

## 1 Guidance on Combustible Dusts / Powders

This guidance should be read in conjunction with the ATEX Delivery Guide on the HSA website.

### 1.1 Introduction

A dust explosion is the rapid combustion of fine particles suspended in the air within an enclosed location. Dust explosions can occur where any dispersed powdered combustible material is present in high-enough concentrations in the atmosphere.

Many common materials, which are known to burn, can generate a dust explosion, such as coal dust and sawdust. In addition, many organic materials can also be dispersed into a dangerous dust cloud, such as grain, flour, starch, sugar, powdered milk, cocoa, coffee, and pollen. Powdered metals (such as aluminum, magnesium, and titanium) can form explosive suspensions in air, if finely divided.



Figure 1 Typical powder materials which can be explosive

### 1.2 Characterisation of Powders / Dusts

IEC 60079-10-2:2015 presents a number of definitions:

- *Combustible dust*: is defined as finely divided solid particles, 500 µm or less in nominal size, which may form an explosive mixture with air at atmospheric pressure and normal temperatures
- *Conductive dust*: is a combustible dust with electrical resistivity equal to or less than  $10^3\Omega\text{m}$ .
- *Non-conductive dust*: is a combustible dust with electrical resistivity greater than  $10^3\Omega\text{m}$ .
- *Combustible flyings*: solid particles including fibers, greater than 500 µm in nominal size, which may form an explosive mixture with air at atmospheric pressure and normal temperatures.

Three dust groups are defined as follows:

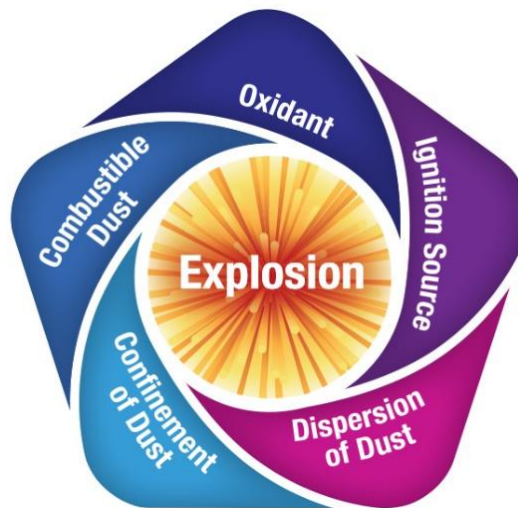
Dust Group	Type
IIIA	Combustible flyings
IIIB	Non-conductive dust
IIIC	Conductive dust

### 1.3 Combustible Properties of Powders / Dusts

The testing of dusts usually starts with a classification go/no-go test to determine if the powder is combustible. If found to be combustible, then a series of more detailed tests can be performed.

**Classification Test:** The classification test is a go/no-go test. It offers a qualitative assessment of whether or not a suspended dust cloud is capable of initiating and sustaining an explosion in the presence of four different ignition sources; 10 KV electric spark, hot coil ignition and low energy chemical igniters. The test is carried out to EN ISO/IEC 80079-20-2 Explosive atmospheres - Part 20-2: Material characteristics -- Combustible dusts test methods and results in one of two possible outcomes:

- Group A (hazardous) - the dust cloud propagates flame from the ignition source and is classed as a combustible and potentially explosible material.
- Group B (non-hazardous) - the dust cloud does not propagate flame from the ignition source and is classed as a non-combustible material.



**Figure 2 Requirements for explosions**

**Explosion Indices  $K_{st} / P_{max}$  :**  $K_{st}$  and  $P_{max}$  are explosive properties measured in the laboratory to quantify the severity of a dust explosion. The explosion indices test follows EN 14034-1 (determination of the maximum explosion pressure  $P_{max}$  of dust clouds) and EN 14034-2 (determination of the maximum rate of explosion pressure rise of dust clouds  $K_{st}$ ). The tests are carried out in a 20 litre sphere apparatus which reproduces a high state of turbulence to simulate worst case process plant conditions.

A Dust Explosion Class (St rating) can then be assigned to dusts in accordance with the table below and used to indicate the degree of explosivity of a powder.

Dust explosion class	$K_{St}$ (bar m <sup>s-1</sup> )	Characteristics
St 0	0	Non-explosive
St 1	$0 < K_{St} \leq 200$	Weak to moderately explosive
St 2	$200 < K_{St} \leq 300$	Strongly explosive
St 3	$300 < K_{St} \leq 800$	Very strongly explosive

The determination of  $K_{St}$  value &  $P_{max}$  is essential to validate explosion protection design (e.g. explosion venting, explosion suppression and explosion containment).

