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WHITEPAPER

Dust Explosions

Safely prevent the big bang - what an important role antistatic and electrically conductive hoses and connection systems play in explosion protection in the US and Europe

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Prevent electrostatic charging with the right hoses and minimize the risk of dust explosions

Dust explosions are one of the most underestimated dangers in industrial manufacturing. Microscopically fine particles can quickly turn the ambient air into an ignitable atmosphere. Then, even a small spark is enough to trigger an explosion with serious consequences. To prevent a big bang from happening in the first place, operators must take preventive measures including the use of safe components such as antistatic or electrically conductive/dissipative hoses: they eliminate electrostatic charges as an ignition source and reduce the risk of dust explosions.

Dust is everywhere - which is exactly what makes it a problem. There are dangerous dusts that are harmful to health when inhaled, dusts that become flammable and **dusts that can explode.** These dusts include metal dusts, carbon based dusts, food dusts (flour, corn, sugar and others), wood dust, plastic dusts and more.

Dust explosions have been around since people started grinding grain in windmills . The first documented dust explosion is considered to be the explosion in an Italian grain warehouse on December 14, 1785.

1785 - 1st recorded dust explosion took place at Giacomelli's Bakery Warehouse, an Italian flour mill, when flour dust came in contact with a mounted lamp, which injured two workers. A local man named Count Morozzo examined the results of the explosion, and wrote a report giving the probable cause of the explosion as the dry flour dust. Due to this report, most of the only recorded explosions for the next 100 years involved grain handling.

Uncomplete History Of Combustible Dust Explosions

If you are not interested in the historical data, go to Page 5.

- **1858** Grain dust exploded in a roller mill in Stettin, Poland and destroyed the mill building.
- **1860** Flour dust in a mill building exploded in Milwaukee, Wisconsin, which destroyed the building.
- **1864** Flour being processed exploded in Mascoutah, Illinois, and demolished the mill building it was in.
- **1869** Pea flour being ground in a German mill exploded, severely damaging the mill.
- **1878** May 2 - The most infamous flour mill explosion occurs in Minnesota when the Washburn 'A' Mill exploded from a buildup of flour dust inside the building. 18 people were killed in the blast, which was so powerful it broke windows in neighboring towns and threw limestone blocks. This incident occurred because, despite the past explosions, no one thought that dust could actually explode.

1887 Dust in a grain silo in Hamelin, Germany exploded when it came in contact with an ignition source, destroying the silo and nearby building.

1893 March - Initially the explosion at a Litchfield, Illinois flour mill was blamed on a boiler malfunction. Further investigation found that the explosion was actually caused by employees not securing the dust collection machine, which was spilling flour dust into the rolling room. A fire broke out in another room and could not be put out before it reached the rolling room, where contact with the airborne dust caused an explosion so powerful that it could be heard 25 miles away. The explosion killed one worker, and destroyed 40 houses and 2 blocks of businesses nearby, which led to regulations for fire suppression systems in mills, and proper training for employees.

1896 NFPA is formed and begins to recognize the explosion hazards of industrial dust and create standards for safely managing these hazards.

1916 Dust explosion at Quaker Oats Cereal Factory in Petersborough Ontario kills 23 of the factory's workers. The fire started in the oatmeal cleaning room, destroyed the entire plant, and continued to burn for 4 days.

1921 Explosion in Germany caused when a tower silo storing 4,500 tons of a combination of ammonium sulfate and ammonium nitrate fertilizer exploded at a plant in Oppau, now part of Ludwigshafen, Germany. The explosion is blamed on killing 500 to 600 people and injuring about 2,000 more.

1922 NFPA Committee on dust explosion hazards is formed.

1924 Corn dust exploded in Pekin, Illinois, this caused 42 people to die.

1948 A Brach's Candy factory in Chicago, Illinois exploded from a cloud of cornstarch, resulting in 18 deaths.

1975 A cloud of grain powder explodes at the Davenport river flour mill in Iowa. The explosion was powerful enough to shatter windows 20 blocks away, and killed 2 workers. This explosion led to changes in safety systems, including the use of confinement systems and no smoking policies.

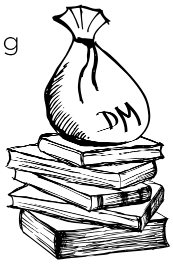
1977 Explosion at a Galveston, Texas grain elevator was caused when low winter humidity made the grain dust dryer and more explosive than usual. 20 workers were killed in this accident.

