

COMBUSTIBLE DUSTS

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This Tech Talk discusses the fire and explosion hazards associated with combustible dusts and provides property loss prevention guidance.

AT-A-GLANCE

- There are a wide variety of dusts from many different industries that are explosible under the right conditions.
- Most large property losses from dust explosions are caused by fugitive dust within the building or process.
- A process hazard analysis (PHA) of the facility should be completed when explosible dust is present.

INTRODUCTION

Every year, there are several large property losses at industrial plants caused by combustible dust explosions. While combustible dust explosions have been commonly associated with occupancies such as grain elevators, some of the more recent losses have involved dusts which many people did not know were explosive, such as sugar, metal and plastic dusts.

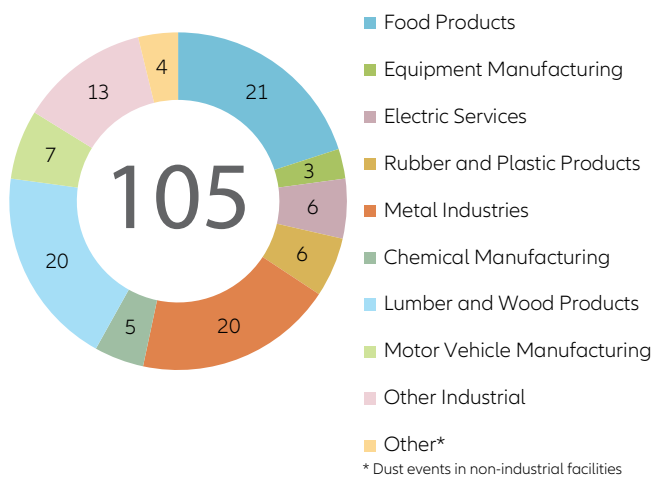
Some examples of dust explosion losses include:

- **Corn dust explosion in 2017:** A combustible dust explosion occurred at this corn milling facility at the gap mill. The explosion caused the complete collapse of the multipurpose building, the warehouse railcar loading bay, and one of the mills, and severely damaged the remaining three mill buildings, bulk loadout, and the front office. A total of five employees were killed and 14 were injured.
- **Sugar dust explosion in 2008:** This facility manufactured sugar and had been in business for over 100 years. The explosion caused major damage to parts of the processing area, packaging buildings, palletizer room, silos and bulk train car loading area. The explosion was fueled by significant accumulations of combustible sugar dust throughout the packaging department. A total of 14 people were killed and 38 were injured.

- **Phenolic resin dust explosion in 2003:** The plant manufactured fiberglass insulation for the automotive industry. A fire in a malfunctioning oven ignited a cloud of phenolic resin dust generated during the cleaning of a production line. The dust explosion caused extensive damage to the production area. Seven people were killed and 37 were injured.

According to the U.S. Chemical Safety and Hazard Investigation Board (CSB), there were 105 dust explosions in the U.S. from 2006 to 2017, resulting in 59 deaths and 303 injuries. A variety of industries are represented by these 105 dust explosions as noted below.

Number of Dust Incidents by Industry, 2006-2017



U.S. Chemical Safety and Hazard Investigation Board

DUST EXPLOSION BASICS

Most organic based materials can be explosible and some of the more common explosive dusts include grain, starch, flour, sugar, coal, paper and wood. In addition, many inorganic dusts can also be surprisingly explosible. Some common examples include metals, plastics, powder coat materials, rubbers and pharmaceuticals. See Appendix A for a more comprehensive list of combustible dusts that can be explosible.

The following four conditions are required for a dust explosion to occur:

1. **Combustible dust** – The dust particles must be combustible and small enough to be explosible. The National Fire Protection Association (NFPA) historically characterized combustible dust by size (≤ 420 microns in diameter or about the size of granulated sugar). However, the definition was revised to “a finely divided combustible particulate solid” to account for nonspherical particles such as flakes, platelets, and fibers.

