OsecoElfab

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Is your dust combustible?
And if so, what do you need to know?

Dust Explosion Protection: An Informal Introduction

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TABLE OF CONTENTS

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IGNITION

"Fire in the hole!" Once a common phrase heard throughout mines, the words warn that a dynamite charge has been set and an explosion is imminent.

Dynamite... Gunpowder... TNT. We all associate these terms with explosions, detonations and fire. But did you know that gunpowder is actually classed as a low explosive powder? In fact, in high concentrations, common household flour dust is several times more dangerous than gunpowder. And sugar dust is four times more powerful, weight-for-weight, than TNT.

Even powders that are well-known and trusted as food ingredients can become highly dangerous given the right conditions. Imagine a bustling Pennsylvania chocolate factory: Easter eggs and bunnies making their way along the production line, truffles being dusted in cocoa powder, vats of delicious chocolate pouring their gooey contents into corn starch-coated molds. But on March 24, 2023, this sweetly innocent scene takes a sudden and deadly turn. A gas leak ignites the powder-laden atmosphere, causing the cocoa powder and corn starch to detonate in milliseconds. The blast rips through the factory at a speed faster than sound, destroying several buildings and ultimately claiming seven lives.

This tragic example is just one of many devastating explosions that have occurred worldwide over decades at facilities where dusts are present. The constant risk of a deflagration has led regulators to draw up a series of standards for explosion protection. These are aimed at ensuring safer working environments at any manufacturing or processing plant that handles combustible dusts.

So how do dusts and powders ignite? What can be done to prevent or mitigate deadly dust explosions? And what regulations should bulk solid handlers be aware of?

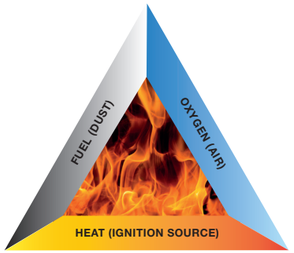
This white paper answers these questions, providing a concise overview of the regulatory landscape and methods of dust explosion protection. The paper also introduces a new flameless vent for passive explosion protection.

WHAT CAUSES DUST TO IGNITE?

Fire, Deflagrations and Explosions

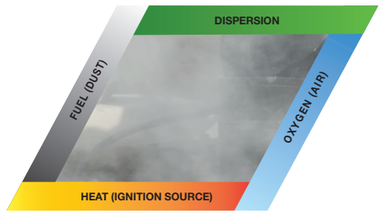
If sufficient concentrations of dust are mixed with oxygen, all it takes is an ignition source - a spark from moving machinery or static electricity, a stray hot ember, or even a cigarette butt - and the dust will burst into flame. Three forms of combustible dust hazard are fire, deflagration/flash fire, and explosion.

Fire Triangle



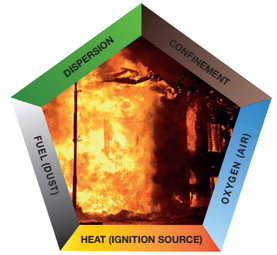
A fire requires three elements: Fuel (dust), oxygen (air), and an ignition source. This is represented in the Fire Triangle. Fires can occur if dust settles on a hot surface and ignites, or if an ignition source reaches a build-up of dust. Hazards include flame, heat, smoke and toxic by-products.

Deflagration



A deflagration or flash fire requires the three elements of the Fire Triangle, and the dust must be dispersed in the air at the right concentration. The dust ignites and forms a fireball that expands rapidly, generating a flame front and a rapid pressure rise. Deflagration hazards include damage to buildings and equipment, with a risk to life as the flame front can engulf employees.

Dust Explosion Pentagon



A dust explosion requires all the four elements for deflagration plus confinement - the Combustible Dust Pentagon. With the added element of confinement, explosion hazards are particularly dangerous. Where an explosion risk has been identified, equipment should comply with explosion prevention and protection measures outlined in NFPA 68 and NFPA 69.

Anatomy of a dust explosion

A primary dust explosion or deflagration can disperse unburned dust through the air and form a dust cloud. Heat from the primary explosion can ignite this cloud and cause a secondary explosion. This secondary explosion can often be larger and more violent than the primary one. Secondary explosions can also occur when energy from the primary explosion reaches more dust through piping, ducts, ventilation systems or conveyors.

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IS YOUR DUST COMBUSTIBLE?