1977 The worst flour mill explosion on record occurred in Westwego, Louisiana when a buildup of grain dust came in contact with static electricity. The explosion blew the top off the silo, and caused another 48 silos to catch fire. 36 workers were killed in this disaster, many from being crushed by the collapsing silos. Building code reforms for grain silos were based off this event.

1979 The Roland Mill in Bremen, Germany, was destroyed by a flour dust explosion, killing 14 and injuring 17 and damaging property totalling 112 million euros.

1981 Custard dust that had accumulated in the factory ceiling and rafters blew down to create a dust cloud, which then exploded at a Bird's Custard factory in Banbury, England. The explosion blew the roof off the building. As a humorous side note, custard is created when heat and water are added to the custard powder; the water from firefighters and the heat from the explosion caused gallons of custard to suddenly be created inside the building, which then came pouring out.

1997 A huge explosion occurs in Blaye, France during the unloading of a truck loaded with corn killing 11 people when the silos and nearby administration buildings were destroyed. The debris field was more than 100 yards (or meters) in diameter. The property damage amounts to over 50 million marks. The cause of the catastrophe: Dust had formed a cloud with the air inside the silo. One spark was enough to ignite the explosive mixture.



1998 A series of grain dust explosions began in a grain elevator before travelling throughout the grain storage facility in Haysville, Kansas. These explosions resulted in 7 people losing their lives.

1999 A natural gas boiler exploded at the Ford River Rouge Power Plant in Dearborn, Michigan, which caused a buildup of coal dust to create a secondary explosion, killing 6.

1999 Buildups of phenol formaldehyde resin had accumulated heavily in the ductwork and on high surfaces throughout the Jahn Foundry building in Springfield Massachusetts. The dust inside the ductwork ignited, causing an explosion to travel through the ducts to different areas of the factory, where high surface dust was shaken down and ignited. The explosion was able to lift the building's roof and blow out its walls. 3 workers died later from burns they received during the explosion.

2002 Buildups of rubber dust at Rouse Polymerics in Vicksburg, Mississippi created an explosion that left 5 workers dead.

2002 When loading a ship with soybeans in the port of San Lorenzo, Argentina, a dust explosion occurs, destroying the entire terminal.

2003 Plastic dust explosion occurred at the West Pharmaceutical Services facility in Kinston, North Carolina after it had accumulated above tiles in a dropped ceiling. 6 workers were killed and dozens were injured when the building was completely destroyed.

2007 A serious explosion occurs at the „Molino Cordero“ flour mill in Cuneo, Italy. Five people were killed and the four story plant was completely destroyed. According to reports this explosion was caused by an electrostatic arc in the flexible pneumatic trasnsport hose between the transport vehicle and the facility.

2008 Explosion at the Imperial Sugar Refinery in Port Wentworth, GA (USA): one of the largest sugar refineries in the United States. A series of sugar dust explosions kills 14 workers and injures 36 others, some of them seriously. This landmark explosion changed the way dust safety in manufacturing was regulated by OSHA (Occupational Safety and Health Administration) and other agencies in the US.

2011 An explosion of combustible dust in a pipeline at Foxconn (one of the manufacturing partners of Apple) in Chengdu, China kills 3 people and injures 15.

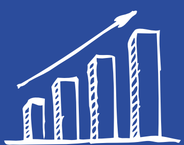
2014 At least 69 people are killed in an explosion in a car wheel rim factory in Kunshan, China: The cause was a dust explosion in a polishing station for wheel hubs caused by deflagrated metal dusts, also highly explosive.

However, these registered cases are often only the tip of the iceberg. Many explosions, mostly smaller, but with equally devastating consequences, do not appear in many reports.

Dust explosions are thus one of the underestimated dangers in industry.

With increasing industrialization, the number of dust explosions and the extent of the damage rose:

- **According to the U.S. Chemical Safety and Hazard Investigation Board (CSB), 281 dust explosions occurred in the United States between 1980 and 2005, killing 119 people and injuring 718.**
- **One U.S. insurance carrier reported 450 incidents in its customer base attributable to bulk material fires and dust explosions over a ten-year period. The total amount of capital loss is $580 million, with an average gross loss from dust explosions of $1.9 million and of $1.2 million from dry bulk fires.**
- **In the UK, the Health and Safety Executive (HSE) recorded 303 dust explosions over a 9-year period.**
- **The documentation of the Berufsgenossenschaftliches Institut für Arbeitssicherheit (BIA) (Institute for Occupational Safety and Health) shows two deaths and 48 injured with property damage of several million marks in Germany between 1987 and 1997. However, the BIA admits that this list only covers an estimated 10% of the explosions that occurred during this period.**



It is difficult to say how high the number of unreported cases actually is.

