FOCUS ARTICLE

Preventing and Protecting Against Dust Explosions in the Food Industry

Knowledge Is Safety

The risk of explosion in food processing plants may go dangerously undetected. Understandably, the problem is virtually unknown outside the chemical industry, but even within the industry it doesn't typically get the attention it deserves. This is a precarious state of affairs, since the overwhelming majority of powders in the food industry can form dust clouds that are prone to explosion under the right conditions. While these conditions occur less frequently in processing buildings, dust clouds regularly form during bin filling, powder conveying, or dust collection.

Two important factors affect the **explosibility** of a dust cloud: particle size and moisture content. In terms of size, fine particles have more surface area per unit of mass, which makes them more explosible. In dust clouds composed of a variety of particle sizes, the finer particles are the ones more likely to ignite and propagate an explosion. No matter the initial size of the particles in a given material, the chances of a dust cloud forming must be taken into account when analyzing the hazards of a process stream.

The second risk factor, a low moisture content, also contributes to the likelihood of explosion. Dust with less than 5% moisture is considered dry, but even those with moisture contents between 12 and 18%, common in many agricultural products, can lead to explosion. Of course, a dry dust with a small particle size poses the most risk and can produce the most violent explosions.

Three Steps to Addressing Dust Explosion Risk

Recognizing that **dust cloud explosion hazards** are a serious issue in the food industry is crucial, but it doesn't concretely address the issue. To reduce risks, there are three basic steps that organizations involved in food processing can take: assessing materials and processes; introducing measures to prevent explosion; and taking precautions that minimize the consequences should an explosion occur.

Responsible manufacturers know the properties of their materials well, calling on outside expertise if necessary. Laboratory testing of dust samples provide the data for calculating the ignition sensitivity and explosion severity characteristics of a dust cloud. In addition to knowing these properties, an assessment of potentially **hazardous areas** in the facility – where dust clouds could form under both normal and abnormal conditions – is vital to prevention and protection, as is the identification of potential ignition sources.

After gathering data on process materials and reviewing the processes, organizations should determine which prevention measures to implement. This means preventing explosible dust clouds from forming as well as reducing their size and duration. Ignition is a precondition for explosion, so manufacturers must also either eliminate or control ignition sources where dust clouds may be present.

Finally, there need to be protective measures in place that limit damage if an explosion occurs despite prevention efforts. Some options include explosion relief venting, explosion suppression, explosion containment, and explosion isolation. Under the right circumstances, manufacturers might also consider inert-gas purging or padding to prevent combustion.

The Role of Laboratory Testing

When seeking to understand and quantify risk, enlisting the help of an **experienced laboratory** can be game-changing. Generally speaking, laboratory personnel test dust samples to determine how likely it is that the dust will explode, as well as what the consequences of an explosion might be. These two characteristics taken together constitute a material's dust explosion risk.

The following is a compilation of tests that determine the probability of a dust explosion:

- Explosion Classification (Screening) Test (ASTM E1226, "Standard Test Method for Explosibility of Dust Clouds") answers the question, "Can this dust explode?"
- Minimum Ignition Energy [MIE] (ASTM E2019, "Standard Test Method for Minimum Ignition Energy of a Dust Cloud in Air") is used primarily to assess the susceptibility of dust clouds to ignition by electrostatic discharges (sparks).
- Minimum Ignition Temperature [MITCLOUD] of a Dust Cloud (ASTM E1491, "Standard Test Method for Minimum Auto-ignition Temperature of Dust Clouds") evaluates the ignition sensitivity of dusts to ignition sources such as heated environments, hot surfaces, electrically-powered devices, and frictional hot spots and sparks.
- Minimum Ignition Temperature [MITLAYER] of a Dust Layer (ASTM E2021, "Standard Test Method for Hot Surface Ignition Temperature of Dust Layers") is used in evaluating the ignition sensitivity of powders to ignition by hot surfaces, as on electrically-powered devices.
- Self-Heating tests (J. A. Abbott, "Prevention of Fires and Explosions in Dryers," Institute of Chemical Engineers, 1990) predict the onset temperature for self-ignition and the induction time to self-ignition.
- Electrostatic Volume Resistivity (in general accordance with ASTM D257, "Standard Test Methods for DC Resistance or Conductance of Insulating Materials") classifies powders as low, moderately, or highly insulating. Insulating powders have a propensity to retain electrostatic charge and can produce hazardous electrostatic discharges.
- Electrostatic Chargeability (in general accordance with ASTM D257, "Standard Test Methods for DC Resistance or Conductance of Insulating Materials") provides data that can be used to develop appropriate materials-handling guidelines from an electrostatic hazards point of view.
- Minimum Explosible Concentration [MEC] (ASTM E1515, "Standard Test Method for Minimum Explosible Concentration of Combustible Dusts") answers the question, "What are the exhaust-ventilation requirements?"
- Limiting Oxygen (Oxidant) Concentration [LOC] (ASTM E2931, "Determination of the Limiting Oxygen Concentration of Dust Clouds") is used to study explosion prevention or severity reduction through the use of inert gases and to set oxygen concentration alarms or interlocks in inerted vessels.

