the basics of dust-explosion protection

STAHL

Dust-Ex

Powders or dust like substances are processed or are byproducts of the production process in many industries.

Whether the dust is useful (e.g. for the production of synthetics, pigments or pharmaceuticals) or waste, a large majority of dustlike substances pose the danger of fire or possibly even explosions. Eighty percent of all industrial dusts are combustible, and even a dust layer of 1 mm in a closed room is sufficient to trigger an explosion when the dust is swirled up and ignited. These facts, combined with the fact that those affected are not sufficiently aware of the danger (in contrast to the danger of gas explosions) underlines the importance of preventing dust explosions. This brochure is intended to help you analyse the danger of a dust explosion in your facilities and to take the suitable technical and organisational steps to minimise this risk.

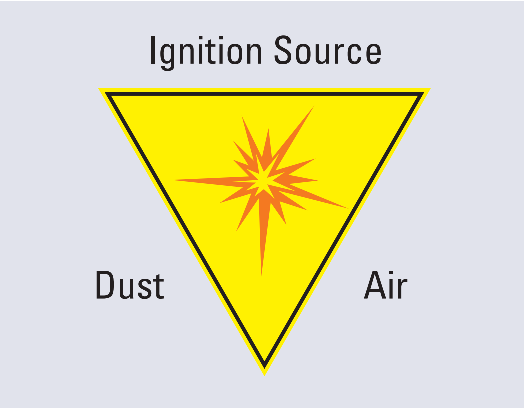
contents

1. Dust as a Risk Factor

As with combustible liquids and the flammable gas/air mixes that result from them, certain requirements must be fulfilled for a suitable ignition source to ignite a mix of dust and air and thus trigger an explosion. No explosion can occur if one of the following is not present: combustible dust, air, ignition source.

Dust explosions have different characteristics than gas explosions and can in some cases be much more devastating. If a gas/air mix is ignited, the force of the resulting explosion causes the gas cloud to dissipate rapidly and thus dilutes the gas/air mix to a concentration lower than that necessary for further combustion. Thus, if no further gas is added, the explosion is over after several milliseconds.

Figure 1: **Explosion Risk Triangle**



With combustible dusts it is different. If, for example, a draft of air swirls up a layer of dust in a small area, the dust, along with oxygen, forms a combustible dust/air mix. If this mix is ignited by an ignition source, an explosion is triggered. The force of the resulting explosion swirls up more dust, which is in turn ignited. This process continues, and under some conditions chain reactions such as these sweep through entire buildings or facilities, destroying them.

As is the case with gases, there are various ignition sources for dusts, such as sparks from electrical or mechanical processes, arcs, open flames, an electrostatic discharge, electromagnetic waves and others.

Figure 2 shows the results of statistical studies in North America, which examined the distribution of the ignition sources of dust explosions. It shows that mechanically produced sparks were responsible in almost one third of the cases. Add to that the 13 % of explosions caused by open fire and welding, and it becomes obvious that many people are not aware of the danger of dust explosions. Figure 3 shows that a wide variety of industries are affected, including branches of the food and wood processing industries, paper and synthetics production, pharmaceuticals production and others.

The data given above are confirmed by German property insurers, who state that on average there is one dust explosion per day in the Federal Republic of Germany. Approximately one fourth of these are caused by dust from food products or animal feed.

Figure 2: **Ignition Sources of Dust Explosions**

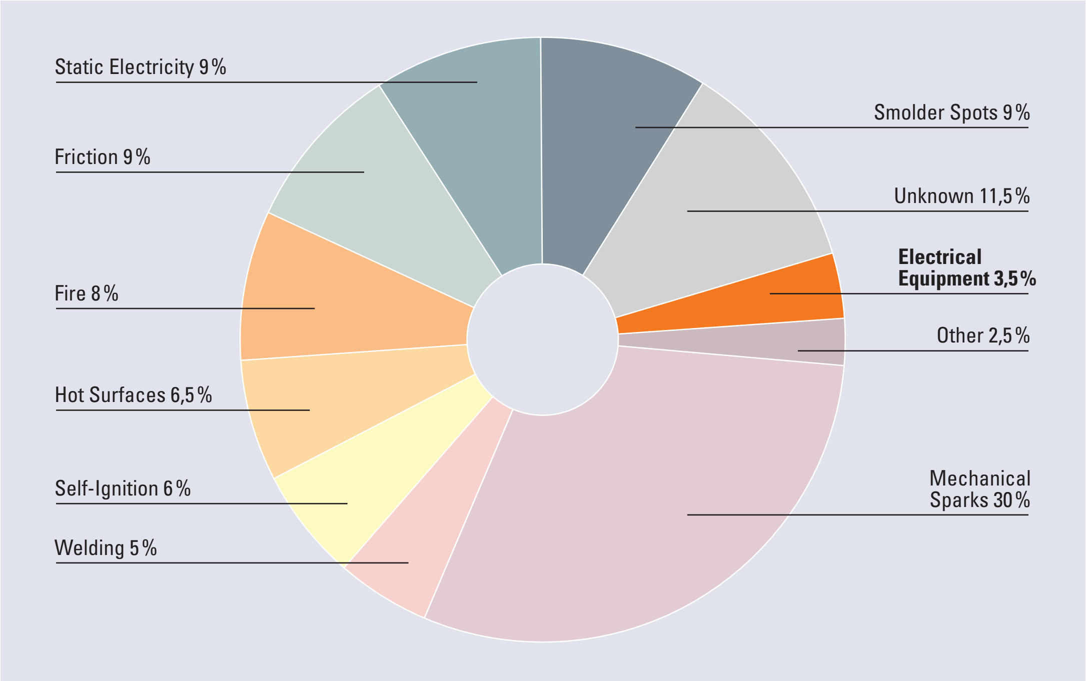
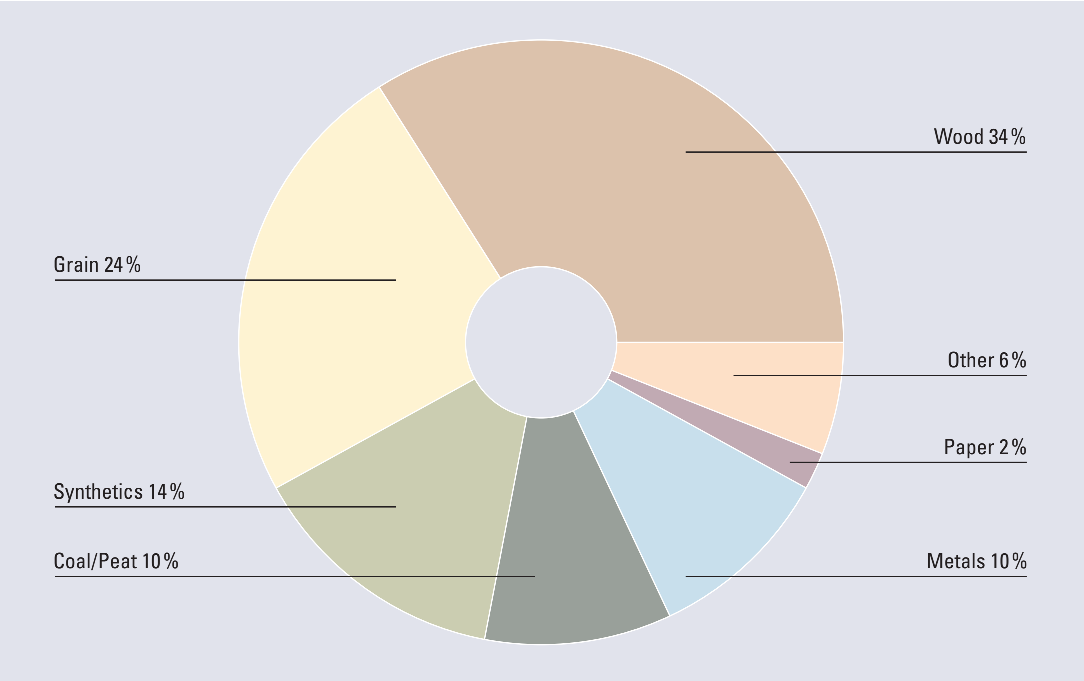


Figure 3: **Types of Dusts Involved in Dust Explosions**



2. Definitions and Parameters

What does the word dust really mean?
The European Standard EN 50281-1-1 defines it like this:
Dust consists of small solid particles in the atmosphere which settle due to their own weight, but which remain airborne as a dust/air mix for a time (this includes dust and grit, according to the definitions in ISO 4225).