**Lower Explosion Limit (LEL):** The LEL - also known as the minimum explosible concentration or MEC - is the lowest concentration of dust cloud that will allow combustion. Testing follows EN 14034-3 (determination of the lower explosible limit LEL of dust clouds).

**Minimum Ignition Energy (MIE):** Testing for minimum ignition energy gives guidance on whether ignition by electrostatic discharge from plant personnel or process conditions is likely to occur in practice. The test is carried out according to EN ISO/IEC 80079-20-2 (Explosive atmospheres Part 20-2: Material characteristics - Combustible dusts test methods).

**Minimum Ignition Temperature (MIT):** The MIT is the lowest temperature of a hot surface that will cause a dust cloud, rather than a dust layer, to ignite and propagate flame. The test follows EN ISO/IEC 80079-20-2 (Explosive atmospheres Part 20-2: Material characteristics - Combustible dusts test methods).

**Layer Ignition Temperature (LIT):** The LIT test determines the lowest temperature at which a layer of dust of specific thickness, usually 5mm, ignites on a heated surface. The test follows EN ISO/IEC 80079-20-2:2016 (Explosive atmospheres Part 20-2: Material characteristics - Combustible dusts test methods).

**Powder volume resistivity:** This test determines powder volume resistivity by the simultaneous measurement of voltage and current passing through a test sample of known cross sectional area and depth. The test method is described in EN ISO/IEC 80079-20-2 (Explosive atmospheres Part 20-2: Material characteristics - Combustible dusts test methods). Powder volume resistivity has units Ohm.m.

## 1.4 Explosion Test Data

If the explosive properties of a powder / dust are not known it will normally be necessary to have the powder tested in a certified laboratory for explosion tests and these are usually based in the UK.

There are however a number of sources where dust explosion properties are available.

- The German Safety Association have a detailed data base (GESTIS-STAUB-EX<sup>1</sup>) on dust explosive properties developed from 7,000 test samples, which is now also available in English and this data can serve for orientation purposes.
- NFPA 652 provides some generic explosion data for food / agricultural powders.

Particle size can have a large effect on flammable properties of dusts as the finer the particle size the more explosive the dust properties. In general the particle size has to be less than 0.5 mm for the dust to be explosive. Moisture content is also critical, dry dusts and powders are more explosive, while if the moisture content is greater than 25% the dust is unlikely to be held in suspension.

The presence of flammable gas or vapour as an admixture of low concentration can increase the explosive violence of a dispersed dust cloud markedly. These are so-called 'hybrid mixtures'.

<sup>1</sup> <https://staubex.ifa.dguv.de/explosuche.aspx?lang=e>

## 1.5 What Zones can be assigned?

Under Directive 1999/92/EC hazardous places are classified in terms of zones on the basis of the frequency and duration of the occurrence of an explosive atmosphere.

For combustible dusts, the following zones apply:

- Zone 20 is a place in which an explosive atmosphere in the form of a cloud of combustible dust in air is present continuously, or for long periods or frequently.
- Zone 21 is a place in which an explosive atmosphere in the form of a cloud of combustible dust in air is likely to occur in normal operation occasionally.
- Zone 22 is a place in which an explosive atmosphere in the form of a cloud of combustible dust in air is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

Layers, deposits and heaps of combustible dust, if disturbed, can form an explosive atmosphere.

Figure 3 illustrates typical hazardous area classification for a dust separator and dust filter plant.