There are no current figures, e.g. based on reports, accident reports from the technical supervisory services of the trade associations, trade supervisory offices or from affected companies themselves. Nevertheless, reports on dust explosions can be found regularly in the trade and daily press. The Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA) has evaluated statistics from property insurers and comes to the conclusion that Germany can be expected to have an average of about 300 dust explosions per year (events with property damage exceeding 25,000 euros).

Dust explosions are also a major threat to people, facilities and materials because they can develop a devastating destructive force due to the extreme increase in pressures. A dust explosion often leads to fatal chain reactions and thus to the complete destruction of operating facilities.

What is dust made of?

Dust is the smallest particles floating in the air - this is why they are also called suspended dust. Depending on the need, dust is classified according to **particle size** or **type of dust.**

Dust particles can consist of **organic** (e.g. pollen, bacteria, fungal spores) or **inorganic** materials (e.g. rock dust, mineral fibres). One form of dust that everyone is probably familiar with is the dust in your home, which is made from organic and inorganic material.

In principle, dust can be produced by various processes:

- the mechanical processing of solids (crushing, surface treatment, abrasion, etc.)
- physical influences on solids (e.g. erosion by wind and weather)
- by chemical reactions in the atmosphere with particle formation
- by raising particles into suspension

If the dust is caused by natural phenomena such as volcanism, soil erosion or sandstorms (wind), we speak of **natural dust sources.** If the dust does not originate from natural processes, but from man-made processes, then they are **anthropogenic dust sources.**

Important natural (suspended) dust sources are: Soil erosion, volcanism, oceans, sandstorms, pollen flight or forest and bush fires with natural causes (e.g. lightning). Important anthropogenic (airborne) dust sources are Industrial processes, energy production (power and district heating plants), transport, agriculture, construction, households or forest and bush fires (e.g. slash-and-burn).

What makes dust so dangerous?

In addition to health aspects, the flammability and explosiveness of dusts play a role in industrial environments.

A dust explosion cannot occur by accident. They only occur under certain conditions, namely the elements of the fire triangle.

- **dust**, i.e. fine combustible solid matter (particles smaller than 0.5 mm) is present
- the dust is present in a certain **mixing ratio with air** (dust cloud),
- an **oxygen concentration** sufficient for combustion is available (atmospheric oxygen is sufficient) and
- an effective **ignition source** is present. This includes the spontaneous ignition capability of a substance.

Organic dusts such as plastics, coal, flour, cocoa, starch, wood, cellulose, animal feed, paint and spray dusts as well as metallic (inorganic) dusts such as magnesium or aluminium can be „reaction partners“ for explosions.

The rule is: any finely ground substance can explode if it is made of combustible material. Inorganic substances and elements such as magnesium and aluminium are also explosive or at least flammable in this form.

The causes of dust content in critical concentrations are as diverse as they are usually unavoidable. They are particularly prevalent when combustible dusts such as powder or flour are produced or transported or when flammable solids are processed or handled - and dust is created in the process.

It also plays a role whether dust is **present in bulk quantites or airborne form**.

Deposited layers of dust tend to glow on hot surfaces and are not as likely to explode, while stirred-up dust clouds, which are ignited by local ignition sources or on hot surfaces, can immediately produce explosions.

Database Combustion and explosion characteristics of dusts

About 80 percent of the dust found in industry is combustible. As a basis for the safe handling of combustible dusts and for the planning of protective measures against dust explosions in dust generating and processing plants, the German GESTIS-STAUB-EX database contains important combustion and explosion characteristics of over 7,000 dust samples from almost all industries. Similar databases exist around the world.

More information: https://staubex.ifa.dguv.de/

Dust explosions are often the result of stirred up glowing dust layers, which carry the energy for the ignition initial within them. If such layers are made airborne, a dust explosion can easily be triggered. Even a 1 millimetre thick layer of dust in a closed room is sufficient to trigger an explosion after being stirred up and ignited.

Where dusts can become a fire hazard

In many branches of industry, powdery and dusty products are processed or are created during the production process. The majority of these dusts pose a fire and possibly explosion hazard.

