Dust Explosions in the Food Industry

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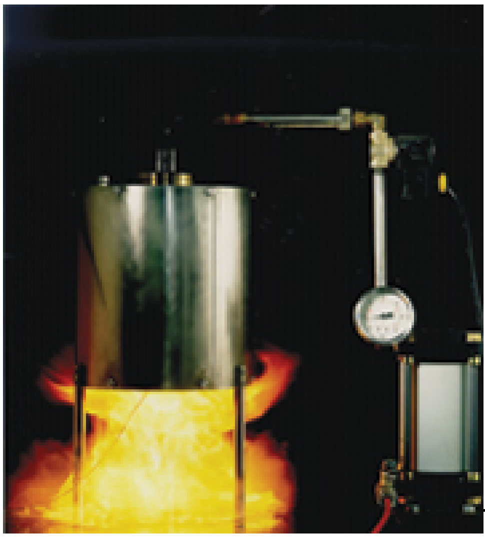

The vast majority of powders in the food industry can form explosible dust clouds if the particle size is small and moisture content is low. Although explosible dust cloud concentrations are not normally expected to be present within processing buildings, explosible dust clouds are regularly formed inside material handling or processing equipment when bins are being filled, powders are being transferred or dust is being collected in a dust collector.

The particle size of the dust is a property which influences the explosibility of the dust cloud. The finer the particles the greater the surface area per unit of mass and thus the more explosible a given dust is likely to be. When the cloud is composed of a series of particle sizes ranging from fine to coarse, the fine particles play a prominent part in the ignition and the explosion propagation. The presence of dusts should therefore be anticipated in the process stream, regardless of the starting particle size of the material.

The moisture content of a product will also affect the explosion risk. A dry dust contains less than five percent moisture. Dry dusts of small particle size will be more easily ignited and produce more violent explosions. It must be noted that particles with moisture contents in the range of 12 to 18 percent, as found naturally in many agricultural products, can still be explosible.

Assessing Dust Explosion Hazards

A systematic approach to identifying dust cloud explosion hazards and taking measures to ensure safety involves:

- Determining the dust cloud's ignition sensitivity and explosion severity characteristics through appropriate laboratory tests on representative dust samples.

- Identifying areas of the facility where combustible dust cloud atmospheres could exist under both normal and abnormal conditions.
- Identifying potential ignition sources that could exist under both normal and abnormal conditions.
- Preventing the formation of explosible dust clouds in the plant and reducing the extent and duration of any clouds that may form.
- Taking measures to eliminate and control ignition sources.
- Taking measures to protect against the consequences of dust cloud explosions. Explosion protection measures include explosion relief venting, explosion suppression, explosion containment and explosion isolation. Where practical, one could consider the application of inert gas purging or padding to prevent the combustion process.

Laboratory Testing

To assess the possibility of an explosion in a facility and to select the most appropriate basis of safety, explosion characteristics of the dusts that are being handled and processed in the facility should be determined.

The explosion characteristics of powders normally fall within one of two groups, “likelihood of an explosion” and “consequences of an explosion.” Taken together, these two characteristics determine the dust explosion risk of a material.

The following tests provide information on the likelihood of a dust explosion:

- Explosion Classification (Screening) Test (ASTM E1226, Standard Test Method for Explosibility of Dust Clouds): This test answers the question “Can this dust explode?”
- Minimum Ignition Energy (ASTM E2019, Standard Test Method for Minimum Ignition Energy of a Dust Cloud in Air): The test is used primarily to assess the susceptibility of dust clouds to ignition by electrostatic discharges (sparks).
- Minimum Ignition Temperature (MIT) of a Dust Cloud (ASTM E1491, Standard Test Method for Minimum Auto-ignition Temperature of Dust Clouds): The MIT Cloud is an important factor in evaluating the ignition sensitivity of dusts to such ignition sources as heated environments, hot surfaces, electrical devices and friction sparks.
- Minimum Ignition Temperature (MIT) of a Dust Layer (ASTM E2021, Standard Test Method for Hot Surface Ignition Temperature of Dust Layers): The MIT Layer is used in evaluating the ignition sensitivity of powders to ignition by hot surfaces.
- Self-Heating (JA Abbott (ed.) “Prevention of Fires and Explosions in Dryers,” Institute of Chemical Engineers, 1990): The minimum onset temperature for self-ignition of a powder depends mainly on the nature of the powder and on its dimensions. If these variables are predictable, a reliable assessment of the onset temperature for self-ignition and also the induction time to self-ignition can be made by appropriate small-scale laboratory tests.
- Electrostatic Volume Resistivity (General Accordance with ASTM D257,

Standard Test Methods for DC Resistance or Conductance of Insulating Materials): Volume Resistivity is the primary criterion for classifying powders as low, moderately or highly insulating. Insulating powders have a propensity to retain electrostatic charge and can produce hazardous electrostatic discharges.
- Electrostatic Chargeability (General Accordance with ASTM D257, Standard Test Methods for DC Resistance or Conductance of Insulating Materials): This test provides data that can be used to develop appropriate material 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): This test answers the question "How easily can an explosible dust cloud be formed?"
- Limiting Oxidant Concentration (LOC) (EN 14034-4, Determination of the Limiting Oxygen Concentration of Dust Clouds): The LOC test is used to study explosion prevention or severity reduction involving the use of inert gases and to set oxygen concentration alarms or interlocks in inerted vessels.

This test determines the consequences of an explosion and explosion severity:

- Maximum Explosion Pressure, Maximum Rate of Pressure Rise, Deflagration Index (Kst Value) (ASTM E1226, Standard Test Method for Explosibility of Dust Clouds): The maximum explosion pressure and maximum rate of pressure rise are measured and the latter is used to calculate the Deflagration Index (Kst) value of the dust cloud. These data can be used for the purpose of designing dust explosion protection measures such as explosion relief venting, suppression and containment and to classify a material's explosion severity. This test answers the question, "How bad is it if it happens?"

Approaches To Process Safety Testing

The table below specifies the type of data that might be required to assess dust explosion hazards associated with some common unit operations in the food industry.

Dust Explosion Test Data Requirements for some Specific Unit Operations

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

[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] LOC is determined if the basis of safety is inert gas blanketing.
[3] Volume Resistivity should be considered if the Minimum Ignition Energy is less than 25mJ.
[4] Chargeability should be considered if the Minimum Ignition Energy is less than 25mJ.

Explosion Prevention & Protection Measures

Safety from dust cloud explosions includes taking measures to avoid an explosion (explosion prevention) or designing facilities and equipment so that in the event of an explosion people and processes are protected (explosion protection).

The risk of an explosion is minimized when one of the following measures is ensured:

- An explosible dust cloud is never allowed to form.
- The atmosphere is sufficiently depleted of oxidant (normally the oxygen in air) that it cannot support combustion.
- All ignition sources capable of igniting the dust cloud are removed.
- People and facilities are protected against the consequences of an explosion by “protection measures” such as explosion containment, explosion suppression or explosion relief venting.
- Housekeeping activities must ensure that secondary fuel sources are not available. Of key importance is the evaluation of dust release points and exhaust ventilation needs. It is much easier to replace a gasket, refit a manway, install local dust aspiration systems, etc., than to spend the time cleaning up the dust that has escaped.

Dr. Ebadat is a regular speaker at training courses on gas and vapor flammability, dust explosions and controlling electrostatic hazards. For more information, please call Ebadat at 609.799.4449, or email safety-usa@chilworthglobal.com [1] *or visit* www.chilworth.com *[2]* .

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