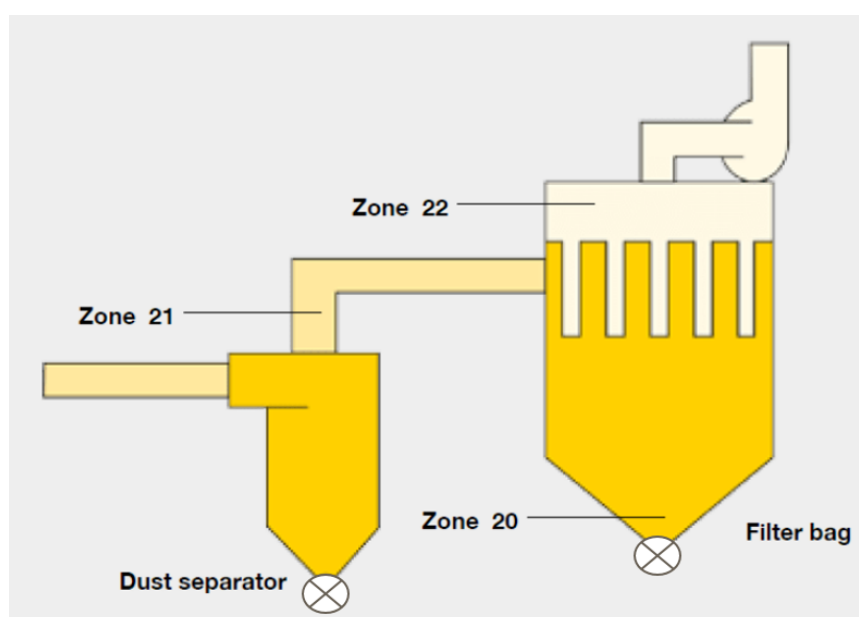


Figure 3 Typical Zones at Dust separator and Filter bag

## 1.6 Safety Protection Measures

The prevention of dust clouds and dust layers is the first measure which should be pursued. The use of well-designed sealed equipment is important when handling powders.

The importance of good housekeeping cannot be over-sated. IEC 60079-10-2 discusses housekeeping and defines three levels of housekeeping:

- Good: Dust layers are kept to negligible thickness, or are non-existent, irrespective of the grade of release. In this case, the risk of the occurrence of explosive dust clouds from layers and the risk of fire due to layers has been removed.
- Fair: Dust layers are not negligible but are short-lived (typically less than one shift). The dust is removed before any fire can start.
- Poor: Dust layers are not negligible and persist for a long period of time (typically more than one shift). The fire risk and secondary explosion risk may be significant.

Where dust levels are likely to arise, well-designed dust extraction systems are necessary.

### 1.7 Equipment Protection

The next step is to implement measures to avoid ignition. This invariably involves specifying ATEX rated equipment with additional protection if such equipment has to be located in zoned areas.

The equipment categories and levels of protection for the different zones are summarised as follows:

Zones	Equipment Protection Level (EPL)	Level of Protection
20	EPL1	2 levels of protection; or 2 independent faults based on rare malfunctions
21	EPL2	1 level of protection based on frequent disturbances; or equipment faults
22	EPL3	1 level of protection based on normal operation

### 1.8 Electrostatic Hazards

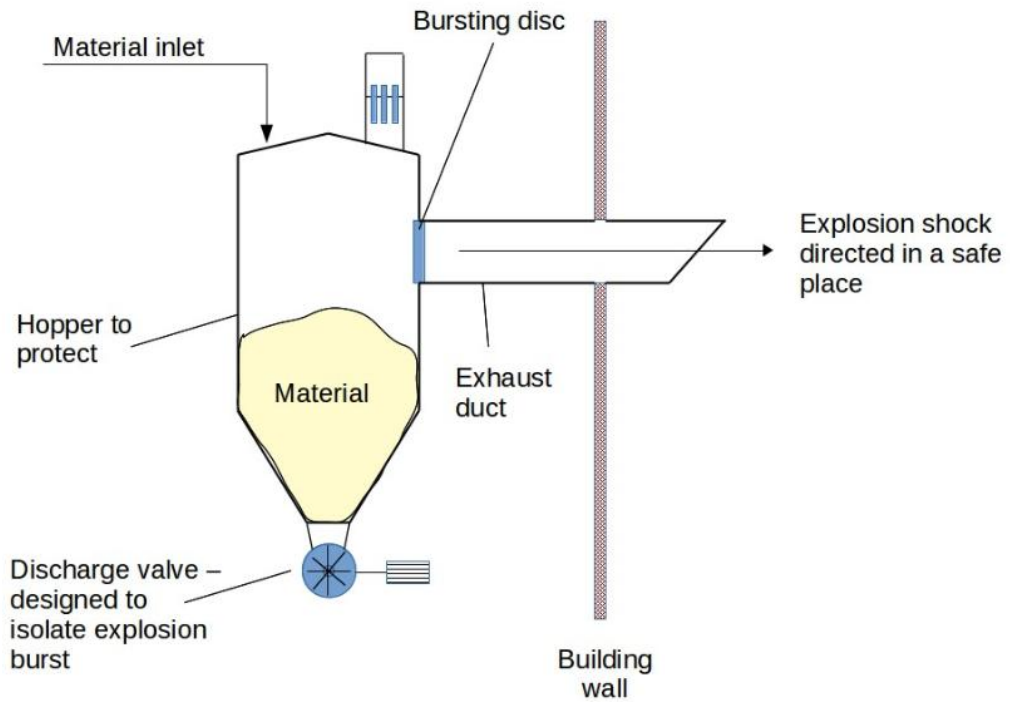
According to experience the ignitability of bulk material ranging from fine dust to granules or chips increases with decreasing particle size and decreasing minimum ignition energy (MIE). Explosion hazard assessment should always be based on the minimum ignition energy of the finest particle size fraction that may be present. This fraction is usually obtained by sieving a sample through a 63µm sieve. For a list of MIE of powders see BIA-Report 12/97 "Combustion and explosion characteristics of dusts". A method for determining the MIE is given in IEC 61241-2-3, ASTM E2019-03 and EN 13821.