In Table 2, the important parameters determining the combustibility of dust are listed. It is necessary to assess your technical procedures in view of potential ignition sources, combustible volume, operating temperature, etc. Subsequently, the potential for a dust explosion under the current conditions must be evaluated.

The most important terms in dust explosion protection are listed in Table 1 along with their definitions. In Table 3, the parameters of some materials from the various product groups are given. These technical safety data have been determined under standard conditions in the laboratory. As a rule, conditions are in practice less likely to lead to an explosion, so that the figures are less alarming.

Be aware that a general term, such as flour dust, can lead to false assessments. Wheat flour has different technical safety parameters than rye flour, for example.

Table 1: **Definitions in Dust Explosion Protection**

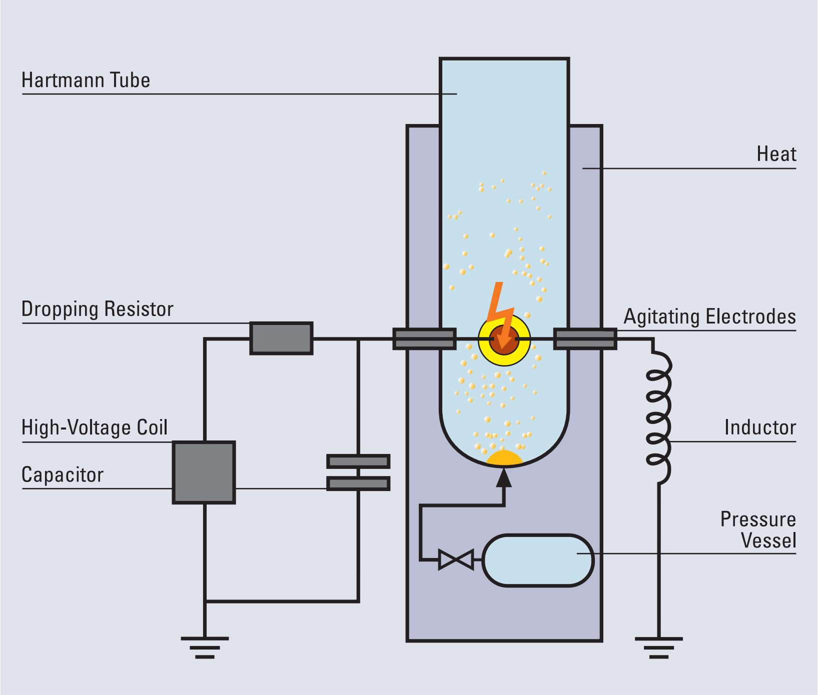
Term	Definition	Remarks
Explosive Dust Atmosphere	A mix of combustible substances in the form of dust or fibers mixed with air under atmospheric conditions that, after ignition, cause the reaction to spread to the noncombusted mix. (DIN EN 50281-1-1, 3.4)	The condition is that the process ends only after one reactant has been entirely consumed.
Atmospheric Conditions	Mix pressure between 0.8 and 1.1 bar Mix temperature between -20°C and +60°C	
Hazardous Explosive Atmosphere	Explosive atmosphere in dangerous quantitites. The presence of a hazardous explosive atmosphere must be assumed if ignition triggers an exothermal reaction that endangers people, domestic animals and property (ExRL).	A dust layer of less than 1 mm on the floor of a normal room is sufficient to cause a hazardous explosive atmosphere.

Table 2: **Technical Safety Parameters of Dusts**		
Parameter	Definition/Description	Remarks
Size of particle	Dust particles larger than 400 µm are not combustible. Dust particles are combustible when they measure less than 400 µm and up to 20 µm	Transportation and processing of large-particle dust often cause abrasion, producing finer dusts.
Combustible dust concentrations	As with gases, dust is combustible within certain concentration parameters: lower combustibility limit: approx. 20…60 g/m^3 air upper combustibility limit: approx. 2…6 kg/m^3 air	These parameters vary widely across the spectrum. Highly combustible dusts can form a flammable mix with less than 15 g/m^3.
Maximum explosive pressure	In simple closed containers, flammable dusts can cause an explosive pressure between 6 and 10 bar.	In exceptional cases, such as with light metal dusts, explosive pressure of up to 20 bar is possible.
K_{St}-value	This is a classifying parameter that describes the volatility of the combustion. It equals the figure for the max. speed of pressure build-up during the explosion of a dust/air mix in a container measuring 1 m^3.	This figure is the basis for calculating pressure discharge surfaces.
Moisture	The moisture of a dust is an important factor for potential ignitions and explosions. Although no exact parameters exist, it is known that a moister dust requires a higher ignition energy and is less likely to be swirled up.	
Minimum ignition energy E_{min}	The min. energy of an electrical spark which, under defined conditions, is able to ignite the explosive dust/air mix.	Not every spark is capable of causing ignition. The decisive factor is whether sufficient energy is introduced into the dust/air mix to trigger an independent combustion of the entire mix. A modified Hartmann tube (Figure 5) is used to determine the minimum ignition energy.
Ignition temperature T_i	The lowest temperature of a heated wall that ignites the dust/air mix upon brief contact.	The shape of the vessel in which the ignition temperature is measured has proved to be especially critical. It may be assumed that ignition on differently shaped surfaces is, in practice, only possible at much higher temperatures. In the case of dust from food products and animal feed, this figure is between 410 and 500 degrees C, depending on type.
Smouldering temperature T_s	The lowest temperature of a hot surface on which a 5 mm dust deposit is ignited.	The smouldering temperature describes the ignition characteristics of thin dust layers. If the layer is thicker, or if the ignition source is completely buried in dust, the thermal insulation provided by the dust layer increases, which changes the smouldering temperature entirely, sometimes lowering it considerably, which could trigger an exothermal reaction. Experiments have shown that the smouldering temperature decreases nearly linearly as the thickness increases. T_s is sometimes considerably lower than T_i for an airborne mix of the same dust. The estimated maximum permissible surface temperature for electrical equipment may be higher, depending on the dust's thermal conductivitiy. Unnoticed smoulder spots can be present for long periods in thick layers of dust and can, if the dust is swirled up, become effective ignition sources.

Table 3: **Examples of Explosion Parameters for Dusts**

Substance	T_i [°C]	T_s [°C]	Ø E_{min} [mJ]	min [mJ]
Wood	≥ 410	≥ 200	≥ 100	6
Brown Coal	≥ 380	≥ 225	–	5
Coal	≥ 500	≥ 240	≥ 1000	13
PVC	≥ 530	≥ 340	≥ 5	< 1
Aluminium	≥ 560	≥ 270	≥ 5	< 1
Sulphur	≥ 240	≥ 250	10	5
Lycopodium	≥ 410	–	–	–

Figure 4: **Determining a Dust's Minimum Ignition Energy**



Thus it is impossible to provide generally valid parameters for a particular kind of dust. There are wide variations for identical dusts. Depending on conditions, limit values often cannot be determined exactly; nor then, can the risk of explosion. The minimum ignition energy can also vary to a large extent. In Table 3, the limit values for several products are listed; that is, values that border on the hazardous. In rare cases, the dust/air mix in question can also be ignited at considerably lower temperatures.

Note that it is not possible to directly infer the minimum ignition temperature from the minimum ignition energy, and vice versa.