Take cereals, for example: not only during storage in a silo, but also during the production of flour, there is an increased risk of an explosive atmosphere developing. This is a mixture of oxygen and dust consisting of flammable fine solid particles. The difference in density causes constant circulation via ambient or directed air sources, resulting in a homogeneous mixture. If this dispersed dust hits an ignition source, there is a high probability that an explosion will occur.

Three independent studies, which examined a total of 1,100 dust explosions in the USA, Great Britain and Germany, list **process equipment** as a primary and proven sources of dust explosions.

The following processes are most at risk of being affected by such explosions:

- Dust extraction,
- Powder grinding and pulverization,
- Powder transfers,
- Filling of silos and containers and
- Mixing and blending of powder.

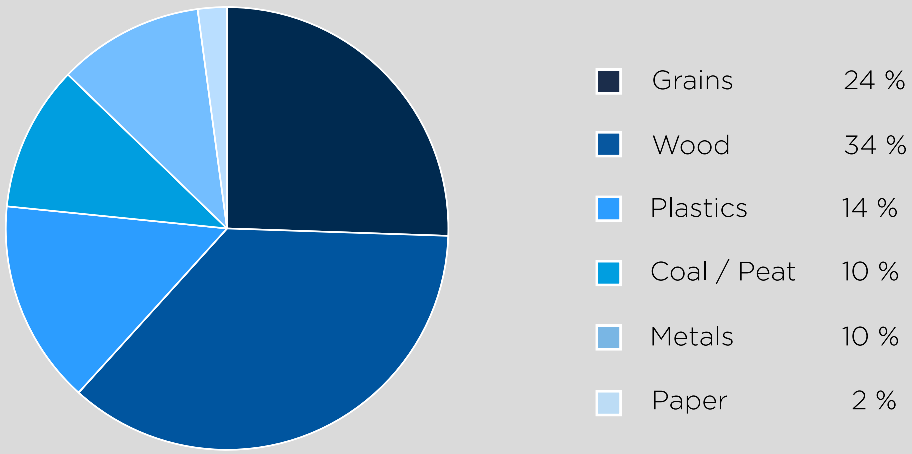
Danger exists above all in production, filling and packaging plants, conveyor systems, silos, bunkers and other storage facilities. **Mills** (due to the flour dust produced, starch and other influences) as well as **plants and warehouses** are particularly at risk

- agricultural holdings (e.g. grain storage facilities)
- in many areas of food production,
- the woodworking industry,
- the plastics and the metal processing industry,
- the chemical industry, in particular the pharmaceutical industry and the paint industry
- the paper industry,
- the waste management industry

Dust fires and explosions can occur, among other things

- during the handling and storage of grain,
- in grinding, mixing and mechanical conveying of organic products (e.g. animal feed, cereals, baking powder, fish meal, sugar, pharmaceuticals, dyes, etc.),
- in spray drying of organic products (e.g. milk),
- when extracting and conveying wood dust in filter and separation systems,
- when grinding light metals and their alloys,
- in the production and processing of metal powders,
- when grinding and drying coal and when filling coal dust silos,
- during drying, granulating or coating of solids in fluid bed apparatus

Share of dust types in dust explosion



*These figures come from North America (2004), but according to the property insurer are transferable to Germany and Europe

One spark is often enough

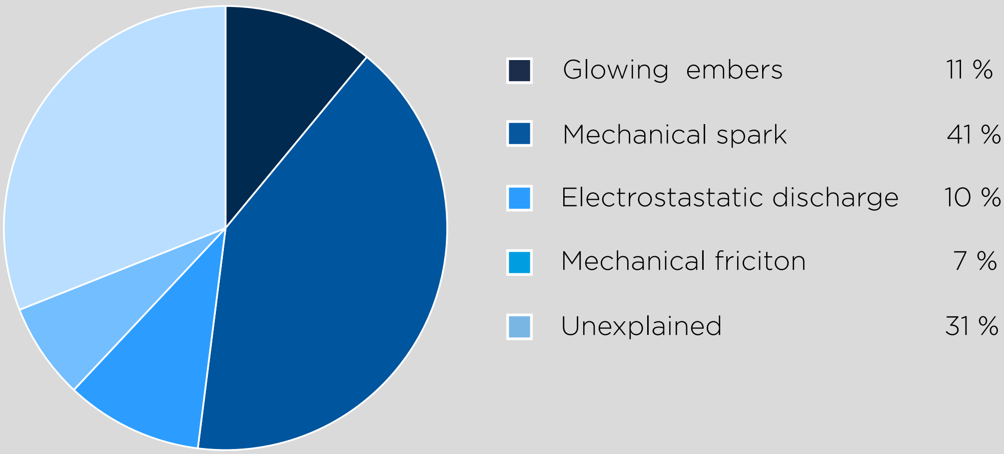
Dust can form a potentially explosive atmosphere when mixed with air. If an effective ignition source occurs, a devastating explosion can be triggered. According to the German Employers‘ Liability Insurance Association for Raw Materials and the Chemical Industry (BG RCI), the following ignition sources have proven to be particularly significant in operational practice:

