equipment. For example, a bucket elevator that is protected using standard deflagration vents will protect the elevator in the event of a deflagration, but the energy from the deflagration is often transmitted upstream to the unloading bins and/or downstream into the silos, causing a secondary explosion. In the absence of isolation, for example, a rotary airlock at the feed and discharge ends, installation of explosion suppression systems to protect the elevator, is recommended. The systems will prevent an event occurring inside the elevator from transmitting energy, both up and downstream, to connected processes, including unloading grain hoppers and silos and bins downstream of the bucket elevator.

Other mechanical conveying equipment that has experienced a high incidence of fires includes belt conveyors. Similar to bucket elevators, out-of-alignment belts and slipping of belts on the tail pulley can initiate fires. In addition, the bearings inside the rollers or idlers on which the belt travels can seize, which may cause the rollers to stop turning. Friction will build up between the roller and the moving belt and if the belt is stopped, a point source of ignition at the seized roller can initiate the fire. NFPA 61 also provides requirements for belt conveyors. Accumulations of material around the rollers will prevent heat dissipation around the bearing and can result in their early failure. Some of these requirements parallel those of bucket elevators and include a requirement **(Section 9.3.15)** for belt alignment and monitoring of bearing temperature at the head and tail pulleys.

Grain Dryers

Grain dryers experienced the second-highest total number of incidents reported during the four-year period. Fires in grain dryers are most common at the beginning of the harvest season. Failure to clean out the dryer from the previous season can result in blockages in dryer columns caused by leftover grain or other debris. In some cases, the grain may sprout adding to the problem. When the dryer is first started up, this material may start to burn causing a fire. It's important that a grain dryer preventative maintenance program be developed and implemented. This program would include inspection of the dryer prior to operation to ensure that there is no debris remaining in it, and that all burner components, including safety features, are operational.

Reference No. 4

In many cases reported grain dryer fires were caused by inadequate operator training, which resulted in the dryer operating at high temperatures, increasing the likelihood of the fire.

NFPA 61 provides requirements for grain dryers which include a design that will minimize the accumulation of material and will ensure that cleanup is not problematic. In addition, in case of fires, the dryers must be designed with a means for unloading (emergency dumping) of the dryer contents to a safe outside location. Burner systems and controls for dryers fired by fuel oil, natural gas or other fossil fuels must comply with the NFPA 86 Standard for Ovens and Furnaces.

Silos/Bins

Bins and silos represent the equipment involved with the highest percentage of fires over the reported four-year period. NFPA 61 is the only commodity-specific standard that does not specifically require explosion protection on bins and silos.

Flammable atmospheres may exist inside of silos and bins handling agricultural and food products during filling. Assessment of whether or not these atmospheres will exist is predicated upon the particle size distribution of the product, or raw material entering the silo or bin. If the suspended particles are small enough to present an explosion hazard, four of the five conditions (fuel, suspension, oxygen and confinement) required for explosions will be present during these times. The only condition that prevents explosion inside of the bin is the absence of a credible ignition source. Failure of a pneumatic transport blower, entrance of tramp metal into the pneumatic transport system or problems inside of filter receivers or sifters could produce a credible ignition source.

The risk of an explosion occurring is based on the product of the severity of the event multiplied by the frequency or likelihood of the event occurring. **(Risk = Severity*Likelihood)**. Based on DEKRA's incident investigation experience, the likelihood of having an event is considered to be small, but the consequences (severity) can be significant. Since the severity factor can be quite high, the overall risk is considered to be low to medium. In instances where the silo/bin is located outside of the building, the risk to personnel is considered to be lower, when compared to situations where the silos/bins are enclosed or where a penthouse is constructed at the roof level.

The 2020 revision of NFPA 61 has added additional language concerning explosion protection. Where deflagration venting or explosion suppression cannot be provided, explosion prevention methods should be considered. These methods include: (1) separating the bin or silo from other structures and from areas where personnel are located; (2) avoiding inter-tank or inter-bin venting of bins and silos; (3) incorporating a weak seam roof design into the bin or silo or (4) designing fill equipment in a manner such that the fill spouts are closed on bins and silos not being filled.

The standard also recognizes, however, that although situations may arise where it is not possible to provide calculated deflagration venting, as required in NFPA 68, that these situations do not justify the exclusion of all venting, and recommends that the maximum practical amount of venting should be provided since some venting should reduce the damage potential. The standard also states that consideration should be given to other protection and prevention methods.

In cases where explosion protection is not practical and the equipment is located indoors, administrative controls should be considered to prohibit personnel access to these areas when the silos or bins are being filled.

SUMMARY

Fire and explosion incident reporting in the last four years has indicated an increased number of incidents involving the agricultural and food processing industry. Silos/bins, grain dryers and grain elevators have experienced the most fire and explosion incidents based on this reporting period.

Strategies to prevent or mitigate the consequences of fire and explosion in this equipment include:

> the design and installation of explosion protection and ignition control systems
> inspection and preventive maintenance programs
> adequate training of employees involved in maintaining this equipment.

In some cases, administrative controls should be considered in addition to engineering solutions.

References:

1. Code of Federal Regulations, 29 CFR Part 1910. 272 Grain-handling facilities
2. NFPA 61 (2020) Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing and Handling of Combustible Particulate Solids
3. NFPA 86 (2018) Standard for Ovens and Furnaces
4. National Grain and the Feed Association, NGFA Safety Tips: Preventing Dryer Fires, www.ngfa.org

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