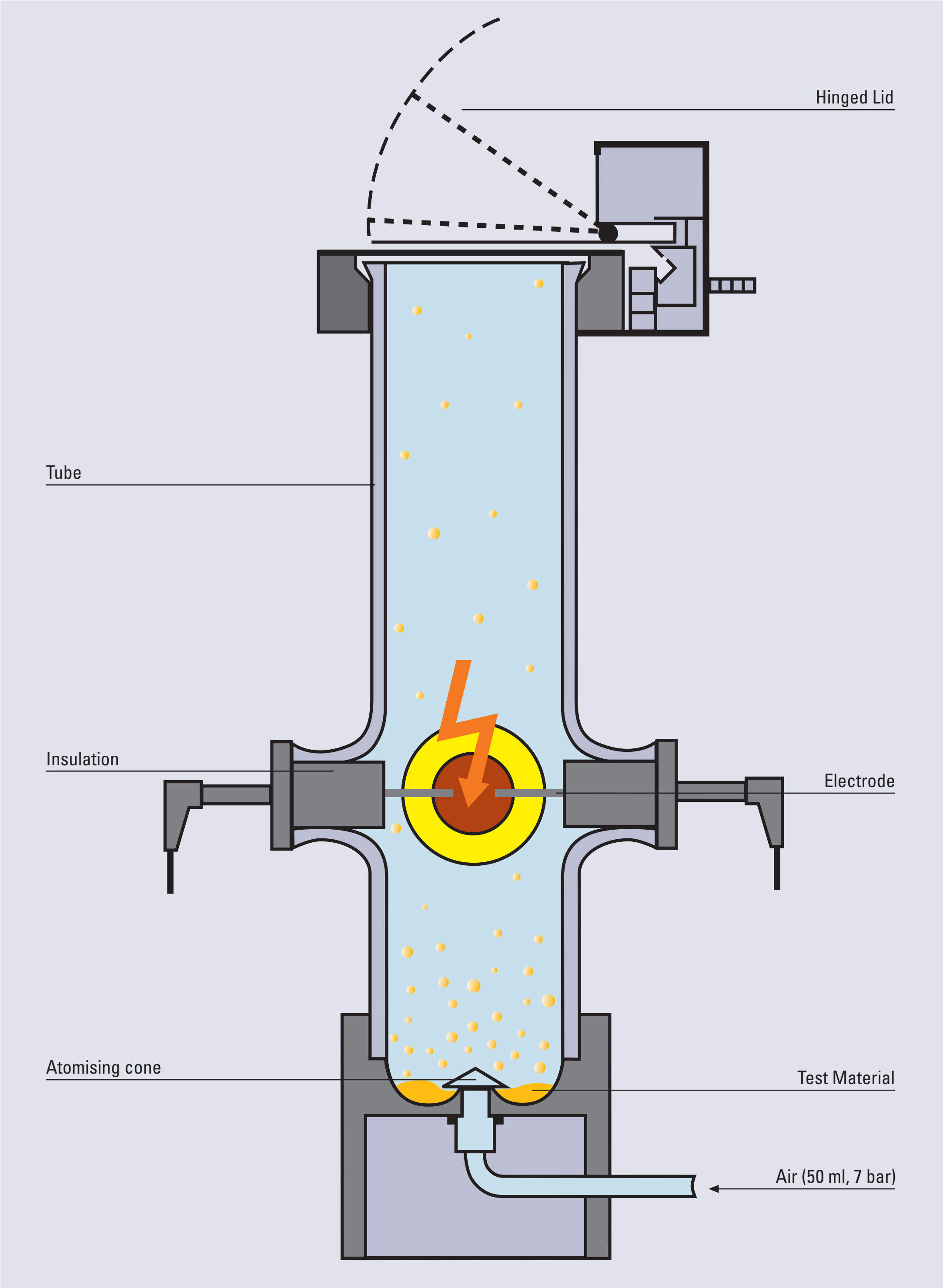
Table 2 includes detailed commentary on the parameters for dusts.

Functional Description of a Modified Hartmann Tube (Figure 5):

Not every spark is capable of ignition. The deciding factor is whether the energy added to the mixture is sufficient to initiate self-sustaining combustion of the entire mixture. The modified Hartmann tube is used as a qualitative test apparatus for this purpose. At the base of the tube is an atomising cone which is employed to dispense a defined quantity of the dust being investigated. A compressed air blast of 7 bar disperses the dust in the glass cylinder and the resulting mixture is then ignited by a spark created between two electrodes.

A test is considered to be positive if the indication instrument shows a deflection of the hinged cover (indication "1" or "2"), or if a dust fire occurs (even if the hinged cover is not moved, indication "0").

Figure 5: **Modified Hartmann Tube**



3. Directives and Standards

Before the new European directives for explosion protection (94/9/EC and 1999/92/EC) came into force, explosion protection regulations in Europe existed at the national level. Beginning in 1976 the ExRL, issued by the German insurer BG Chemie, was valid in Germany; as of in 1978 it was the DIN (German Standardisation Institute) standard VDE 0165: "Installation of Electrical Equipment In Hazardous Areas," and finally, from 1980, the "Electrical apparatus for explosive atmosphere," known as ElexV.

Two zones were defined: Zone 10 and Zone 11. A design certification was not required.

The minimum requirements for electrical equipment for plants at risk of dust explosions, to be fulfilled by the manufacturer on his own responsibility, were stipulated in the regulation VDE 0165/4.66, without reference to zone classification. The first attempts to introduce standards for the construction of electrical devices to be used in areas at risk of dust explosions were undertaken in the mid-80s by the IEC.

Although the special risk posed by dust explosions has long been known, due to devastating accidents in coal mines, the problem received widespread attention in Germany only after the flour dust explosion that completely destroyed the Rolands Mill in Bremen in 1978.

Table 4: **Dust Explosion Protection Standards**

	IEC	EN	DIN/VDE
General stipulations	61241-0	prEN 61241-0	0170/0171 Part 15-0
Protection by enclosure ignition protection "tD"	61241-1 (61241-1-1)	50281-1-1 in future EN 61241-1	0170/0171 Part 15-1-1 0170/0171 Part 15-1
Selection and installation	61241-14 (61241-1-2)	50281-1-2 in future EN 61241-14	0165 Part 2 0165 Part 2/A2
Testing and maintenance	61241-17	prEN 61241-17	0165 Part 10-2
Testing methods:			
> Min. ignition temperature	61241-20-1 (61241-2-1)	50281-2-1	0170/0171 Part 15-2-1
> Resistance from dust deposits	61241-20-2 (61241-2-2)	61241-2-2 (50281-2-2)	0170/0171 Part 15-2-2
> Min. ignition energy	61241-20-3 (61241-2-3)	50281-2-3	in future at CEN
> Lower combustibility limit	61241-2-4	50281-2-4	in future at CEN
Classification into Zones	61241-10 61241-3	50281-3	0165 Part 102
Protection by pressurisation "pD"	61241-2 (61241-4)		0170/0171 Part 15-4
Protection by intrinsic safety "iD"	61241-11		0170/0171 Part 15-5
Protection by encapsulation "mD"	61241-18		0170/71 Part 15-8

After this, design certification of electrical equipment to be used in Zone 10 became a legal requirement, along with ElexV of July 1, 1980. Following action by the IEC, VDE 0170/0171, Part 13 was drawn up. Based on this standard, BVS (German Association of Publicly Certified and Qualified Experts) and now EXAM (formerly known as DMT) have been certifying electronic devices for use in Zone 10 since 1980, in co-operation with legal authorities and the PTB (the German National Metrology Institute).

Directive 94/9/EC provided a new regulation for explosion protection in Europe. This directive (ATEX 95) formulates the requirements to be fulfilled by manufacturers of electrical equipment. The Explosion Protection Regulation of December 1996 made this directive into German law. In Annex 1, Directive 94/9/EC mentions, in the course of an explanation of Equipment Group 2, only the danger presented by an explosive atmosphere consisting of a dust/air mix, which does not seem to include dust deposits. The special risk presented by these dust deposits as a source of dispersal is only taken into account in the zone classification insofar as other circumstances, such as a swirling up of the dust by air currents, could cause an explosive atmosphere.

The questions of proper use are addressed by Directive 1999/92/EC (ATEX 137). The current treatment of dust explosion protection in Directive 1999/92/EC is not very comprehensive and is limited to a simple definition of zones and a reference to deposits of flammable dust. ATEX 137 was made into German law as part of the Industrial Safety Ordinance (BetSichV) of September 2002.

CENELEC, the European Committee for Electrotechnical Standardization, has drawn up Standards EN 50281-1-1 and EN 50281-1-2, which have been issued as German standards (see Table 4). As part of the consolidation of standards dealing with dust and gas, the goal at the IEC level is to adapt the numbering of the dust standards to the IEC 60079 standard series (Table 5). This plan is laudable, because it would create analogous standards for gas and dust explosion protection.