Market Segments with Combustible Dusts

As we know, even apparently innocuous dusts such as cocoa powder, flour, coffee and sugar can become explosive. Any company involved in the production, handling, processing, packaging, and storage of dry particulate matter and/or bulk materials is likely to be at risk of a deflagration of combustible dust. These materials could include fine powders such as flour or pharmaceutical substances, or coarser particles such as sand, plastic pellets or agricultural products.

The powder and bulk solids industry covers a broad and diverse range of sectors. These include (but are not limited to):

Agriculture
Ceramics and Glass
Chemicals
Construction
Cosmetics and Personal Care
Energy
Food and Beverage
Mining, Metals and Minerals
Oil & Gas
Paints and Pigments
Pharmaceutical and Medical
Plastics and Rubber
Textiles
Waste and Recycling
Wood, Pulp and Paper

Dust has always been a risk: Firemen tackling a blaze at the Patterson-Sargent paint and pigment factory in Cleveland, Ohio, in 1913.

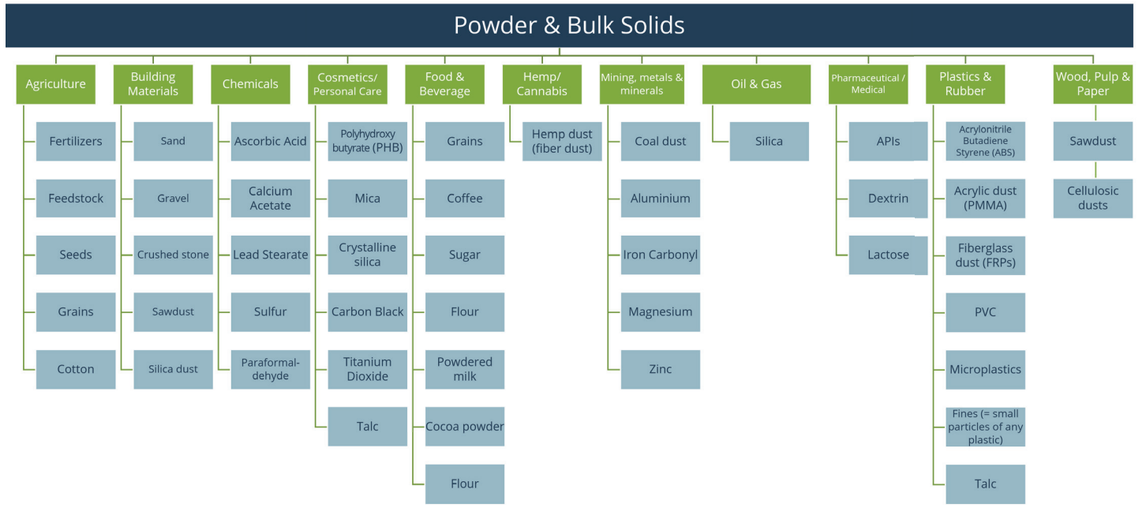

Figure 1: Some key segments in the Powder and Bulk Solids industry, with some of the combustible dusts commonly found in them.

IS YOUR DUST COMBUSTIBLE?

The Deflagration Index

Whether or not your industry sector is listed on the page opposite, it is crucial to determine whether your dust is considered combustible, and if your application requires deflagration venting.

The explosiveness of a particular dust in comparison to other dust types is measured using the Deflagration Index, denoted as Kst. Among other factors, Kst values depend on particle size, dust cloud concentration, and particle agglomeration. OSHA considers a Kst of 1.5 bar-m/s to be the minimum threshold for an explosion. However, any combustible dust with a Kst value greater than St0 could be subject to dust deflagration and must be treated accordingly.

Four Kst Classes identify the severity of the explosion produced by the dust:

St0	0 bar-m/s *e.g. Silica*	Does not explode
St1	1 to 200 bar-m/s *e.g. Milk, charcoal, sulfur, sugar, zinc*	Weak explosion
St2	201 to 300 bar-m/s *e.g. Cellulose, wood flour, polymethyl acrylate*	Strong explosion
St3	> 300 bar-m/s *e.g Aluminum, magnesium, Anthraquinone*	Very strong explosion

Although OSHA and NFPA publish data on the Kst classes of different dust types, the actual combustibility of a dust can be influenced by local conditions within facilities and processes. Additionally, no two dusts will have the same composition and characteristics. It is therefore essential to test the combustibility of the dust present in your facility and ensure appropriate safety measures are in place.

How to Test the Kst Value of your Dust

1. **Find a certified test lab:** OSHA's Salt Lake Technical Center or another licensed laboratory using recognized testing methods should be selected. The lab should adhere to standards such as ASTM (American Society for Testing and Materials) or ISO (International Organization for Standardization), and follow guidance provided by OSHA and NFPA.