- Flames and smouldering nests
- Hot surfaces
- Mechanically generated sparks
- Electrically generated sparks (electrical equipment)
- Electrostatic charges (where hoses and flexible duct can either contribute to the problem or help create a solution)

In addition, trivial sources of ignition also occur, for example during repair work via metal strike or when carelessly throwing away a cigarette butt.

In many cases, **electrostatic charges** are directly connected with industrial processes. A German study shows that electrostatic discharges account for up to 10 percent of known primary ignition sources.

Overview of know primary ignition sources



The category „unexplained“ stands for incidents for which no physical evidence (electrical or mechanical causes) could be determined. Electrostatic discharges are also likely a very common cause in this category. However, since there are usually no witnesses to prove that they saw or heard a spark, ignition sources of this type are not reported and remain unexplained

When conveying solids and liquids through pipes or hoses, electrostatic charging (=charge separation) can occur due to the **friction of the conveyed material against the wall or the friction within the medium.**

It can cause interference and damage, and it can cause fires and explosions if ignitable discharges occur.

How do electrostatic charges occur?

Everyone knows the phenomenon: You can get charged while walking if the floor or your own shoes are not conductive. Electric shocks, which are sometimes transmitted from door handles or cars to people, can have a voltage of up to 35 000 volts. They are caused by the sudden discharge of accumulated frictional electricity. However, because the process only lasts a fraction of a second and there is little energy involved, it has no harmful consequences for the person affected apart from a moment of shock.

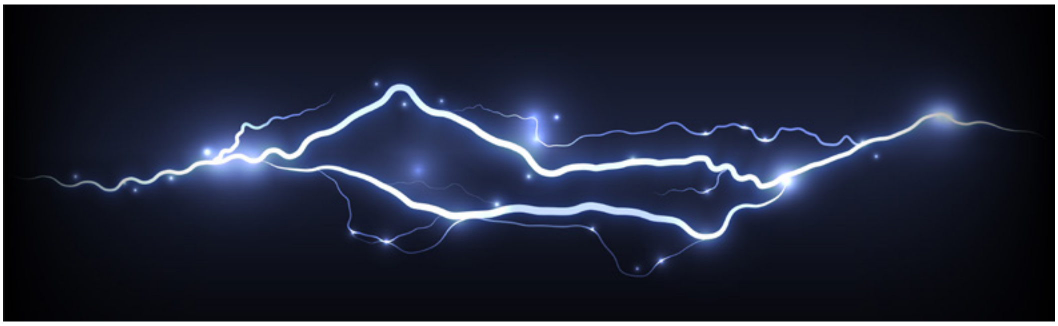
Quite different in industrial maufacturing.

Under certain conditions, such a spark can trigger an explosion - in extreme cases with serious consequences for employees and for plant and machinery.

If, for example, a powder is poured out of a sack or conveyed through a pipe or hose any of the components can become charged. The same is true if the powder is sieved or poured through a hopper or of a liquid flowing through a pipe or hose.

How tension is discharged

Depending on the structure and resistance of the wall material, different types of discharges can occour:



Corona discharge

Corona discharges generally occur at surfaces with a small radius of curvature (e.g. tips, corners). The range of possible discharges is relatively small due to low electric field strength. Corona discharges are also difficult to detect. Their ignitability is much lower than that of spark discharges - they are normally not ignition effective.

Bunch discharge

Bunch discharges can occur when a grounded conductor (e.g. a person's finger) moves towards a charged, insulating object (e.g. a plastic surface). They are of shorter duration than corona discharges, can be visible and audible and can ignite most combustible gases and vapors. According to DIN EN 1127-1:2011, however, this can exclude the ignition of dust/air mixtures.

