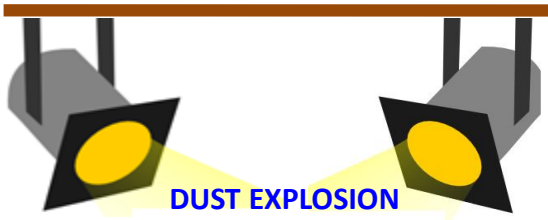

DUST EXPLOSION

What is Combustible Dusts ?

"A combustible particulate solid that presents a fire or deflagration hazard when suspended in air or some other oxidizing medium over a range of concentrations, regardless of particle size or shape" is defined as combustible dust. As a general rule of thumb, combustible particulates having an effective diameter of **420 µm or smaller** are generally considered as combustible dusts. Any particle that has a surface area to volume ratio greater than that of a 420 µm diameter sphere should also be considered a combustible dust according to NFPA definition.

Dust is defined as "solid particles generated by handling, crushing, grinding, rapid impact, detonation, and decrepitation of organic or inorganic materials, such as rock, ore, metal, coal, wood, and grain." Dust is a by-product of different processes that include dry and powdery material conveying, solids crushing and screening, sanding, trimming of excess material, tank and bin feeding and storing of granular materials, and a number of other processes.

The unit of measure used to characterize dust particle size is the 'micrometre', more commonly known as a **micron or µm.**

Size and Shape: Size has a direct influence on material properties including reactivity or dissolution rate e.g. catalysts, tablets; in the stability in suspension e.g. sediments and paints; for efficacy of delivery e.g. asthma inhalers; in the texture and feel e.g. food ingredients; in product appearance e.g. powder coatings and inks; in terms of flowability and handling e.g. granules; in viscosity e.g. nasal sprays; in the packing density and porosity of a product, e.g. ceramics.

Particles are 3- dimensional objects and as they are not perfect spheres, it is convenient to define particle size using the concept of equivalent sphere having the same property as the actual particle like volume or mass for example. Different equivalent sphere models are :

1. Sphere with the same weight of a particle
2. Sphere with the same volume as a particle
3. Sphere with the same surface area of a particle
4. Sphere capable of passing through the same sieve aperture as a particle
5. Sphere having the same settling or sedimentation rate as a particle
6. Sphere with the same maximum or minimum length of a particle

Size Distribution : The term particle size distribution actually refers to an index, which is a means of expression indicating the **sizes of particles that are present in specified proportions.** Terms used to define distributions are :

1. Weighted distributions
2. Number weighted distributions
3. Volume weighted distributions
4. Intensity weighted distributions

Examples of combustible dusts & Industries :

- Pharmaceuticals (e.g., vitamins; cosmetic powders)
- Plastics (e.g., phenolics, polypropylene)
- Resins (e.g., lacquer, phenol-formaldehyde)
- Food products (e.g., grain, cellulose, powdered milk, sugar, flour, starch, cocoa, maltodextrin, candy, spices)
- Coal and other carbon dusts
- Inorganic materials (Aluminium, Iron, Magnesium Powder, Manganese, Sulphur) and Metal powder processing or storage (especially magnesium and aluminium)
- Agriculture (Pesticides, Herbicides, Fertilizer manufacturing)
- Wood (e.g., wood dust, wood flour)
- Textiles (e.g., cotton dust, nylon dust)
- Biosolids (dried wastes from sewage treatment plants)
- Tobacco
- Chemical manufacturing

Conditions for Dust Fires and Explosions

Important points for dust explosion to occur are :

1. Combustible particulates sufficiently small to burn rapidly when ignited
2. A suspended cloud of these combustible particulates at a concentration above the minimum explosible concentration (MEC)
3. Confinement of the dust cloud by an enclosure or partial enclosure
4. Oxygen concentration greater than the limiting oxygen concentration (LOC) for the suspended dust cloud
5. Delayed ignition source of adequate energy or temperature to ignite the suspended cloud

Minimum Explosible Concentration (MEC): The lowest concentration of dust that can support a self-propagating explosion. MEC corresponds to the smallest concentration that produces a pressure at least twice as large as the initial pressure at ignition. MEC values are not very sensitive to particle diameter for diameters less than about 60 µm, but increase significantly with increasing diameter above this approximate threshold. The majority of the materials known to cause explosions have MEC values in the range **30 to 125 g/m3.**

Ignition Sources : The ignition form can be :

- Electrostatic Discharges
- Impact and Frictional Heating
- Hot Surfaces
- Burning Embers and agglomerates
- Self Heating
- Electrical Equipment

Primary and Secondary Dust Explosions

Dust explosions can either be **primary or secondary**. A primary dust explosion occurs when a dust suspension within a container, room, or piece of equipment is ignited and explodes.