2. **Collect a sample:** Collect a representative sample of your dust for testing. OSHA recommends collecting a full 1-liter bottle of sample whenever possible.

3. **Ship your sample:** Contact your chosen lab for instructions on safely packaging and shipping your dust sample.

4. **Lab testing:** The lab performs tests to measure your dust's Kst value. This involves dispersing the dust sample in a chamber and igniting it to precisely measure the rate of pressure rise.

5. **Results:** The lab will send you a report with the Kst value.

6. **Implement safety measures:** Use the Kst value and other findings to introduce appropriate safety measures in your facility to protect against dust fires, deflagrations, and explosions.

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SAFETY STANDARDS FOR COMBUSTIBLE DUSTS

The OSHA *Technical Manual, Section IV, Chapter 6, Combustible Dusts*, provides an extensive list of relevant safety references and standards. A few key standards are listed below. Please consult OSHA and local guidance for all applicable regulations and standards.

OSHA Standards
The *Code of Federal Regulations Title 29, Part 1910 - Occupational Safety And Health Standards* (29 CFR 1910) contains sections relevant to combustible dusts. Areas covered include housekeeping, equipment, electrical hazards and inspections.

NFPA 652
NFPA 652, *Standard on the Fundamentals of Combustible Dust*, outlines the processes that employers should follow to ensure that equipment, systems, process buildings, and other structures containing combustible dusts are designed, installed, operated, and maintained in a manner that protects workers.

NFPA Commodity-Specific Standards
Following on from NFPA 652, there are several Commodity-Specific Standards applicable to different dust types, including:

NFPA 61 – Agricultural and food processing dusts
NFPA 484 – Metal and metal alloy dusts
NFPA 654 – Combustible particulate solids
NFPA 655 – Bulk and liquid sulfur
NFPA 664 – Woodworking and wood processing dusts

NFPA 68
NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, applies to "devices and systems that vent the combustion gases and pressures resulting from a deflagration to minimize damage." *(nfpa.org)*

NFPA 69
NFPA 69, *Standard on Explosion Prevention Systems*, applies to systems for the prevention and control (protection) of explosions by methods other than those covered in NFPA 68.

OSHA *Occupational Safety and Health Administration*

NFPA *National Fire Protection Association*

CCPS *Center for Chemical Process Safety*

FM Global *Factory Mutual Property Loss Prevention Data Sheets*

NFPA 660

From 2025, NFPA 652 and the Commodity-Specific Standards will be consolidated into a single new standard, NFPA 660.

*The **NFPA Guide to Combustible Dusts** draws on real-life incidents and is useful for employers wishing to understand more about explosion hazard controls.*

METHODS OF DUST EXPLOSION PROTECTION

Active

Explosion suppression systems

These detect and automatically (actively) extinguish explosions as soon as they begin, often within milliseconds. Sensors detect a rapid rise in heat and/or pressure and send a signal to the control panel. This triggers the suppression mechanism, which releases a suppressing agent (a dry powder, liquid nitrogen, water or other specialist chemical) into the explosion zone. This ends combustion, reduces flame propagation, and lowers pressure, preventing prevent the explosion from spreading any further.

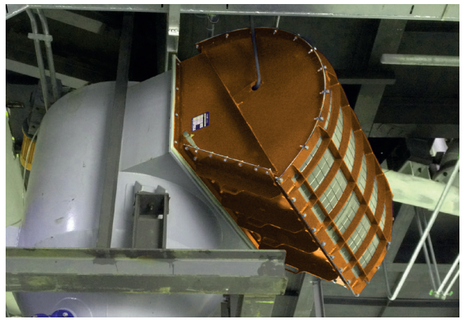
Passive

Explosion panels

Explosion panels prevent catastrophic damage from explosions and deflagrations by opening at a set pressure before other parts of the system begin to fail. Fire, heat, and pressure are vented into a safe area outside the building or vessel.

Flameless vents

Flameless vents present a compact alternative to panels and ductwork. They combine an explosion panel with a stainless steel mesh. During a deflagration, the panel bursts, allowing pressure, heat, gas, and particles to safely exit the vessel or pipework. The risk of a secondary explosion is reduced as the mesh quenches the flame and cools the burning dust or gases to below their ignition temperature. Fire and dust are retained within the flameless vent body. All that emerges is smoke.