Spark and lightning

The best known electrostatic discharge is lightning. Lightning can injure or kill people and animals, cause damage to equipment or cause fire and explosions, especially when flammable gases are present in the air. In a broader, colloquial sense, lightning occurs whenever the electric limit field strength between two differently charged bodies is exceeded and a spark discharge occurs between the bodies. An electrostatic discharge during landing, for example, ignited the hydrogen contained in the hull of the airship Hindenburg. The hull covering and the contents of the hull of the airship burned up as a result.

Sliding handle tuft discharge

Sliding stem tuft discharges can occur when bipolar charged layers (e.g. packaging films or coatings on conductive objects) are present. The TRGS 727 (Technical Rules for Hazardous Substances, specifically: Avoidance of ignition hazards due to electrostatic charges) also mentions as special requirements a high breakdown voltage, strongly charge-generating processes (belt drives, pneumatic transport of bulk material) and low spraying of charges (by corona discharges). After a charge, the discharge can be triggered by piercing of surfaces, electrical breakdown, contact of the surface by a person or similar. Sliding stem tuft discharges are normally ignitable for both flammable gases and flammable dusts. They usually have a tree-like, brightly shining structure and are accompanied by a bang.

How great is the danger of an explosion due to electrostatic charge?

The decisive factor in assessing the hazards of electrostatic charge is the **probability of the local and temporal coincidence of a potentially explosive atmosphere and a dangerously high charge.**

Such a coincidence is most likely when handling a product leads both to dangerously high charges and to the formation of an explosive atmosphere. This occurs, for example, with non-conductive flammable bulk materials. However, conductive materials can also become dangerously highly charged if they are processed in non-conductive systems. Furthermore, non-conductive systems themselves or non-grounded conductive systems can be dangerously charged up.

In the case of electrostatic charge

- Corona and brush discharges not suitable for igniting dust/air mixtures (brush discharges can only ignite combustible dust/air mixtures if combustible gases or vapours are present at the same time)
- In contrast, spark discharges, sliding stem tuft discharges, cone discharges and discharges similar to thunderstorm lightning are quite suitable for igniting dust/air mixtures.

Preventing the big bang

To prevent an explosion, at least one of the triggering factors must be avoided. This is commonly referred to as removing one leg of the fire triangle i.e:

- Avoiding the dust-air mixture (the dust cloud)
- Displacement of oxygen by non-flammable gases such as nitrogen or carbon dioxide
- Avoidance of ignition sources

Since not all of the three possibilities are equally practicable or difficult to implement, the main focus is on **avoiding ignition sources.**

As the sole protective measure, however, it requires an appropriate risk analysis. Ignitable electrostatic sparks usually occur when a thorough risk assessment has not been carried out, when unintentional changes have been made to plant and equipment during ongoing maintenance, or when safe working practices are not followed.

In order to prevent explosions, the legislation of most states has developed corresponding requirements in the form of laws, regulations and standards.

Explosion protection in the European Union (EU)

All systems, machines, equipment and components used in potentially explosive atmospheres are subject to the **European explosion protection directive ATEX** (Atmosphères Explosibles). ATEX classifies explosive atmospheres and assigns devices and components.

ATEX

The following zones apply for areas that are at risk of explosion due to combustible dusts:

Zone 20	is a place in which an explosive atmosphere in the form of a cloud of combustible dust in air is present continuously, 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 may occasionally occur during normal operation.
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 occur only rarely and for a short period only.

The frequency and duration of the occurrence of a hazardous explosive atmosphere is critical: the more likely it occurs, the higher the requirements for the protective equipment used there. According to the German Ordinance on Industrial Safety and Health (BetrSichV), **the operator of a plant is solely responsible** for safe operation.

Depending on the hazardous -zone in which an item of equipment is to be used, it is divided into so-called equipment categories.

Equipment is defined as machines, operating equipment, stationary or mobile devices, control and equipment parts as well as warning and prevention systems which, individually or in combination, are intended for the generation, transmission, storage, measurement, control and conversion of energy and for the processing of materials and which have their own potential ignition sources and can therefore cause an explosion.

Components are defined as those parts which are necessary for the safe operation of equipment and protective systems without themselves performing an autonomous function.

In **Germany**, the **Technical Rules for Hazardous Substances TRGS 727** also reflect the current state of safety technology for avoiding ignition hazards due to electrostatic charges and the assessment of an ignition hazard of bulk materials.