Table 5: **Comparison of "Old" IEC 61241 Standards and New Proposals**

Number of Current Standard	Proposed New Number	Subject	Planned Date
IEC 61241-1-1	IEC 61241-0	General requirements	2003
	IEC 61241-1	Protection by enclosures "tD"	2003
IEC 61241-1-2	IEC 61241-14	Selection & installation	2003
IEC 61241-2-1	IEC 61241-20-1	Test methods	2005
IEC 61241-2-2	IEC 61241-20-2	Test methods	2005
IEC 61241-2-3	IEC 61241-20-3	Test methods	2005
IEC 61241-3	IEC 61241-10	Zone classification	2003
IEC 61241-4	IEC 61241-2	Protection by pressurisation "pD"	2005
IEC 61241-5	IEC 61241-11	Protection by intrinsic safety "iD"	2002
–	IEC 61241-18	Protection by encapsulation "mD"	2004
–	IEC 61241-17	Inspection & maintenance	–
–	IEC 61241-19	Repair & overhaul	–

4. Dust Explosion Protection Measures

4.1 (Primary) Explosion Protection by Avoiding an Explosive Atmosphere

The complexity of the processes that can lead to a dust explosion means that it is extremely difficult to assess the actual risks in dealing with combustible dust/air mixes. This makes explosion prevention measures especially important. These are generally considered to mean avoiding or limiting the build-up of a hazardous explosive atmosphere. One possibility is to reduce the concentration of the flammable substance to values below the "lower combustibility limit" (see Table 2), such as by mixing it with nonflammable products. Another possibility is to prevent the dispersal of combustible substances or at least to limit it. Both of these measures can be effectively supported by thorough and regular cleaning and by implementing suitable construction measures (see p. 15). If dispersal cannot be avoided, the surrounding air with its oxygen can be replaced as a potential reactant by a noncombustible gas such as nitrogen (inertisation).

However, high operational costs mean that this method is limited to a small number of special applications. Should all these measures prove to be unreasonably costly, there are other effective explosion protection alternatives available.

4.2 Explosion Prevention by Avoiding Ignition Sources

This measure prevents the hazardous explosive atmosphere from being ignited. This can be achieved by:

> Analysing potential ignition sources
> Determining the necessary extent of protective measures
> Using suitable equipment

This type of protection involves taking steps to prevent ignition, which means that potential ignition sources can be eliminated. A precondition is that the workflow process in question be assessed in adequate detail for potential ignition sources.

The type of the protection measures and the level of safety required depend on the hazard zone. The probability of the existence of an explosive atmosphere containing airborne dust and the zone classification of endangered areas derived from it are important factors to be considered when deciding on necessary protection measures (see Section 5).

4.3 Constructive Explosion Protection

Constructive explosion protection is a method of avoiding the dangerous effects of explosions and/or of reducing the effects of an explosion to a harmless level. There are several categories:

> Explosion-resistant construction limits an explosion to the inside of compression-proof or blast-proof containers – which, however, also means that connected equipment such as tubes/pipes and decoupling mechanisms must fulfil the same requirements.
Explosion-resistant containers or apparatus are those that can withstand many times the predicted explosive pressure without being permanently deformed.
Blast-resistant containers or apparatus are constructed so that they can withstand the predicted explosive pressure without tearing open; however, permanent deformations may be a result. In this case, then, the robustness of the material may be brought closer to its limits.

> Explosion venting (defined venting by means of bursting discs, pressure-relief flaps, etc.)
This measure is intended to prevent the build-up of excessively high explosive pressure in the inside of containers by prompt release through certain openings. This measure addresses only the effects of the explosion, and can be implemented without additional control mechanisms. As soon as the static response pressure is reached or exceeded, an outflow process from the protected apparatus into the surrounding area begins. Apart from the flame and pressure wave, this outflow from the venting openings, which is a part of explosion venting, also contains combusted and non-combusted substances. It must always be established whether the effects of the explosion in the location in question can be managed.

> Explosion suppression
This process is generally used in containers and production facilities for which an explosive pressure exceeding the explosion resistance of the container/facility is predicted. The explosion is suppressed in its initial stages, before a hazardous rise in pressure can take place. To accomplish this, an extinguishing agent is used in the protected area within fractions of a second of the explosion being detected. For the suppression of an explosion (use of extinguishing agent) it is mandatory that the explosion be detected promptly. In the case of explosions that begin slowly, the initial pressure build-up is not adequate for prompt detection. Additional measures such as optical fire detectors or supplementary pressure detectors may be necessary.

> Explosion barriers (prevention of explosion spread, isolation of devices/facilities)
Isolation as an explosion protection measure allows the explosion to reach full force, but prevents it from spreading to other, unprotected parts of the facility. This is accomplished by mechanical barriers which immediately block connecting pathways, or by a barrier consisting of chemical extinguishing agent(s).

5. Classification of Dust Explosion Risk Areas into Zones

The classification into zones has proved its effectiveness in gas atmospheres for years. The definition of zones adopted by all of Europe in accordance with Directive 99/92/EC applies only to swirled-up dust. Layers and deposits of flammable dust must be taken into consideration as well, like all other factors that could lead to the creation of an explosive atmosphere.

Dust deposits are seen merely as a "source of dispersal" for an explosive atmosphere.

Among other sources, EN 50281-3 (Classification of areas where combustible dusts are or may be present) or the explosion regulations of BG Chemie can provide help with the classification.

In Table 7, zone classification and zone definitions are once again given, as well as the connection between the zones and the equipment categories of Directive 94/9/EC.

Table 6: **Zone Definitions**

Zone 20	Area in which an explosive atmosphere in the form of a cloud of flammable dust is continually or often present. NOTE: These conditions are usually to be found only inside containers, pipes, apparatus, etc.
Zone 21	Area in which an explosive atmosphere in the form of a cloud of flammable dust may be expected to appear occasionally, caused by normal operations. NOTE: Also areas in the vicinity of dust removal or work stations where dust is poured into containers, as well as areas where there are dust deposits and where a combustible dust/air mix could form in the course of normal operations.
Zone 22	Area in which no explosive atmosphere in the form of a cloud of flammable dust can be predicted to occur during nor mal operations, but if it does, it will take place within a short period. NOTE: This could also include areas in the vicinity of devices containing dust, protection systems or components from which dust leaks and forms deposits (e.g. milling / grinding facilities, from which dust leaks and forms layers).

Table 7: **Zone Concept and Effects of ExVO and Directive 94/9/EC**

	Presence of Dangerous Explosive Atmosphere D (Dust)	No Effective Ignition Source During	Equip. Category in Dir. 94/9/EC	Certification Required for Electrical Devices
Zone 20	continual, long-term or frequent	Normal operations and rare device breakdowns, in case of two independent errors	Category 1D	yes
Zone 21	occasional	Normal operations and frequent device breakdowns	Category 2D	yes
Zone 22	rare, at short notice	Normal operations	Category 3D	no (maker's statement)

Classification According to Cleanliness of Facility

High clealiness standards are important in dust explosion protection, as in contrast to gases a series of dispersals which are below the combustibility limit themselves could lead to a dangerous accumulation of dust (see also 4.1, Primary Explosion Protection).

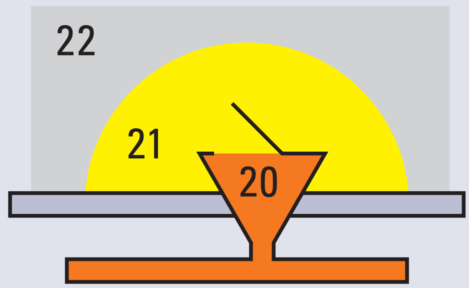
General stipulations in EX-RL (BGR 104) Paragraph E 1.5 refer to obligatory cleanliness standards.

In the new "Classification of areas where combustible dusts are or may be present" according to IEC 61241-10 and EN 50281-3, the degree of cleanliness is quantified and included in the classification of the areas (Table 8).

Table 8: **Cleanliness and Explosion Risk**

Degree of Cleanliness	Thickness of Dust Layer	Period of Time Dust is Present	Risk of Fire or Explosion
good	zero or negligible	none	none
satisfactory	not negligible	shorter than one working shift	none
bad	not negligible	longer than one working shift	Risk of fire, in case of swirling up Zone 22

Figure 6: **Example of the Classification of Dust Explosion Risk Areas According to IEC 61241-10**



Zone 20 Funnel in sack emptying station

Zone 21 Immediate vicinity (radius 1 m) around loading opening

Zone 22 Area outside Zone 21 due to dust deposits

6. Types of Dust Ignition Protection

The goal of ignition protection is to prevent excessive temperatures and energies in the form of sparks, arcs and so forth in a facility.

Currently four types of dust ignition protection exist (see Table 9):

6.1 Dust Ignition Protection "tD"

In Europe, this is generally regarded to be the most important model for power engineering equipment.

EN 50281-1-1 stipulates the ignition protection type for the constructive explosion protection of electrical equipment: "Protection by Enclosure." Two dust protection degrees are defined for dust explosion protection:
1. Dustproof: for the use of devices in Zone 20, Zone 21 and even in Zone 22 (in the presence of conductive dust).
2. Dust-protected: for use in Zone 22a (where non-conductive dust is present).

