Risk information – Property

Dust hazards

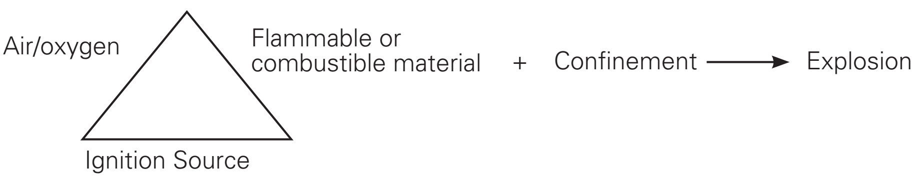
Introduction

Dust explosions result in deaths and millions of dollars of property damage and business interruption at industrial facilities each year. Despite this they are one of the least understood and recognised industrial hazards. To many, dust remains an inert and innocuous substance. For many dusts this is not so.

If combustible dusts are present they can become dispersed in air, and if an ignition source is present, an explosion hazard exists.

Industries where such hazards exist include agricultural grain storage and handling, milling and malting operations, food (grinding, mixing and drying), chemical, forest products, mining, plastics (including regrinding), and even metal processing.

Common combustible dusts include; flour; milk powder; potato, soup and custard powders; sugar; corn meal and starch; grits and grain dusts and mill feeds such as bran, hulls and screenings. Others include wood, coal, rubber, plastics, tobacco and many metal dusts.



Discussion – Science of fires and explosions:

Three basic conditions must be present for a fire or explosion to occur:

- A flammable or combustible material must be present in significant quantities. This can be a liquid, gas, vapour, mist, dust, fibres flying or a combination of combustible materials;
- The materials must be mixed with air or oxygen in proportions needed to produce an explosive mixture (dust in suspension); and
- An ignition source of sufficient energy to ignite the explosive mixture must be present.

Explosions are also characterised by confinement. This provides resistance, allowing pressure build up. Elimination of any of these parameters will prevent an explosion.

Explosions are a chemical reaction with a sudden release of energy resulting in sudden and significant pressure rise. The term **deflagration** is used for an explosion where the speed of the flame front is less than the speed of sound within the explosion medium. **Detonation** is used where the speed of the flame front is greater than the speed of sound in the explosion medium.

Dust explosions are typically deflagrations due to the relatively slow process of combusting solid particles. Factors in the severity of dust explosions include the heat release rate of the material involved, particle sizes and the Kst – value.

The Kst – value is a universal dust explosibility constant, defined as the maximum rate of pressure rise of a dust explosion in a one cubic metre vessel. The units are bar metre per second (bar m/s). By applying the "cubic law", a Kst value is obtained which is independent of the vessel volume.

It is generally regarded that organic materials (both natural (grains, sugars, etc.) and synthetic (plastics, organic pigments and pesticides)), peat and coal, and metals such as aluminium, iron and zinc, etc. are capable of being explosive when in dust form.

The degree of explosivity for a particular dust will vary from process to process.

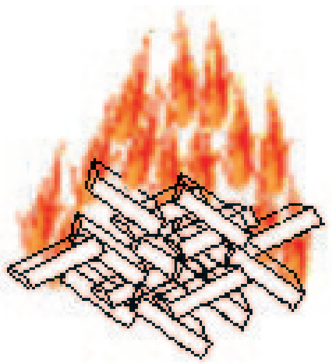
If no data is available for the particular dusts handled at your facility there are various testing bodies which are able to undertake testing to determine Kst values.

The following dust explosion classes are assigned to the Kst – values:

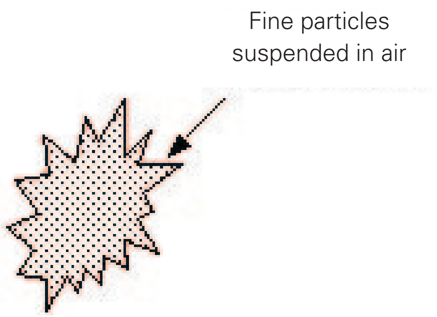
Chemistry of dust explosions

The rate at which a solid burns in air increases with increased surface area. If the heat released is more than it took to generate the fire then the fire won't just burn it will burn more rapidly and possibly become an explosion.

(a) Slow combustion



(b) Fast combustion



(c) Explosion

Figure 1

Illustration of how the combustion rate of a given mass of combustible solid increases with increasing sub-division.