TRGS

It deals in detail with electrostatic charges when handling liquids (§ 4 ff), gases (§ 5 ff) and bulk materials (§ 6 ff). In addition, TRGS 727 also provides information on which hoses may be used when handling the individual media.

The TRGS 727 differentiates between **aspiration** (vacuum conveying) and **pneumatic transport** (pressure conveying) of bulk materials.

> Hose lines made of insulating materials are permitted for **aspiration** if there is only a low dust load inside and therefore the occurrence of a dangerous explosive dust atmosphere is to be expected only rarely and for a short time. Irrespective of the hose material, all conductive parts of the hose (e.g. support spiral, fittings) must be earthed.

On the other hand, when **pneumatically transporting** flammable bulk materials with air inside the hose assembly, a potentially explosive atmosphere caused by fine dust is to be assumed. Depending on the place of use, a potentially explosive atmosphere may also be present in the surrounding area. For this reason, various requirements are placed on the wall construction of the hose assemblies to avoid ignition sources.

The decisive unit for determining the area of application for aspirative conveying is the **surface or leakage resistance.**

In pneumatic conveying, on the other hand, only the **specific resistance** of the wall material is used.

Explosion protection in the USA

Where electrical safety is concerned in the US, standards have been developed by the NEC (National Electrical Code), CSB (U.S. Chemical Safety and Hazard Investigation Board) and NFPA (National Fire Protection Association) which are enforced by OSHA (Occupational Safety & Hazard Administration) which inspects to and enforces the standards. The city and county electrical inspectors are also charged with such enforcement.

The other key player here are the insurance companies. Obviously limiting their exposure to losses in hazardous environments is in their best interest so they generally perform an annual inspection where any deficiencies in explosion protection are observed. The insurer offers them the opportunity to address the issue or the company can face higher rates or cancellation of coverage.

Industry typically uses NEC 500 as the traditional standard understood by most using classes divisions and groups to indicate the degree of protection a piece of equipment offers. NEC 505 is also recognized, which uses the same type of class and zone approach used under the ATEX system. Because it is newer it is not as widely understood and accepted.

Under NEC 500 areas with combustibe dusts are considered **Class II** and either **Division 1 or 2**:

Class II	**Class II** refers to combustible or conductive dust particles that are or may be present in the atmosphere in significant enough quantities to produce a fire or explosion if ignited.
Division 1	A **Division 1** classification means that the substance in the Class it is paired with has a high probability of producing an ignitable or explosive mixture due to it being present continuously, intermittently or periodically. The substance may also come from the equipment in the area under normal circumstances.

Division 2	A **Division 2** classification means that the substance in the Class it is paired with has a low probability of producing an ignitable or explosive mixture due to it being present only during abnormal circumstances or for a short period of time, such as a system breakdown or container failure.

Dusts are further subdivided into groups that are based on their ingition temperature. The lower the temperature the easier a dust is to ignite or create an explosion.

[NEC] Group E	refers to an area containing combustible metal dusts such as aluminum, magnesium, bronze, chromium, titanium, zinc and other commercial alloys.
[NEC] Group F	refers to an area containing dusts with carbon or carbon compounds, carbon black, coal black, charcoal, coal or coke dusts.
[NEC] Group G	refers to an area that contains combustible dusts that are not included in Groups E and F, such as flour, grain, sugar, wood, starch, chemicals and plastics.

Under the NEC zone system where dusts are concerned it is very similar to the ATEX system:

NEC Zone 20	refers to flammable dusts, fibers or flyings that are present continuously or for long periods of time in ignitable concentrations.
NEC Zone 21	refers to flammable dusts, fibers or flyings that are present in ignitable concentrations that are likely to occur under normal operating conditions.
NEC Zone 22	refers to flammable dusts, fibers or flyings that are present in ignitable concentrations that are not likely to occur under normal operating conditions and are present for only a short period of time.

There are multiple standards developed by the NFPA concerning combustible dusts including:

- 61, Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities
- 484, Standard for Combustible Metals
- 654, Standard for the Prevention of Fires and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids
- 655, Standard for Prevention of Sulfur Fires and Explosions
- 664, Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities

NFPA 652

The most recently developed is NFPA 652 is titled the Standard on the fundamentals of Combustible Dust. It is designed to offer a consolidated approach to combustible dust safety for any industry. It offers operational and process guidelines to give specific direction to industry. Within the document is a list of all of the different dusts that are considered combustible and various values for each that indicate its degree of combustibility and propensity to combust.