Enclosures as ignition protection function by limiting the maximum surface temperature of the enclosure and by limiting dust infiltration (dustproof and dust-protected enclosures):

> Dustproof enclosure
An enclosure which prevents visible dust infiltration (IP 6X).
This means that a non-risk area is created inside the enclosure. Please note that as combustible dust particles are approx. 20 to 40 µm in size and thus below the gap width required by EN 50018 for ignition-proof openings. Pressure-resistant enclosures are not in themselves dustproof and must be separately checked and certified according to their condition.

> Dust-protected enclosure
An enclosure which does not entirely prevent dust infiltration, but which does not allow sufficient dust to enter to cause difficulties with the safe operation of the equipment. Dust must not be allowed to accumulate where it "could cause risk of explosion" (IP 5X).

The material used for the enclosure is especially important. It must be subjected to material tests. The enclosure must provide the necessary protection from dust in spite of the deterioration of the material and usual mechanical wear and tear. Possible materials are:
- Metals (such as coated steel plates, high-grade steel, light metal)
- Glass (for enclosure parts, eg. viewing panes)
- Moulded plastic

Metals used for this purpose may have to be subjected to an impact test at low temperatures, as some metals (light metals) have less favourable mechanical properties at low temperatures than at higher ones.

In addition, light metal may contain a maximum of 6 % magnesium, as it otherwise tends to throw off sparks upon impact with materials such as rusty iron. Glass must withstand a thermal shock without cracks or without such extensive damage that it breaks during a subsequent impact test.

6.1.1 Enclosures of Moulded Plastic

Thermal Resistance

Moulded plastic must certainly fulfil the most complex requirements. For electrical devices from Categories 1D and 2D, the temperature index "TI" must be known, according to EN 50281. This figure allows conclusions about the long-term mechanical properties of moulded plastic to be drawn. The temperature index is identical to the 20,000-h point on the thermal resistance diagram, with a reduction of the bending strength (tensile strength) of < 50 %. This figure must be 20 K higher than the temperature at the hottest area of the enclosure. In addition, the moulded plastic must be proven to have sufficient thermal resistance for the intended application. Enclosures or enclosure parts made of moulded plastic for electrical equipment from the Categories 1D and 2D must be subjected to heat and cold resistance tests according to EN 50014 (artificial deterioration). The deterioration process caused by extreme temperatures must not cause the moulded plastic to become brittle, and thus unable to provide protection according to IP regulations.

For electrical equipment from Category 3D, it is sufficient for the material to have a TI at least 10 K higher than the temperature at the hottest area of the enclosure. Proof of a continuous operating temperature (COT) which fulfils the same requirement as the TI is also sufficient. No heat and cold resistance tests are carried out in this case.

Table 9: **Types of Dust Ignition Protection in the Current Standards**

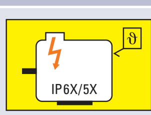
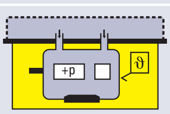
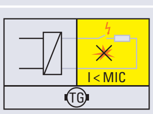
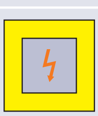
Abbreviation	Principle	Type of Ignition Protection	Current Status at IEC	Future Status at IEC	Status at CLC
tD		IP cabinet (tightness and temperature control)	IEC 61241-1-1	IEC 61241-0 IEC 61241-1	EN 50281-1-1
pD		Pressurisation	IEC 61241-4 (2001-03)	IEC 61241-2	
iD		Intrinsic safety	31H/171/CDV	IEC 61241-11	
mD		Moulded compound	31H/153/CDV	IEC 61241-18	

Table 10: **Summary of Requirements for Electrical Equipment**

Requirement for:	Cat. 1+2 – Zone 20+21	Cat. 3 – Zone 22
No dust infiltration in enclosure	IP6X	IP5X
No dust infiltration at cable glands	IP6X	IP5X
Propagating brush discharges must be avoided (in accordance with DIN VDE 0170/0171 Part 13)	Bleeder resistance $\leq 10^9\,\Omega$ Breakdown voltage $\leq$ 4 kV Thickness of layer $\geq$ 8 mm	
Laser beam (in accordance with EN 50281-1-1)	5 mW/mm^2 continually 0.1 mJ/mm^2 impulses	
Ultrasonic beam (in accordance with EN 50281-1-1)	0.1 W/cm^2 / 10 MHz continually 2 mJ/cm^2 impulses 0.1 W/cm^2 average	
Outer connection for potential equalisation	as in "e"	as in "n"
Plugs, sockets and connectors (in accordance with DIN VDE 0165, 7.1.4/1991)	Isolation with power off except up to 10 A, 250 V; here IP6X sufficient for isolation; dust must not fall into opening	
Light fixtures (in accordance with DIN VDE 0165, 7.1.3/1991)	Light source with cover, lock or warning sign; no sodium low-pressure lamps	
Air and creepage gaps in connection components	DIN VDE 0110	DIN VDE 0110
Certification required	yes	no
Label: CE compliance according to Directive 94/9/EC	CE	CE
Conforms to standards	Ex	Ex
Surface temp. in °C, (not temperature class)	T … °C	T … °C

Gaskets

Ignition-protection enclosures depend on the elastomeric gaskets used. These are tested using the stipulations in Annex B3.3 of EN 50014. This is a deterioration test using specially shaped test objects (ISO 48/ISO 1818) which tests the increase in hardness of the material. This figure must not exceed 20 % difference between the initial and the final figure. Materials that have hardened to a greater degree may lose their sealing properties.

Electrostatics

An electrostatic discharge is a "very effective" ignition source. When moulded plastic is used for enclosures, the outer surface must be prevented from becoming charged. Otherwise, one of the following types of discharge will occur:

> Spark discharge
These discharges take place between grounded and ungrounded components and are sufficient to ignite all gases and vapours, and almost all dusts.

> Brush discharge
This is a special form of the corona discharge. Pipes, elbows, screws, and tools may serve as electrodes with the maximum field strength. This type of discharge poses no danger to most dusts, but caution is warranted with regard to gases and vapours.

> Propagating brush discharge
This is a discharge of a chargeable material in a thin layer (<8 mm) atop a sufficiently conductive lower layer.

An example: Moulded plastic in the pipes of pneumatic conveyor systems initially receives a strong electrostatic charge from friction on the inside. This charge produces an opposite charge on the outer side, which is coated with moulded plastic and dust. This double charge may contain large amounts of energy. If one short-circuits both sides of the doubly charged layer, all the stored energy is violently discharged. This causes brightly glowing discharge channels to form on the surface of the moulded plastic. This discharge may contain several joules of energy, so that nearly all gases and vapours and the majority of dusts could be ignited. However, propagating brush discharges are relatively rare in practice.

The following measures can prevent discharges such as these:

- Adjusting the surface resistance to $10^9\ \Omega$ and grounding the moulded plastic.
- Limiting the breakdown voltage of the non-conductive material to 4 kV.
- Avoiding thicknesses > 8 mm for the non-conductive material.
- Limiting isolated capacities to < 10 pF.
- Increasing humidity to > 65 % in order to reduce the surface resistance of non-conductive materials.

Table 11: **Summary of the Requirements for Rotating Electrical Machines**

Requirement for	Cat. 2 – Zone 21	Cat. 3 – Zone 22
Dust protection of enclosure	IP6X	IP5X
Magnesium content in enclosure	≤ 6 %	≤ 6 %
Thermal properties of non-metal enclosures	as in “e”	as in “n”
Bleeder resistance of enclosure, ventilator cowls	$\leq 10^9\ \Omega$	$\leq 10^9\ \Omega$
Bleeder resistance of the fan at all speeds	$\leq 10^9\ \Omega$	$\leq 10^9\ \Omega$
Outer connection for potential equalisation	as in “e”	as in “n”
Dust protection of cable glands	IP6X	IP5X
IP protection type for outside ventilator	as in “e”	as in “e”
Protective roof for design type V1	as in “e”	
Mounting of ventilator and cover	as in “e”	as in “e”/”n”
Distances in ventilation system	as in “e”	
Magnesium content of fan	≤ 6 %	≤ 6 %
Air and creepage gaps in connection components	DIN VDE 0110	DIN VDE 0110
Certification by appointed site necessary	yes	no
CE conformity	CE	CE
Conformity to standards	Ex	Ex
Surface temperature in °C (not temperature class)	T … °C	T … °C

Mechanical Stability

For equipment from Categories 1D and 2D, mechanical tests are carried out in accordance with EN 50014. The enclosures must withstand a high-impact energy of 7 joules.