Kst – Value (bar m/s)	Dust Explosion class
>0 to 200	st 1
>200 to 300	st 2
>300	st 3

Other than surface area, factors such as the chemical composition of the dust, moisture content, particle size (finer particles, lower ignition energy) and shape (surface area), dispersion and concentration are important. Properties of the dust cloud such as turbulence, temperature, pressure and radiative heat transfer also affect the likelihood and severity of an explosion. The presence of any additional fuels (gases or vapours) can also be a negative factor.

A dust cloud of any combustible material will explode where; the concentration of the dust in air falls within the upper and lower explosive limits (LEL < X < UEL) **and** a source of ignition of the required energy is present. The dust cloud ignition temperature is the temperature at which a dust cloud ignites.

As a general rule of thumb the lowest concentration of dust that can sustain a dust explosion is 40 to 100 g/cu.m. and the maximum about 3-4 kg/cu.m. Typically these sorts of concentrations are not found in the workplace but are confined to specific pieces of process equipment where the dust is generally suspended in air allowing the appropriate conditions for a primary explosion to occur.

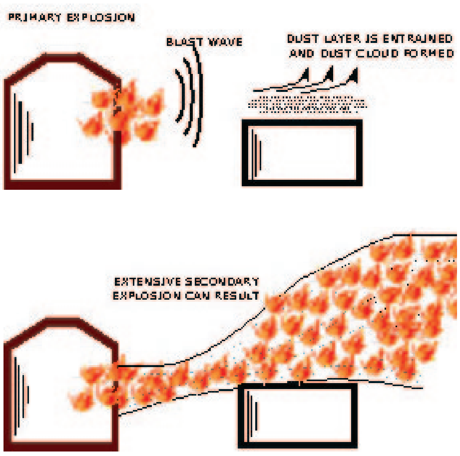
In industry this includes common equipment such as mixers, mills, cyclones, dryers, screens, hoppers, bucket elevators, dust collectors, silos, aspirators and pneumatic transfer lines.

Outside of process equipment, the concentrations of dust required for an explosion are typically not seen.

Most severe dust explosions begin within a piece of equipment. If the equipment has insufficient pressure relief or venting this can result in rupture.

There are various resources available providing indicative Kst values for tested dust samples.

A secondary (and usually more devastating) explosion is then able to occur when dust on raised surfaces (tops of equipment, on ledges etc.) is disturbed by the primary explosion, forming a dust cloud which is then ignited by the heat from the primary explosion. A series of devastating explosions can result if there is a large amount of dust that is disturbed.



Just a 1.0 mm layer of dust with a density of 400 kg/cu.m. can give rise to a 4 m deep cloud with a density of 100 g/cu.m.

Ignition sources

In industry there are numerous potential ignition sources of varying strength. These include open flames (including cutting, welding, matches/smoking), hot surfaces (motors, dryers, bearings, heaters), sparks from faulty electrical equipment, electrical and electrostatic discharges, smouldering and burning dusts (spontaneous combustion), mechanical impact and friction. Ignition sources as low as 10 milli joules (mJ) can ignite dust clouds.

Dusts have a layer ignition temperature which is the lowest temperature at which a heated surface can ignite a layer of dust. This ignition temperature also decreases as the thickness of the dust layer increases.

Prevention and mitigation/ control of dust explosions:

Prevention of dust explosions

Prevention of explosions centres upon the exclusion of either the dust (and hence potential dust cloud) or the ignition source.

Eliminating dusts: Means of eliminating the fuel sources includes:

- Scrupulous cleanliness (housekeeping),
- Automated dust control/collection systems,
- Elimination of fugitive dust sources, leaks etc.

Often the initial design of a plant to facilitate cleaning can assist significantly, such as minimisation of ledges and flat surfaces where dusts can collect.

When cleaning, vacuuming, washdown and sweeping are preferred to the use of compressed air for blowing down, which by nature places the dust in suspension.