The central component is the dust hazard analysis (DHA) which is also included in NFPA 61. The DHA is a test performed by a certified testing agency for any industrial manufacturing facility handling any of the dusts on the list as a part of their process. It consists of an assessment of materials and processes, an analysis of the hazards posed by these materials and processes and a hazard management plan. Introduced in 2015, a previous addition of 652 had set a 2018 deadline for completion but the 2019 edition extended the deadline to September 7, 2020.

Within this standard hoses and ducting are referred to as „flexible connectors“ and the specifics are few. In sections eight and nine it is stated that they must be static dissapative or conductive and in some cases grounded. The most specific guidance offered is in section 9.4.7.1.4 where it states that flexible connectors longer than 2 meters (six feet) used in areas where combustible dusts and vapors are present should have an end to end resistance **less than** ($R_0 < 10^8$) to ground with a grounding wire connected to the equipment that the hose is attached to. Where flammable vapors are not present the level of conductivity only needs to be equal to or **greater than** ($R_0 < 10^8$).

A global standard that is becoming more common is one that is being adopted for the industrial vacuum market and the use of flexible hoses since it is so common with this equipment. The **ISO 8031** standard requires specific testing of flexible hose materials used in areas with combustible dusts to conductivity standards to assure that no arcs or sparks can be created by the use of this equipment. The Masterduct EC hoses were tested by a testing lab in France and determined to be compliant with this standard. Our products were also the most effective at conducting the energy to ground.

The Operator is Responsible

Standards are aimed at the operator of a plant. The operator must assess the explosion risk of the plant, divide the plant into hazard zones and document and ensure all measures for the protection of employees in the explosion protection document. He is also obliged to use suitable equipment.

If all recommendations are complied with, it can generally be assumed that a plant has been operated safely in accordance with the current standards. In the event of an accident, the employer can prove that he cannot be accused of negligence. If the employer chooses another solution, he must achieve at least the same safety and health protection for the employees. In the US, if the operator is found to not be in compliance during a routine inspection or as a result of an incident large fines can be assesed against the company by OSHA. These fines can go up into the millions in the event of major violations that often include catestrophic property destruction and/or loss of life.

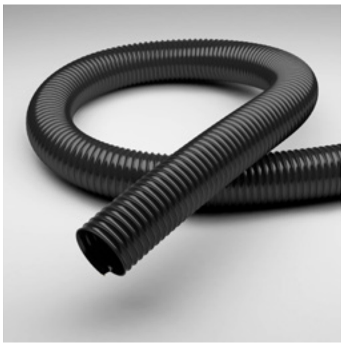
Safety first - also for components !

The selection of suitable equipment is fundamentally important for the functionality of an industrial plant, especially in hazardous areas or when handling combustible bulk materials. Responsibility is also clearly regulated: It lies with the operator.

He must examine and classify the explosion risks in his company and document the results. Delaying the risk analysis would be grossly negligent. Converting the affected systems to explosion-protected equipment or providing ventillation where possible to bring down the concentration of dust (measured in parts per million) under the required levels will bring the facility into compliance.

Our experts ensure that your operation is safe and that all regulations are observed with appropriately certified components such as antistatic, electrically conductive or dissipative hoses and the appropriate fittings.

Our antistatic and electrically conductive hoses comply with the ATEX standards.

The suitability is confirmed with a corresponding declaration of conformity:

You can find the declaration of conformity here

Masterflex has also carried out an extensive series of tests which confirm the suitability of the hoses in different areas of application. The results have been verified by TÜV Süd in the technical report 713082091.

A recommendation for a certain hose type or a special connection solution always depends on the specific application situation. For example, TRGS 727 once again points out that a hose that can be used for the transport of flammable liquids is not automatically suitable for the safe transport of dust. It deals specifically with the requirements for aspiration and pneumatic transport of bulk material. By the way, TRGS 727 also applies to existing plants - we will be pleased to check for you whether the hoses installed are suitable.

In the US these same specific approvals do not exist so there is more room for interpretation but our product application experts can help review the specifics of your application and recommend the correct anti-static or electrically conductive product to assure the safety of your facility and employees. In most manufacturing facilities the engineering team selects the hose that meets their needs then must provide the safety team documentation that it is safe to use in that specific area of the facility.

LET'S TALK!

Contact us - together we will find the best solution for the specific requirements of your industry!

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