A secondary explosion occurs when dust accumulated on floors or other surfaces is lofted and ignited by a primary explosion. Depending on the extent of the dust deposits, a weak primary explosion may cause very powerful secondary dust explosions. The best way to prevent secondary dust explosions is to **minimize dust accumulations on surfaces. Preventing dust leaks, the application of well-maintained dust collectors, minimizing flat surfaces** where dusts may accumulate, and **sealing hard-to-clean areas** can prevent secondary dust explosions.

Factors Influencing Dust Explosibility :

Following factors influence dust explosibility :

- Particle size and particle size distribution
- Dust concentration
- Oxidant concentration
- Ignition temperature
- Turbulence of the dust cloud
- Maximum rate of pressure rise
- Admixed inert dust concentration
- Presence of flammable gases

Dusts are combustible within certain concentrations. General ranges are 20-60 g/m3 air as the lower combustibility limit to 2-6 kg/m3 air as the upper combustible limit. Highly combustible dusts can form flammable mixes at concentrations less than 15 gm/m3.

Minimum Ignition Temperature (MIT) : The MIT is defined by convention to be the lowest temperature of a hot surface that will cause a dust cloud, rather than a dust layer, to ignite and propagate flame.

Classification of Dusts :

It is expected that all explosible dusts are combustible; however not all combustible dusts are easily explosible.

The Combustion Class is a measure of Ignitability of a dust layer and burning intensity of a dust layer and six-tier classification based on it is :

1. **CC1: No ignition; no self-sustained combustion**
2. **CC2: Short ignition and quick extinguishing; local combustion of short duration**
3. **CC3: Local burning or glowing without spreading; local sustained combustion but no propagation**
4. **CC4: Spreading of a glowing fire; propagation smoldering combustion**
5. **CC5: Spreading of an open fi re; propagating open flame**
6. **CC6: Explosible burning; explosive combustion**

'K_{st} value' : This is a term which quantifies the maximum rate of pressure rise in 1 m3 vessel when a dust is ignited. It may be thought of as a parameter that defines the degree of **'dust explosion violence'**. General Ranking based on it :

1. K_{st} = Group St_0 : Non-explosible
2. $0 < K_{st} < 200$ = Group St_1 : Weak explosibility
3. $200 < K_{st} < 300$ = Group St_2 : Strong explosibility
4. $300 < K_{st}$ = Group St_3 : Very strong explosibility

Note that the subscript "St" is by convention and refers to the German word for dust.

Explosion of **Dust comprise of volatile substances** explode in three steps in very quick succession :

1. Devolatization (where volatile materials are released from the particles or the particles themselves vaporize)
2. Gas phase mixing of fuel (released by dusts) and oxidant (usually air)
3. Gas phase combustion

Equipments that have been involved in dust explosion include :

- Bag openers (slitters)
- Blenders and mixers
- Dryers and ovens
- Dust collectors
- Pneumatic conveyors
- Size reduction equipment (grinders)
- Silos and hoppers
- Hoses
- Loading spouts
- Flexible boots

Good Industry Practices are :

- Separation of hazardous processes from other work areas
- Ventilation systems (especially local exhaust ventilation near the source)
- Use of dust collection equipment
- Placing vents on equipment where a dust explosion could occur
- Use of dust extraction on hand held tools
- Separation of heat and ignition sources from combustible dusts
- Using spark detection systems
- Using wet or damp work methods
- Adopting an aggressive cleaning program (including areas where dust may be unseen) –i.e., good housekeeping
- Using vacuum (using high efficiency "HEPA" filters) or wet cleaning instead of dry sweeping or compressed air cleaning
- Employee training and supervision
- Supply and use of appropriate personal protective equipment
- Monitoring and health surveillance : Air monitoring can help an organization determine whether controls are working properly, or if hazardous dust/fume/fibre levels are present.
- Fire & Explosion prevention in Grinders & Pulverisers by :
  - ✓ Monitoring the mill motor current
  - ✓ Incorporating an interlock shutdown upon high current draw
  - ✓ Using magnetic separators to find and remove tramp metal before it enters the mill
  - ✓ Using special enclosed mills to allow inerting of powders with extremely low MIE and AIT values
- In case of Vacuum dryers ensure manhole is securely fasten to avoid any Air ingress. The purging/inerting can be automated by applying a set point pressure in the dryer such that if the pressure rises above, say 4 psia, the rotation is stopped, an alarm sounds, and a nitrogen purge starts automatically.
- Dust should be screened to determine whether it is prone to self-heating. The dust temperature during the process and in storage should be controlled.
- Cool the dust prior to storage.
- In case of bucket elevators bearings must be mounted externally to the leg casing or provide vibration, temperature or other monitoring inside the leg casing.
- Belt alignment monitoring & tracking devices implementation.
- Use anti-static belting material, dryer clothes etc.

DUST EXPLOSION PENTAGON