During handling of bulk materials electrostatic charging normally occurs. In addition to avoiding the hazardous accumulations of charge additional explosion protection measures may have to be taken as inerting, the use of explosion resistant equipment, explosion venting or explosion suppression. Some useful process parameters can be employed to help reduce electrostatic hazards. These include:

- a) increasing the conductivity of the bulk material, e.g. by coating,
- b) replace insulating equipment by earthed conductive equipment,
- c) humidification of powders,
- d) ionisation,
- e) reducing the quantity of fines in the bulk, e.g. avoiding fine fractions caused by wear and abrasion,
- f) limiting dispersion, e.g. dense phase conveying instead of dilute phase conveying,
- g) reducing the conveying speed, throughput or air velocity,
- h) avoiding big heaps of bulk material,
- i) preferring gravity transport to pneumatic transport,
- j) using conductive or antistatic hoses for pneumatic transport.

The most common type of explosion venting is to cover an opening in a hopper or silo with a pre-cut membrane, typically in steel. The membrane is designed to withstand the normal process conditions, in terms of vacuum or pressure, but to open if the pressure reaches a certain level, which would be the sign of an explosion. Such vents are called bursting discs or explosion vents.

The figure below illustrates a typical explosion vent that can be required for bulk silos where electrostatic hazards are present.



**Figure 4: Explosion venting on bulk powder to silo**

The design of explosion vents must follow some norms in order to be set properly in terms of opening pressure and size (area). The design should be carried out by competent engineers.

Developments in flameless venting can allow explosion venting indoors. Flameless vents are particularly useful if access to an external wall is limited.



**Figure 5: Example of a Flameless Vent**

## 1.9 Big Bags

Flexible Intermediate Bulk Containers (FIBCs) or Big Bags are used frequently for storing and handling powders. Depending on the resistivity of the powder, Big Bags can give rise to electrostatic hazards particularly during filling and emptying activities.



**Figure 6: Type C Big Bag with earthing tab**

The electrostatic standard ISO 60079-32-1 presents four different types of Big Bags (FIBCs) suitable for powder handling. The four types should be selected in accordance with the following table:

Bulk Product in FIBC	Surroundings		
	Non-flammable atmosphere	Dust Zones 21-22	Gas Zones 1-2
MIE > 1000mJ	A,B,C,D	B,C,D	C,D
3mJ < MIE < 1000mJ	B,C,D	B,C,D	C,D
MIE < 3mJ	C,D	C,D	C,D

Type A FIBCs are made of non-conductive material. Type B,C and D have increasing dissipative properties for handling electrostatic charges.

## 1.10 Relevant Standards

The principal standards governing powders and dusts are:

1. IEC 60079-10-2: 2015 Classification of Areas - Combustible dust atmospheres.
2. IEC 60079-14 Part 14: Electrical installations design, selection and erection.
3. IEC 60079-17 Explosive atmospheres Part 17 Electrical installations inspection and maintenance.
4. IEC 60079-31 Explosive atmospheres Part 31 Equipment dust ignition protection by enclosure t.
5. IEC TS 60079-32-1 Explosive atmospheres Part 32-1: Electrostatic hazards, guidance. This standard covers static generally and includes liquids, gases and powders.
6. IEC 61241-0 Part 0: General requirements - Electrical apparatus for use in the presence of combustible dust.
7. IEC 62784 Vacuum cleaners and dust extractors providing equipment protection level Dc for the collection of combustible dusts - Particular requirements.
8. IEC 80079-20-2 Explosive Atmospheres: Material Characteristics – Combustible Dusts Test Methods