Explosion isolation

Explosion isolation valves prevent explosions from spreading upstream from a dust collector or other vessel. A flap in the valve closes as the pressure wave from the explosion hits it, preventing further travel upstream, and protecting workers, equipment, and the facility.

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METHODS OF DUST EXPLOSION PROTECTION

Prevention

“Prevention is better than cure”: Deflagrations and explosions are often caused by nothing more than a simple accumulation of dust, which could be avoided by taking preventive measures such as:

- **Ventilation**
  Maintain adequate ventilation throughout the facility to prevent dust collecting or reaching dangerous concentrations.

- **Good equipment maintenance**
  to ensure machinery and systems do not exceed allowable temperatures and pressures.

- **Good housekeeping**, including:
  Routine Cleaning
  - Conduct routine clean-up of settled dust to prevent excessive accumulation
  - Identify, monitor and regularly clean places prone to dust accumulation
  - Avoid improper cleaning methods such as compressed air or high-pressure water sprays. The NFPA provides guidance on proper cleaning methods and protections.

  Proper Process Containment
  - Carry out measures to prevent or minimize the escape of dust, especially by addressing fugitive dust emissions and leaks.

  Regular Inspection, Measurement and Evaluation
  - Conduct regular inspections
  - Measure dust thickness regularly
  - Collect samples from different locations for analysis
  - Consider other parameters such as the total area of the enclosed space, the dusted area, and bulk density.
  - Be familiar with OSHA and NFPA standards that provide guidance on excessive dust loading.
  - Use safety data sheets, explosibility and combustibility analyses, and other relevant data to assess potential risks.

QUENCHING THE FLAMES: XPLO-GARD

An innovation in passive explosion protection

Xplo-Gard is an innovative flameless venting solution for enhanced explosion and deflagration protection. Designed for ease of use and maximum efficiency, Xplo-Gard presents a range of pioneering features that improve safety and accuracy.

EASY TO INSTALL AND MAINTAIN

1 INSPECTION WINDOW

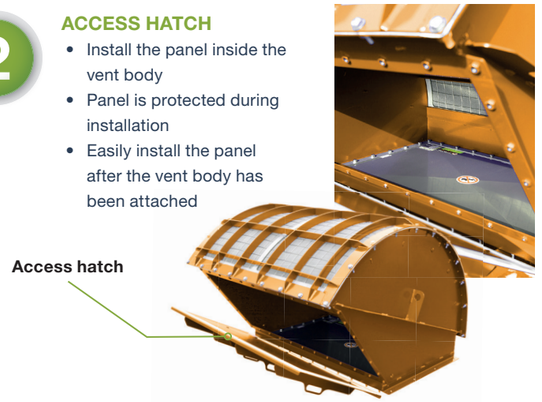
- Easily check dust levels and panel status while system remains pressurized

3 LIGHTWEIGHT (LW) VERSION

- Easier to install at height
- Cost-effective option with no compromise on safety or efficiency

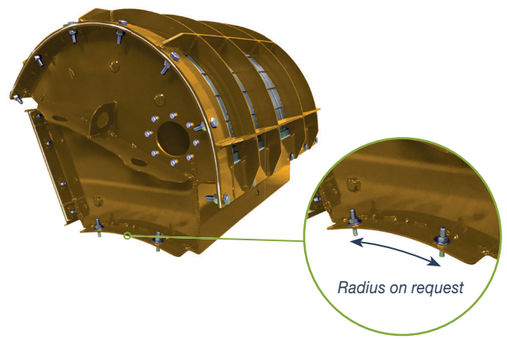
2 ACCESS HATCH

- Install the panel inside the vent body
- Panel is protected during installation
- Easily install the panel after the vent body has been attached



4 CURVED FLANGE AVAILABLE

- Install Xplo-Gard directly onto cylindrical vessels
- Minimize dust build-up



SAFE, EFFICIENT, COMPLIANT

- Pstat tolerance of +/-15% outperforms the industry standard of +/-25%
- Complies with NFPA 68 requirements
- Certified to European ATEX standards

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CITATIONS

Citations

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AFTERBURN: KEY TAKEAWAYS

1. If dust is present in your facility, you should test it to determine its level of combustibility.
2. A licensed laboratory can carry out the test for you.
3. Depending on the test results, there are a number of safety measures you must follow to comply with industry standards and guidelines.
4. Explosion protection measures include active, passive and preventive measures.
5. OsecoElfab provides a full range of passive explosion protection measures, including explosion panels and flameless vents.
6. OsecoElfab offers training on explosion protection in the powder bulk industry. Contact your local OE representative for further details.

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