If the enclosure contains transparent parts, they are subjected (without protection) to a test with 4 joules or (with protection) to one with 2 joules.

Depending on temperature change resistance, tests such as these are to be carried out at a temperature 10 to 15 K higher than the highest operating temperature and 5 to 10 K below the lowest operating temperature.

After the mechanical stability test, the protection type required by IP can be found in Table 10.

In the case of hand-held electrical equipment, a drop test in accordance with EN 50014 must also be carried out.

Table 12: **Selection of Pressurisation Type of Protection**

Equipment in Enclosure		
Zone	with ignition source during operations	no ignition source during operations
20	"pD" not permissible	"pD" not permissible
21	Switching off as in 7.5.1.1	Warning as in 7.5.1.2
22	Warning as in 7.5.1.2	"pD" not required

Cable Glands

Supply and measurement cables are connected to the explosion-protected electrical equipment. The cable glands must be in accordance with Annex B of EN 50014. This means that the certified "increased safety" cable glands for endangered areas may be used. It must be noted, however, that the Ex e cable must only be in accordance with IP 54, whereas for dust explosion protection, devices from Categories 1D and 2D must be in accordance with IP 6X and devices from Category 3D with IP 5X. In addition, proof of increase in hardness is required (see Gaskets). This proof can be provided by the tests mentioned here or by data sheets from the gasket manufacturer.

6.2 Dust Ignition Protection Type "pD"

This type of ignition protection, similar to the pressurisation "p", could become important in the protection of switch cabinets in endangered areas. For example, equipment of the type "pD" may only be used in Zone 21 and Zone 22 (not in Zone 20). The pre-rinsing required for gas explosion protection is not allowed for dust explosion protection, as the swirling up of dust layers could produce a hazardous explosive atmosphere. Paragraph 4.3 of the standard explicitly requires that before the pressurisation device is turned on, the inside be cleaned of dust that has accumulated whilst it was off.

The measures to be taken in case the pressurisation device breaks down are classified according to zone and the presence of operational ignition sources (see Table 12).

6.3 Intrinsic Safety "iD"

The current draft (CD) largely corresponds to the 4th edition of IEC 60079-11: 1999 for gas explosion protected equipment of the intrinsic safety ("i") type.

In the final draft, the paragraphs of Standard IEC 60079-11 that are directly relevant will generally be referred to, without being repeated. This is what is to be expected in practice when "iD" equipment is derived from existing and already tested intrinsically safe equipment.

The preliminary translation of the introduction to the future standard IEC 61241-11 mentions the following basic rules:

> Electrical circuits must fulfil the requirements of Group IIB from IEC 60079-11, in order to avoid sparks with ignition potential.

> In general, protection factor IP 6X or moulded compound are required to ensure that air and creepage gaps are not blocked by dust.

> Operational restrictions for equipment or components that are not protected by an enclosure or moulded compound (e.g. non-insulated sensors). This is intended to prevent a layer of dust being transferred from the equipment to combustible dust and being ignited. It is also meant to prevent heat ignition on the surface of components.

> Temperature limits on all outer surfaces of equipment or their components which exceed the operational limits stipulated in IEC 61241-11. The surface may consist of an enclosure or a moulded compound.

Work is continuing on the standard for the intrinsic safety ("iD") ignition protection type, therefore we refer the reader to current articles in our Ex-Magazine.

6.4 Encapsulation "mD"

The dust ignition protection type "mD" in accordance with IEC 61241-18 is to be adapted largely from the gas ignition protection type "m" stipulated in IEC 60079-18, which is currently being revised.

Further proceedings on the draft of IEC 61241-18 will therefore be determined by the development of the new IEC 60079-18.

7. Equipment Selection

After assessment of the facility and its degree of risk, the operating company must consider the following criteria in selecting electrical equipment:

- Determination of the equipment category in accordance with the zone plan.
- Assessment of the properties of existing dust.
- Maximum permissible surface temperature of the equipment, taking into consideration the type of dust and the presence of dust clouds, as well as the smouldering temperature of dust deposits.

The selection of the **equipment category** can be carried out as described in Table 13. This defines the construction of the enclosure in accordance with the requirements of Paragraphs 4 and 6 of EN 50281-1-1. The density of the dust tested using the procedure described in EN 60529 for Category 1D, must be taken into consideration.

The "Essential Safety and Health Requirements" from Directive 94/9/EC deal with the problem of dust deposits in Annex II, Paragraph 1.2.4. In addition to requiring the removal of dust layers, it is stipulated that the surface temperature of equipment and equipment parts be well below the smouldering temperature of the deposited dust. An accumulation of heat must be expected and managed using temperature limitation. Dust deposits should, if possible, be limited or prevented entirely. For the equipment manufacturer, this means the equipment must be produced in such a way that dust deposits do not arise and/or the equipment is simple to clean.

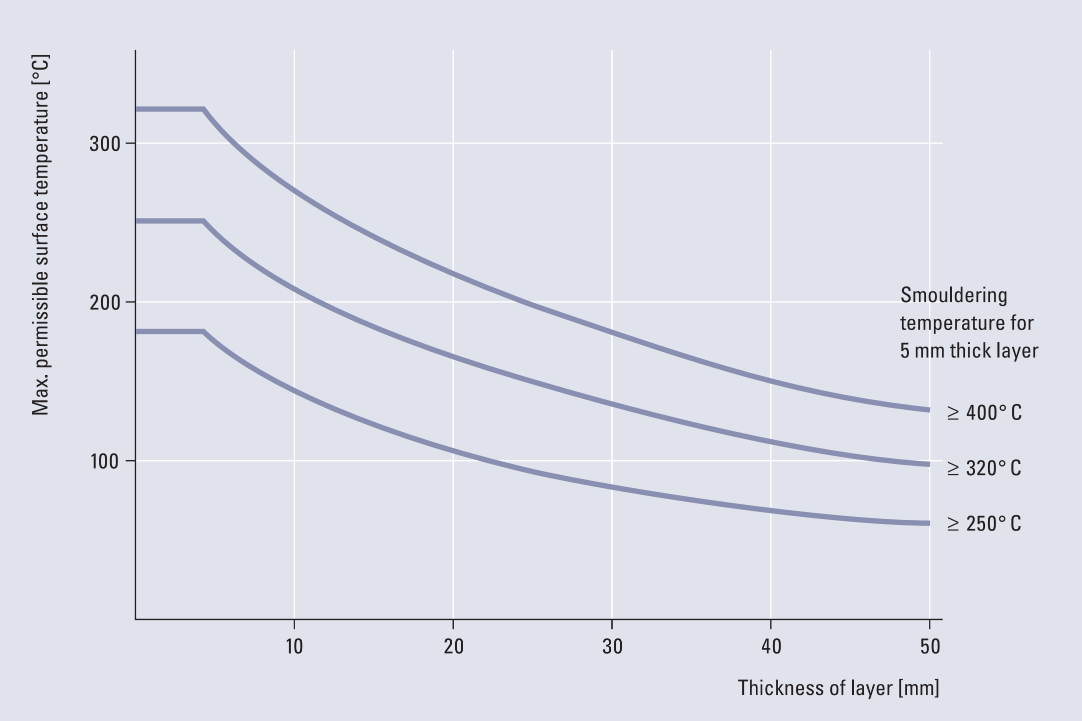
- EN 50281-1-2 addresses the selection of electrical equipment and stipulates that, apart from the classification into zones, the possibility of the equipment being covered or completely buried in dust must be taken into consideration, unless this situation can be avoided.
- EN 50281 does not currently address the question of how dust deposits on electrical equipment influence the safety of the equipment. For equipment from Category 3D, there is no requisite check of possible faults. This would mean that equipment from Category 3D would be subject to a thermal assessment – in extreme cases while entirely buried in dust – yet that common faults need not be taken into consideration.

Zone 21 presents a similar problem. Is the inside of containers in which combustible dust is stored also a part of this zone? The situation is clearer in the case of Zone 20, as per definition complete burial of the equipment must be taken into account. Table 13 presents possible solutions to the problem.