As a general rule, any combustible particulate with a minimum dimension ≤ 500 microns has the potential to be a combustible dust. Typically, the smaller the dust particle, the more explosible it is. When in doubt, have the dust tested.

2. **Ignition source** – A sufficient source of energy is required to ignite the dust. Typical examples include open flames, smoking, cutting, welding, grinding, frictional heat, hot surfaces, ordinary electrical equipment, mechanical impacts, electrostatic discharges, etc.
3. **Suspension** – The dust must be suspended in air (or other oxidizing medium) and must be within sufficient concentration for an explosion to occur. Like flammable vapors, the dust concentration can be “too rich” or “too lean” to explode.
4. **Confinement** – The dust must be in a confined space, which allows for rapid pressure build-up. Typical examples include enclosed buildings, process equipment, silos/bins, dust collection systems, conveyors, etc.

Note: The rapid burning of combustible dust in an unconfined space will still create a hazardous flash fire.

Since all four conditions must take place at the same place at the same time, dust explosions are relatively rare events; however, they can produce catastrophic consequences as highlighted in the above losses.

A dust explosion can be the result of a single event; however, more often it is a series of several explosions occurring within seconds or even milli-seconds. For example, an upset condition occurs inside process equipment handling combustible dust, which causes an initial (primary) explosion. The primary explosion creates a shock wave throughout the facility that dislodges dust accumulations from various surfaces (i.e., building structural members, equipment, etc.). The dust is suspended in air and then ignited by the primary dust flame, which creates secondary explosions.

The majority of property damage is caused by fugitive dust accumulations within the building or process compartment. **The key to preventing combustible dust explosions is to control fugitive dust accumulations.** The photos below depict areas with significant accumulations of fugitive dust.



ARC RECOMMENDATIONS

While not all inclusive, the following basic loss prevention guidelines can greatly reduce the potential for property damage and resulting business interruption caused by combustible dust explosions:

1. Determine if your site handles any combustible dusts. Even if the dust is not listed in Appendix A, it could still be combustible. If in doubt, have the dust(s) tested by a qualified laboratory.
2. If the dust is explosible, have a qualified fire protection engineer perform a process hazard analysis (PHA) of the facility and processes in accordance with the latest edition of NFPA 652, *Standard on the Fundamentals of Combustible Dust*. The PHA should be documented and include written recommendations that will prevent and mitigate fires and dust explosions in the facility. The PHA should be reviewed and updated as needed at least every five years.
3. Develop and implement written procedures to manage change to process materials, technology, equipment, procedures and facilities (Management of Change). Even if properly designed and installed initially, many materials, processes and equipment change over time.
4. Control and limit fugitive dust accumulation throughout the facility as follows:
 - a. Design and maintain all dust handling processes and equipment to minimize the release of fugitive dust. Any dust release prevention measure will significantly reduce the cost associated with cleaning and hazardous electrical equipment installation.
 - b. Implement an effective housekeeping program with regular cleaning frequencies to ensure that the accumulated dust levels on walls, floors, and horizontal surfaces such as equipment, ducts, pipes, hoods, ledges, beams, and above suspended ceilings and other concealed surfaces, do not exceed 1/32 in. (0.8 mm).

A good rule to follow is if you can write your name in the dust, it's time to clean.
5. Control ignition sources in areas handling combustible dust as follows:
 - a. Ensure electrical equipment is listed for Class II hazardous locations.
 - b. Ensure equipment is properly grounded and bonded to prevent electrostatic discharge.
 - c. Use separator devices to remove foreign materials capable of igniting combustible dusts, such as tramp metal.
 - d. Implement an effective hot work management program to control the hazards of cutting, welding, grinding, etc.
 - e. Enforce no smoking policy.
 - f. Maintain equipment to prevent breakdown, which can lead to ignition (i.e., belts, bearings, clearances between moving parts, electrical loading, etc.).
 - g. Use industrial trucks approved for the electrical classification of the area.
6. Preferably locate dust collectors outdoors and equip with explosion relief venting. If located indoors, explosion relief should be vented to a safe area outdoors or explosion suppression provided.



