COMBUSTIBLE DUST EXPLOSIONS IN GRAIN PROCESSING AND HANDLING FACILITIES

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Above; Figure 1: Destruction from a grain elevator explosion in the Port of Aqaba, Jordan on May 14, 2018 which killed seven and injured two. The explosion started on the third story of the tower shown in the top image and propagated through the underground conveyors to the silos shown in the bottom image *(Photo courtesy of personal communication with the authors)*

May 28, 2019 started like any other workday at the Tiwana Oil Mills feed factory in Kharauri village, India. By 1:30am, however, one supervisor was dead and nine workers were injured when a boiler exploded.

The police reported that the explosion occurred when mechanical belts were used to transfer raw material to the boiler. The factory owner swore that this incident was the first of its kind since the factory opened in 1999.

While this may be true, this is not the first explosion involving grain dust to cause death and injury. On January 5th, 2019, a fireman died and another was injured in a silo explosion at a grain processing facility in Clinton, Iowa.

The year before, on May 14th, 2018, a grain silo in Port Aqaba, Jordan, exploded and killed six people (See Figure 1). Two weeks later, a grain elevator exploded in South Sioux City, Nebraska, killing one person, injuring another, and forcing over 50 people to evacuate from their homes.

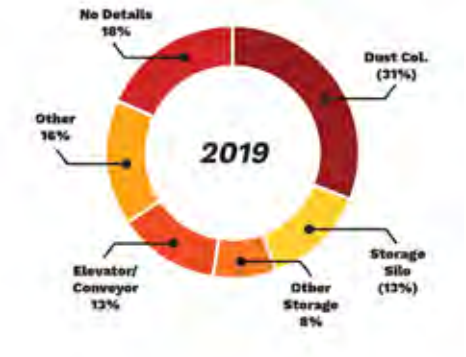
The causes of these incidents remain largely unknown, but details from similar explosions suggest that combustible grain dust was ignited through hot work, overheated bearings, smouldering combustion or an array of other potential ignition sources located in the facilities. Grain dust explosions are catastrophic events that can result in fatalities, injuries, property damage, and significant revenue loss due to downtime.

Grain dust explosions — An overview

Grain dust explosions have been recorded as far back as December 1785, when one of the first documented cases occurred at a bakery warehouse in Turin, Italy. Count Morozzo investigated the explosion and found that a portion of bakery flour, which was exceptionally dry, created a dust cloud when it dropped from an upper portion of the warehouse. Heat from a mounted lamp ignited the flour, causing an explosion that propagated in multiple directions and injured two people.

Over the ensuing three centuries, similar incidents followed. They include:

- 1878: The Washburn 'A' Mill in Minneapolis, Minnesota exploded due to flour dust build-up. The blast, which killed 18 people, also broke windows in nearby homes and hurled limestone blocks everywhere
- 1893: A poorly secured dust collector spilled flour dust into the rolling room at a mill in Litchfield, Illinois. When fire from another room came into contact with the airborne dust, the resulting explosion killed one worker and destroyed homes and businesses within two blocks
- 1916: 23 workers were killed in a dust explosion at an oats factory in Peterborough, Ontario. The resulting fire destroyed the factory and burned for four days



Breakdown of incidents involved in combustible dust fires and explosions in 2019

- 1924: A corn dust explosion at the Corn Products refining plant in Pekin, Illinois, killed 42 people
- 1975: A grain dust explosion at a flour mill in Davenport, Iowa, killed two workers and shattered windows 20 blocks away
- 1977: 20 workers died when an explosion occurred at a grain elevator in Galveston, Texas. The grain dust was drier than usual due to low winter humidity, creating a situation similar to the Turin bakery explosion
- 1977: A grain dust explosion in Westwego, Louisiana blew off the top of the silo, ignited fires in another 48 silos, and killed 36 people. This incident inspired several building code reforms for grain silos
- 1979: A flour dust explosion in Bremen, Germany, killed 14 people and injured 17 others.

When OSHA implemented the Grain Handling Facilities Standard in 1987, it reduced the frequency of grain dust explosions in the United States by 42 percent during the first year due to better understanding of the hazards associated with grain handling. However, grain dust explosions continue to happen every year.