Table 13: **Equipment Selection by Category**

Type of Dust	Zone 20	Zone 21	Zone 22
conductive	Category 1D Temperature limitation and excessive dust deposits	Category 1D or 2D	Category 1D or 2D
non-conductive	Category 1D Temperature limitation and excessive dust deposits	Category 1D or 2D	Category 1D, 2D or 3D

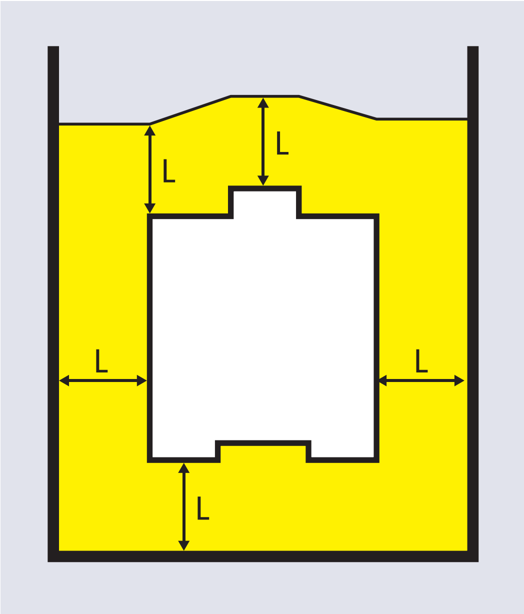
Figure 7: **Maximum Permissible Surface Temperatures for Dust Layers Measuring 5-50mm Thick**



The self-ignition of dust deposits is a critical problem. These processes are often caused by exothermal reactions involving oxygen from the surrounding air. It could be a chemical reaction (oxidation), a physical reaction (adsorbtion) or a decomposition process (mainly in the case of organic dusts). Self-ignition is independent of the temperature of the surrounding area, of the geometric factors and of the volume of the dust. The heat produced during decomposition of materials can produce carbonisation gas, which in turn can lead to an explosive gas/air mix.

Not every case of dust ignition necessarily leads to an explosion. Dusts with low pressure build-up speed may initially burn. Under certain conditions, an explosion may occur, often in a completely different location than the ignition. The fire can spread from the place of origin to other areas by way of transportation facilities. During this process, the flames swirl up noncombusted dust , which in turn takes deposited dust with it.
A sudden change in the volume of the dust cloud as it enters a larger room (e.g. a silo) can produce a hazardous explosive atmosphere. The flames cause ignition. The **smouldering temperature** of a dust layer is determined using the method from EN 50281-1-2. The determination of an electrical device's **maximum surface temperature** must be done by the manufacturer, with potential faults taken into consideration. Temperature limitation measures should be used to manage these faults (electrothermal protection). The maximum surface temperature is measured according to the stipulations in Paragraph 10 of EN 50281-1-1.

Figure 8: **Determining the Maximum Surface Temperature TL Beneath a Dust Layer of Thickness L in mm**



When determining the **maximum permissible surface temperature** (dependent on the surrounding dust), one must take the following figures into account:

1. Maximum permissible surface temperature when a dust cloud is present (calculation in accordance with 6.1 of EN 50281-1-2).
   The ignition temperature of the dust must be taken into account.
2. Maximum permissible surface temperature when a dust deposit is present. When making the calculation, one must take the smouldering temperature (which is dependent on the thickness of the dust layer) into account:

> **For dust deposits up to 5 mm thick**, the calculation must be made in accordance with 6.2.1 of EN 50281-1-2.

> For **dust deposits > 5 mm – 50 mm**, the curves plotted in Figure 7 must be applied.
> The redutions in temperature plotted here were determined empirically for dust deposits of up to 50 mm on top of electrical equipment. The curves take into account both the reduction, specific to dusts, of the smouldering temperature with increasing deposit thickness, and also a predictable rise in the temperature of the electronic device, due to the limited functioning of the heat removal system. In addition, the curves include the customary safety reduction of 75 K.
> Here it must be stated explicitly that the above does not take into account an electricaldevice buried completely in dust.

> **Determining a surface temperature for dust deposits > 50 mm:** According to the currently valid stipulations in Paragraph 6.3 of DIN EN 50281-1-2/VDE 0165 Part 2, if dust deposits of excessive thickness are present, the equipment in question must be tested in a laboratory using the relevant dust (see Annex A of the above-mentioned standard, as well as (2) and (7)).

In the future, manufacturers will have the option, during the type testing, of determining a surface temperature TL under a deposit of thickness L (orientated toward the thickness of the layer during actual use), which may be stated on labels (Figure 8). Paragraph 5.2 of IEC 61241-0 states: "In addition to the maximum surface temperature TL in accordance with 5.1, the maximum surface temperature TL for a specific layer thickness of dust surrounding the equipment on all sides may be stated." For the determination of the temperature TL, 23.4.5.2 stipulates: "The equipment is to be installed according to the manufacturer's directions and surrounded by a dust layer of thickness L. The maximum surface temperature under a dust with a heat conductivity not exceeding 0.003 kcal/m/°C/h is to be measured according to the directions in 23.4.5.1." The operator must take note of Paragraph 6.3.3.4 of the erection guidelines 61241-14: "When the equipment has been labeled for a particular layer thickness, the T_{5mm} (the smouldering temperature for a 5 mm layer) must be replaced by the smouldering temperature for thickness L."

The calculations from 1 and 2 must be made by the operator!

The maximum permissible surface temperature, depending on the ignition temperature T_i and/or the smouldering temperature T_s of the surrounding dust is determined as follows:

1. Maximum permissible surface temperature in presence of dust clouds $T_{max} = 2/3\ T_i$
2. Maximum permissible surface temperature in presence of dust deposits (5 mm thickness) $T_{max} = T_s - 75\,K$

Example: flour

$T_i \geq 380°C$ and $T_s \geq 300°C$

$T_{max\,(1)} = 2/3 \times 380°C = 253°C$

$T_{max\,(2)} = 300°C - 75\,K = 225°C$

Accordingly, the surface temperature of the electrical equipment in this particular case must not exceed the value of 225°C; this must be guaranteed by the manufacturer (see "Determination of the Maximum Surface Temperature" above).

Figure 9: **Explosion Protected Lamp from the 6600 Series for Use in Zone 21 (Category 2D) and Zone 22 (Category 3D).**

Radiation-Emitting Equipment

Visual radiation is a fringe effect in the field of dust explosion protection. The first factor to be considered when determining the limit value is: How high is the power density?

If the power density is ≤ 0.1 W/cm², no further assessment is necessary. Signals in pulse form are assessed according to the energy density. In addition, however, the energy density as an average of the pulse-pause ratio must be taken into account. Besides this, an assessment of possible faults is to be carried out in order not to exceed the limit values for equipment from Categories 1D and 2D. The figure for the pulse-pause ratio, which is the basis of the calculation, is especially important. Visible radiation (especially if it is focussed) can ignite the dust/air mix.
Laser radiation can cause ignition from a great distance, even when it is not focussed.

Limit values to be observed:

> Power density ≤ 5 mW/mm² for continuous beam lasers
> Pulse energy density ≤ 0.1 mJ/mm² für pulse lasers

In the case of **ultrasonic devices** (e.g. sensors), a large percentage of the energy emitted by the ultrasonic transducer is absorbed by dust. This causes a heat rise in the dust particles, which in extreme cases even reach the ignition temperature. Limit values to be observed:

> Power density ≤ 0.1 W/cm²
> Pulse energy density ≤ 2m J/cm²

Plugs and Sockets, Plug Connectors

In Zone 20, plugs and sockets are not permitted. In Zone 21 and Zone 22, for electrical equipment from Categories 2D and 3D, the following requirements apply:

> Plugs and sockets must be locked in such a way that they can only be separated when the power is off, or
> In accordance with 9.2 of EN 50014, plug connectors must be held together by special catches and a warning sign affixed to them: “DO NOT SEPARATE WHEN POWER IS ON”.

Supplementary Requirements

EN 50281-1-1 contains several supplementary requirements for specific electrical equipment from Category 2D which must be taken into account. Here are some important examples:

> Rotating electrical devices, such as spindle-powered outdoor ventilators used for cooling, must be surrounded by a protective cover.
> Switching devices with a flammable dielectric are not permitted. Enclosures must be secured with circuit breakers or labeled with a sign:“DO NOT OPEN WHEN POWER IS ON”, if sliding panels or other remote-controlled components are included in them. If a circuit breaker is built-in, it must disconnect all poles and be set up so that its contact position is completely visible, or so that the “off” position is always shown. The catch between a circuit breaker and the cover or door must only permit the door to be opened when the circuit breaker’s contacts are disconnected.