REFERENCES

- NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities*
- NFPA 68, *Standard on Explosion Protection by Deflagration Venting*
- NFPA 69, *Standard on Explosion Prevention Systems*
- NFPA 70, *National Electrical Code*
- NFPA 484, *Standard for Combustible Metals*
- NFPA 499, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*
- NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations*
- NFPA 652, *Standard on the Fundamentals of Combustible Dust*
- NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*
- NFPA 655, *Standard for Prevention of Sulfur Fires and Explosions*
- NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*
- Occupational Safety and Health Administration (www.osha.gov)
- U.S. Chemical Safety and Hazard Investigation Board (www.csb.gov)

QUESTIONS OR COMMENTS?

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APPENDIX A: COMBUSTIBLE DUSTS (NOT ALL INCLUSIVE)

Agricultural Products

Egg white
Milk, powdered
Milk, nonfat, dry
Soy flour
Starch, corn
Starch, rice
Starch, wheat
Sugar
Sugar, milk
Sugar, beet
Tapioca
Whey
Wood flour

Agricultural Dusts

Alfalfa
Apple
Beet root
Carrageen
Carrot
Cocoa bean dust
Cocoa powder
Coconut shell dust
Coffee dust
Corn meal
Cornstarch
Cotton
Cottonseed
Garlic powder
Gluten
Grass dust
Green coffee
Hops (malted)
Lemon peel dust
Lemon pulp
Linseed
Locust bean gum
Malt
Oat flour
Oat grain dust
Olive pellets

Onion powder
Parsley (dehydrated)
Peach
Peanut meal and skins
Peat
Potato
Potato flour
Potato starch
Raw yucca seed dust
Rice dust
Rice flour
Rice starch
Rye flour
Semolina
Soybean dust
Spice dust
Spice powder
Sugar (10x)
Sunflower
Sunflower seed dust
Tea
Tobacco blend
Tomato
Walnut dust
Wheat flour
Wheat grain dust
Wheat starch
Xanthan gum

Carbonaceous Dusts

Charcoal, activated
Charcoal, wood
Coal, bituminous
Coke, petroleum
Lampblack
Lignite
Peat, 22% H₂O
Soot, pine
Cellulose
Cellulose pulp
Cork
Corn

Chemical Dusts

Adipic acid
Anthraquinone
Ascorbic acid
Calcium acetate
Calcium stearate
Carboxy-methylcellulose
Dextrin
Lactose
Lead stearate
Methyl-cellulose
Paraformaldehyde
Sodium ascorbate
Sodium stearate
Sulfur

Metal Dusts

Aluminum
Bronze
Iron carbonyl
Magnesium
Zinc

Plastic Dusts

(poly) Acrylamide
(poly) Acrylonitrile
(poly) Ethylene (low-pressure process)
Epoxy resin
Melamine resin
Melamine, molded (phenol-cellulose)
Melamine, molded (wood flour and mineral filled phenolformaldehyde) (poly) Methyl acrylate (poly) Methyl acrylate, emulsion polymer
Phenolic resin
(poly) Propylene
Terpene-phenol resin
Urea-formaldehyde/cellulose, molded
(poly) Vinyl acetate/ethylene copolymer
(poly) Vinyl alcohol
(poly) Vinyl butyral
(poly) Vinyl chloride/ethylene/vinyl acetylene suspension copolymer
(poly) Vinyl chloride/vinyl acetylene emulsion copolymer

Tech Talk is a technical document developed by ARC to assist our clients in property loss prevention. ARC has an extensive global network of more than 100 property risk engineers that offers tailor made, customer focused risk engineering solutions.

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