In their Combustible Dust Incident Reports for 2017, 2018, and 2019 the team at the Combustible Dust Incident Database noted the following:

- Grain dust was the most common material in North American incidents in 2017
- Storage silos were the site of 14 percent of dust incidents in 2017, followed by 15 percent in 2018 and 13 percent in 2019. Elevator/conveyor systems, which frequently handle grain, hosted 10 percent of incidents in 2017 and 2018 and 13 percent in 2019
- 20 percent of the overall incidents occurred in agricultural and grain storage industries in 2017
- In 32 percent of all incidents recorded in 2017, some type of food product (including grains) was involved. The rate was 31 percent in 2018 and 30 percent in 2019 (See Table 1). What's equally alarming is the comparatively minor amount of dust needed to trigger an explosion. Any accumulation that is sufficient to coat the floor and conceal the floor and conceal the colour of the surface can support a incident that kills workers and closes down a business forever.

What causes grain dust to explode?

Grain dust explosions occur when these five elements are present (otherwise known as the dust explosion pentagon):

Oxygen, which is in the air at grain processing facilities

A confined space, such as a silo, baghouse, bucket elevator or building enclosure

An ignition source, such as sparks from hot work, static electricity, and friction

A fuel source which, in this instance, is grain dust

Dispersion of the fuel source, which can happen when grain dust spills during processing and handling or from a primary explosion event

Primary explosion or fire: When grain dust, oxygen, and an ignition source are combined, a primary explosion or fire occurs that can disperse combustible dust and trigger a secondary explosion. This can carry throughout the facility and cause significant damage.

How can we make grain facilities safer?

While improvements in facility and equipment design and maintenance and employee training have reduced the number of grain dust explosions that occur, certain critical challenges remain. They include:

- Lack of a preventive maintenance approach
- Multiple sources of dust within the facility
- Poorly maintained processing and handling equipment
- Lack of worker awareness about combustible dust hazards in grain facilities
- Lack of knowledge about the potential danger from dust explosions
- Lax inspection programs which do not clearly identify or assess the risk of dust explosion hazards.

Many of these issues can be addressed and overcome by:

- Careful and effective dust collection at loading and unloading points. Preventive measures could include reducing grain speed as it moves from a bucket elevator to a conveyor; spout liners to minimise dust separation in the spout, and temperature monitors on bearings
- Regular housekeeping to manage dust accumulation within the facility. This includes safely clearing grain dust away from hidden areas like light fixtures, ledges, and ceiling beams
- Installation and routine maintenance of dust collection and explosion suppression systems. All equipment must be adequately designed for their operating environment, and any process changes should only be made after an adequate Management of Change review
- Regular scheduled inspections by experts familiar with combustible dust hazards in grain processing industries.

While the grain processing industry has made significant progress in preventing dust explosions in their facilities, multiple severe incidents occur each year. More awareness and knowledge of grain dust explosion hazards is needed until we reach a point where zero grain dust explosions occur, and even then, best practices will need to remain in place to keep the momentum going.

Upcoming events

Interested in learning more about safe processing and handling of combustible dust? DustSafetyScience.com is hosting a four-day online conference from February 24 – 27th, 2020 including industry training, hazard analysis, regulatory compliance and the latest research in combustible dust safety. Find out more at DustSafetyScience.com/milling-grain-2019.

Table 1: Breakdown of incidents involved in combustible dust fires, explosions, injuries and fatalities reported in the 2019 mid-year combustible dust incident report. *Source: 2019 Mid-Year Report Summary*

	Fires	Exp.	Inj.	Fat.
Dust collector	42	4	3	0
Storage Silo	14	6	13	2
Other storage	9	3	2	1
Elev./Conv.	14	6	0	0
Dryer	11	0	1	0
Other	7	6	20	10
No details	18	9	27	0

About the authors

Rose Keefe is the lead technical writer and research specialist at DustEx Research Ltd. (DustSafetyScience.com), an online platform for awareness, education and training to prevent dust fires and explosions in industry applications.

Dr. Chris Cloney (PEng.) is Managing Director at DustEx Research and lead researcher for the Combustible Dust Incident Database. Chris is a recognised expert in the field of combustible dust research publishing over 15 peer-reviewed journal articles and presenting at conferences on the topic in the US, Canada, China, Norway, the United Kingdom, Germany and Poland.

www.dustsafetyscience.com

Combustible dust explosions in grain processing and handling facilities

Please mark your calendar for the world's first Digital Dust Safety Conference: February 24–27th, 2020. The conference, which is the first online event of its kind, will feature presentations from leading dust hazard researchers and experts. The goal of the event is to increase awareness of combustible dust hazards and initiate cross-industry collaboration that can save lives.

The event is organised by Dr Chris Cloney, a recognised expert in the field of combustible dust research. He has published over 15 peer-reviewed journal articles and speaks regularly at public events and academic conferences on the subject of dust fires and explosions.

You can find more information about the 2020 Digital Dust Safety Conference at www.DDSC2020.com