Additional protective enclosures for equipment whose power is on after the enclosure is opened.

- Fuses: unopenable when power is on, or warning sign for switching devices.
- Lighting: lamps containing loose metallic sodium (e.g. low-pressure lamps according to EN 60192) are not permitted.

Connecting Components

As in gas explosion protected areas, electrical equipment is connected to the outer power circuit using clamps.

The equipment can also be connected using a cable that is continually connected. Devices with attached cables are an exception when only one end of the cable is permanently connected. These devices must be labeled with the mark X.
The operator must be given instructions for the unattached end of the cable (e.g. within Zone 21, the unattached cable end must be plugged into a device from Category 2D).

Operating Instructions and Labeling

Table 15 shows the labels for electrical equipment in accordance with EN 50281 and Directive 94/9/EC. Data relevant to explosion protection, such as equipment group, category and maximum surface temperature are shown as in the following example: II 2 D T 135 °C.

No division of dusts into temperature classes is planned. Unlike gases, dusts require a calculational margin of safety between surface temperature and ignition (smoulder) temperature. Each device has a set of operating instructionswhich must contain the elements shown in Table 14.

Table 14: **Contents of Operating Instructions**

According to EN 50281-1-1
> Initial operation
> Application
> Mounting and de-mounting
> Maintenance
> Installation
> Electrical parameters
> Specific requirements

Table 15: **Labeling of Equipment**

EN according to EN 50281-1-1
> Name and address of manufacturer (trademark)
> Series and type
> Serial number
> Electrical parameters
> Maximum surface temp.T
> Ex
> Equipment Group, in this case II
> "D" for dust
> Category
> Testing site and certification no. (year/Id. no.)
> Year of manufacture
> CE

8. Installation and Maintenance

The protective measures described in Section 4 alone are not sufficient to prevent an explosion. Installation carried out according to requirements, punctual, correct and consistent maintenance are all crucial for maintaining safe operations (DIN EN 50281-1-2 / VDE 0165 : 11.99 Part 2).

During installation, the manufacturer's stipulations in the operating instructions must be followed carefully.

8.1 Installation of Cables and Wires

Selection of Cables and Wires

In general, the customary types of cables and wires are permitted when they are laid in pipes that are seamless, held together by screws, or welded all the way down. Cables and wires whose construction ensures that they are dustproof and immune to mechanical wear and tear may also be used. Examples are:

> Cables and wires with thermoplastic or elastomeric wire insulation, with meshwork or sheet reinforcement and an outer sheath of PVC (poly-vinylchloride), PCP (polychloroprene rubber), or a similar material.
> Cables and wires with a seamless aluminium sheath with or without reinforcement.
> Mineral-insulated cables and wires with metal sheath.

Note: These cables and wires may have to operated below their nominal rate to prevent the surface temperature from exceeding the stipulated values.

> When cables and wires have a protective pipe, or when there is no danger of mechanical damage, cables and wires with thermoplastic or ela-stomeric insulation and a sheath of PVC, PCP, or a similar material are permitted.

Laying Cables

> Cables and wires must be placed so that they cannot become electrostatically charged by moving dust (friction effect).
> Cables and wires must if possible be laid so that no large dust deposits can form. Sufficient access for cleaning must be possible.
> If possible, cables and wires should not be laid in areas at risk of a dust explosion if they are not connected to this area.
> If dust deposits form on cables and wires, preventing free air circulation, a reduction of the electrical current must be considered. This applies especially to dusts with a low smouldering temperature.
> If cables and wires are laid through walls or other structures, this must be done so as to prevent combustible dust from accumulating and penetrating them.
> For movable electrical devices, a suitable cable type must be used. For these purposes, often a suitable connection box must be placed between movable and immovable cables and wires.
> If metal tubes are used, the following must be ensured: that there is no possibility of wire damage at the contact points, that the contact-points are dustproof, that the impermeability of the connected equipment is not reduced, that the contact points are included in the potential equalisation.

Cable Glands

The requirements for dust explosion protected equipment from Categories 1D and 2D are almost identical with those for a gas explosion protected enclosure of the "increased safety" type. Both must be in compliance with Annex B of EN 50014.

The only differences are in the type of protection and in certification:

> Dust-Ex: IP 6X, certification for Zone 20 and/or Zone 21
> EEx e: IP 54, certification for Zone 1 and Zone 2

Cable glands must be assembled and mounted so that they do not compromise the equipment's dust protection. They can also be permanently connected to the equipment, in which case they are certified along with the equipment.

8.2 Maintenance

In addition to the protective measures already taken, an organisational plan must be drawn up for the facility.

> Cleaning, removal of dust deposits.
> Monitoring and maintenance of the safety equipment.
> Monitoring the grounding, especially for the parts of the equipment that could become electrostatically charged.

These measures serve firstly to reduce the risk of explosion and secondly to maintain the effectiveness of the constructive protective measures.

"The testing, maintenance and repair of explosion protected equipment in areas at risk of a dust explosion may be carried out only by trained personnel with knowledge of ignition protection types." (DIN EN 50281-1-2, 12.1)

8.3 Documentation

EN 50281-1-2, 10.3:

"For each facility, plans must be drawn up which contain the following elements:

> Classification and expansion of the areas at risk of a dust explosion; the zone classification and the maximum thickness of the dust deposits (if > 5 mm) must be given.
> Recording of the type of dust explosion protected equipment and their labeling, with sufficient information regarding suitable maintenance.
> Type, location and details of the cable systems."

This task is similar to that required by the EC "Worker Protection Directive" 99/92/EC, which obligates the employer to draw up an explosion protection document. This document must include the following:

> Safety assesment of workplace.
> Safety measures in workplace.
> Installed equipment and warning devices.
> Guarantee of proper use of equipment.

Some Examples of Dust Explosion Protection Products

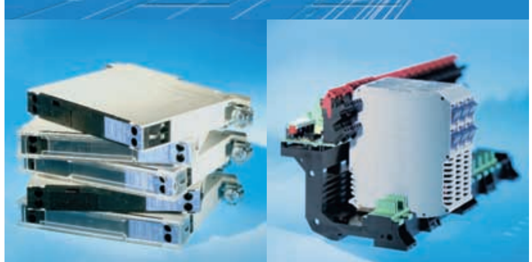
ECOLUX 6608
Emergency Lamp

Optical Beacon 6161
Traffic Light 6091

Control Equipment
Series 8040
Lighting and Heating Panel
Series 8146

Control Panels
CUBEx

Safety Barriers
INTRINSPAK
EX i Isolators IS pac



Remote I/O System I.S.1
Plugs and Sockets
SolConeX

9. Product Overview

R. STAHL has a fully certified product range for the areas of your facility that present the risk of dust explosions. We take dust explosion production just as seriously as gas explosion protection. We can offer you a specially tailored solution for almost every application. At a minimum, all dust explosion protection products comply with the regulations of Group 3D; that is, they can be used in Zone 22 (non-conductive dusts).

The following equipment series and systems are certified for both Zone 21 and Zone 22:

> Lamps Series 6600 and 6608, Compact Lamps 6100 and 6108
> Tank Inspection Lamp 6122 and Optical Beacon 6161
> Traffic Light 6091
> Control System ConSig 8040
> Position Switches 8060 and 8070
> Junction and Terminal Boxes Series 8118
> Control Panel and Terminal Boxes Series 8146 and 8125
> Enclosure System CUBEx
> Safety Barriers INTRINSPAK
> Isolators Series IS pac
> Remote I/O System I.S.1
> SolConeX Plugs and Sockets

Your Safety – Our Reality

If your facility is faced with the risk of a dust explosion, R. STAHL offers the expertise you need.

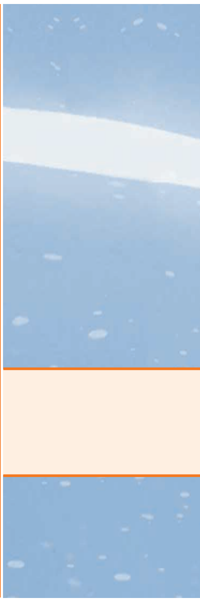
R. STAHL has decades of experience in the field of electrical explosion protection.

We will be glad to help you solve your safety problems. In addition to a comprehensive range of electrical equipment, we offer you expert advice and training in the dust explosion protection field.

Get in touch with us.

You will find a downloadable list of our dust explosion protection products in PDF form at:

www.dust-ex.stahl.de



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