Removing ignition sources: Elimination of ignition sources can include:

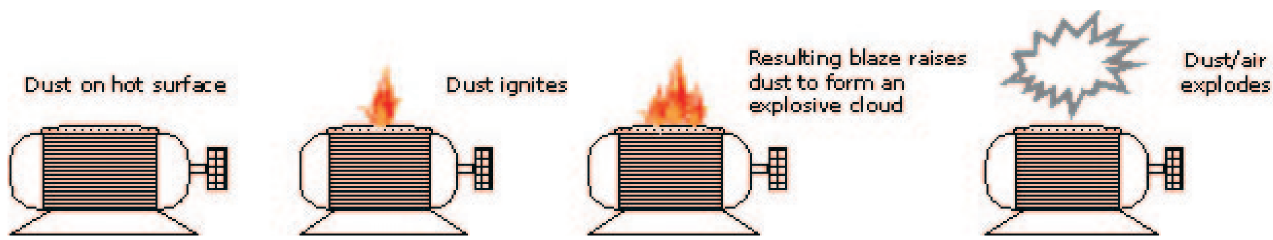
- Ensuring that electrical equipment is correctly rated for the Hazardous Areas, eg. Zone 20, 21 or 22 in accordance with Australian Standard AS61241-Electrical Equipment for use in the Presence of Combustible Dust,
- Strict control of Hot Work using an appropriate permit system,
- Prohibiting smoking in areas with potential for dust clouds,
- Equipment maintenance (eg. bearings lubricated, motors maintained),
- Removal of any other flammables and combustibles,
- Thermography to identify overheating or rubbing equipment, (e.g. bearings)
- Ensuring that equipment with the potential to ignite dust clouds is statically bonded and grounded,
- Removing sources of metal using sieves and magnets,
- Underspeed and alignment interlocks for bucket elevators and conveyors.

The owner/occupier of the premises is usually responsible for the recognition and classification of Hazardous Areas.

Area classification should be carried out by those who are competent and have full knowledge of the processes, systems and apparatus concerned.

The agreement reached on the classification should be formally recorded and copies kept in a verification dossier.

It is rarely practical or possible to remove all the fuel and potential ignition sources. There will typically be means to mitigate/ control explosions and minimise their potential spread.



Mitigation/control of dust explosions

Mitigation/Control of explosions concentrates upon the isolation, redirection or suppression of the explosion.

Isolation of explosions; This relies on preventing the explosion from reaching other areas through process ducts or pipes etc. Choked screw conveyors and rotating airlocks are plant items that will normally prevent propagation of flames throughout the system. Bursting/rupture discs on pipelines also stop flame propagation by reversing air flow.

Location of equipment subject to explosion in isolated areas of the site is also a very effective means of isolating the explosion. Some equipment can also be designed to withstand the internal explosion (explosion resistant).

Redirection of explosion; Explosion relief venting directed to outside or a suitable indoor area with no potential for secondary explosion, or damage to equipment or injury to personnel is a reliable means of controlling an explosion. This should be provided for equipment with potential for explosion such as bucket elevators, dust collection silos and bag houses (filters) etc.

Explosion relief venting should be arranged to shut down the plant following an explosion. This will help prevent fire spread or reoccurrence.

Ideally, explosion relief should also be provided on silos and bins. This is usually more practical at initial design and significantly more costly when retrofitted.

Suppression of explosion; A more costly, though often effective means, in many circumstances, is the use of explosion suppression systems. These systems typically operate by detection of the explosion (optical, thermal or pressure sensors (or combination)) and suppression by flooding with an extinguishing agent. These can be effective as the explosion develops the pressure front travels about ten times faster than the flame front.

In all cases explosion relief venting and suppression requirements should be calculated and designed by an expert in the field using recognised methods.

Conclusion

Many industries have potential explosion hazards. Awareness and understanding of the potential, and means to eliminate or minimise the likelihood or impact of such an event, are critical to ensuring an acceptable level of risk for a facility.

No one solution is the best fit for a particular industry, plant or process. Generally a site with dust explosion hazards will require a combination of prevention and mitigation/control measures to obtain an economically viable as well as effective loss prevention strategy. Further guidance and assistance can be obtained from your Vero Insurance – Risk Engineering Consultant.

As with most fire and explosion hazards, personnel training and education regarding the hazard will greatly assist in recognizing and reducing the risk on site. High standards of housekeeping and elimination of potential ignition sources are critical to reducing the exposure associated with this hazard.

Resources

Dust Explosions In The Process Industry – Rolf K Eckhoff, Butterworth-Heinemann Ltd (1994), Oxford London.

Dust Explosion In The Food Industry – HSE (Health and Safety Executive) Information Sheet.

FM Global – Property Loss Prevention Data Sheets.

NFPA – Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Product Facilities.

AS 2380 – Electrical Equipment for Explosive Atmospheres – Protection Techniques.

AS/NZS 61241 – Electrical Equipment for Use In The Presence of Combustible Dust.