To better understand the consequences of a dust cloud explosion, laboratories test for Maximum Explosion Pressure, Maximum Rate of Pressure Rise, Deflagration Index (Kst Value) (ASTM E1226, "Standard Test Method for Explosibility of Dust Clouds"). These tests yield data that can be used to design appropriate dust-explosion protection measures such as explosion **relief venting**, suppression, and containment. They can also rate the probable severity of an explosion, so that manufacturers can make informed decisions about risk tolerance.

Prevention and Protection: Process Safety Super Twins

The data supplied by laboratory testing need to be put to work in practical, efficient ways in order to ensure safety from dust cloud explosions. The mantra here is prevention and protection. The former includes taking steps to avoid a disaster (explosion prevention), while the latter involves designing facilities and equipment so that people and processes are protected should an incident occur (explosion protection). These approaches are equally important.

As mentioned above, the first order of business is to ensure that no dense dust cloud is allowed to form. Evaluating dust release points and exhaust ventilation requirements contributes to this goal, as it is easier to install and maintain appropriate dust-reducing devices than to clean up dust that has escaped. Prevention is also served when the other conditions conducive to an explosion are eliminated or reduced: oxygen in the process equipment and potential ignition sources.

Just as essential as information about the materials being used is sufficient process safety data. Without a thorough knowledge of process flows and equipment, effective prevention and protection is impossible. While each organization is unique, the table below provides an overview of the type of data that might be required to assess dust explosion hazards associated with some common unit operations in the food industry.

Unit Operation	Explosion Screening[1]	MIE (mJ)	MIT[2] – Cloud (°C)	MIT[2] – Layer (°C)	Deflagration Index [Kst] (bar.m/s)	Maximum Explosion Pressure (barg)	LOC[3] (%)	MEC (g/m^3)	Volume Resistivity[4] (ohm.m); Chargeability	Self-Heating (°C)
Manual Handling / Pouring	×	×							×	
Sieving / Screening	×	×							×	
Tumble / Double Cone Blending	×	×			×	×	×		×	
Ribbon Blending	×	×	×	×					×	
Milling	×	×	×	×	×	×	×		×	×
Jet Milling	×	×			×	×	×		×	
Spray, Fluidized Bed, Tumble Drying	×	×			×	×		×	×	×
Tray Drying	×	×								×
Pneumatic Conveying	×	×						×	×	
Screw Conveying	×	×	×						×	
Transfer to Hopper, Bin, Tote, Container	×	×			×	×			×	
Dust Collector and Exhaust Ventilation	×	×			×	×		×	×	

1 Explosibility Screening test is only conducted if the combustibility of the powder/dust (as being present in the process/facility) is not yet established. If the powder is found to be non-combustible, other tests in the table may not be required.
2 The MIT of dust clouds and layers are needed if Hazardous Area Classification is applied to manage ignition sources from electrical devices in order to specify maximum surface temperatures.
3 LOC is needed if the basis of safety is inert gas blanketing.
4 Volume Resistivity and Chargeability should be considered if the Minimum Ignition Energy is less than 30mJ.

References:

> National Fire Protection Association, "Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids", NFPA 654, (2017).

> Frank, W. L., and S. A. Rodgers, "NFPA Guide to Combustible Dusts", (2012).

> Eckhoff, R. K., "Dust Explosions in the Process Industries", 2nd Ed., (1999).

> National Fire Protection Association, "Standard on the Fundamentals of Combustible Dust", NFPA 652, (2016).

> National Fire Protection Association, "Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities", NFPA 61, (2017).

> National Fire Protection Association, "Recommended Practice on Static Electricity", NFPA 77, (2019).

> The Internet, **https://www.dekra-process-safety.com/guide-to-dust-explosion-hazards**

DEKRA Process Safety

The breadth and depth of expertise in process safety makes us globally recognized specialists and trusted advisors. We help our clients to understand and evaluate their risks, and work together to develop pragmatic solutions. Our value-adding and practical approach integrates specialist process safety management, engineering and testing. We seek to educate and grow client competence to provide sustainable performance improvement. Partnering with our clients we combine technical expertise with a passion for life preservation, harm reduction and asset protection. As a part of the world's leading expert organization DEKRA, we are the global partner for a safe world.

Process Safety Management (PSM) Programs

> Design and creation of relevant PSM programs
> Support the implementation, monitoring, and sustainability of PSM programs
> Audit existing PSM programs, comparing with best practices around the world
> Correct and improve deficient programs

Process Safety Information/Data (Laboratory Testing)

> Flammability/combustibility properties of dusts, gases, vapors, mists, and hybrid atmospheres
> Chemical reaction hazards and chemical process optimization (reaction and adiabatic calorimetry RC1, ARC, VSP, Dewar)
> Thermal instability (DSC, DTA, and powder specific tests)
> Energetic materials, explosives, propellants, pyrotechnics to DOT, UN, etc. protocols
> Regulatory testing: REACH, UN, CLP, ADR, OSHA, DOT
> Electrostatic testing for powders, liquids, process equipment, liners, shoes, FIBCs

Specialist Consulting (Technical/Engineering)

> Dust, gas, and vapor flash fire and explosion hazards
> Electrostatic hazards, problems, and applications
> Reactive chemical, self-heating, and thermal instability hazards
> Hazardous area classification
> Mechanical equipment ignition risk assessment
> Transport & classification of dangerous goods

We have offices throughout North America, Europe, and Asia.
For more information, visit **www.dekra-process-safety.com**
To contact us: **process-safety-usa@dekra.com**

DEKRA