Dust:
a hazardous substance
Why do we need dust protection and explosion protection?

The manufacturing processes used in many sectors of industry involve or result in products in the form of powders or dust. As all solid substances create dusts, which can themselves also become mixed, there is an infinite number of types of dust. Dust consists of a fine suspension of solid substances in the air which are produced during mechanical processes or swirling currents of air. This makes it very difficult to categorise dust, and there are several options available here:

- according to the size of the dust particles
- according to its origin
- according to exposure load for humans
- according to its physical properties

Whether dust is useful (e.g. for metallurgy or the production of dyes, synthetic materials, pharmaceuticals and cosmetics) or is merely waste, all dusts pose a risk to health, while many are also a hazard in terms of fire or even explosion. For example, a layer of mixed wood dust just 1mm thick is enough to cause an explosion! Despite public awareness of protection from gas explosions, there is a general misunderstanding of the hazards involved by many of those at risk here. The combination of these circumstances underlines the importance of preventing dust explosions.

Test dust: smaller than 0.001 mm

Particles suspended in the atmosphere under average conditions

- Mist
- Tobacco smoke
- Smoke
- Viruses
- Flue ash
- Coal / oil smoke
- Pollen
- Dust
- Constant atmospheric impurities

Perceptual limits

- Visual
- Optical microscope
- Electron microscope

Particles that are smaller than 1 μm are constantly suspended in the air as they are borne by means of molecular movement (Brownian motion).
Categorisation of dust by particle size

For the processing and manufacturing industry dust is an inevitable part of production. Although coarse dust is quick to settle, tiny dust particles float in the air for a long time. They are then inhaled deep into the lungs, where they are deposited. This means that in the long term, dust can present a health risk at the workplace. Our top priority of health and safety must also include exposure to dust while at work.

<table>
<thead>
<tr>
<th>Category</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hausedust</td>
<td>- Rock particles</td>
</tr>
<tr>
<td></td>
<td>- Flakes of skin</td>
</tr>
<tr>
<td></td>
<td>- Food waste</td>
</tr>
<tr>
<td></td>
<td>- Abraded material</td>
</tr>
<tr>
<td></td>
<td>- Mushroom spores</td>
</tr>
<tr>
<td></td>
<td>- Bacteria</td>
</tr>
<tr>
<td>Fibredust</td>
<td>- Inorganic fibres</td>
</tr>
<tr>
<td></td>
<td>(asbestos, glasswool...)</td>
</tr>
<tr>
<td></td>
<td>- Organic fibres</td>
</tr>
<tr>
<td></td>
<td>(cotton dust...)</td>
</tr>
<tr>
<td>Stonedust</td>
<td>- Silicates (sand)</td>
</tr>
<tr>
<td></td>
<td>- Loess</td>
</tr>
<tr>
<td>Farina dust</td>
<td>- Pollen</td>
</tr>
<tr>
<td>Agglomerates of dust</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 5, Categorisation by origin

**E-Dust**
The mass fraction of all particles in the breath taken in via the mouth and nose is known as the **inhalable fraction = E-dust.** While smaller particles (diameter < 5 µm) are breathed in more or less in their entirety, inhalability decreases as the size of the particles increases (uninhalable fraction). Part of E-dust (coarse particles) is known as A-dust (fine dust) due to its small particle size.

**E-Dust**
The **alveolic fraction (A-dust)** refers to the part of inhalable dust that is so fine that it reaches the alveoli, the tiniest air sacs in the lung, where it then remains. No exact size can be specified for these particles, only a particle size distribution. This is described in DIN EN 481.

Dust is taken up by the body through:

- inhalation
- swallowing
- skin absorption

Fig. 6, A- and E-Dust

Fig. 7, Uptake by the body
What are the requirements here?

Health and safety work regulations call for the safe removal of dust by extraction or vacuuming. As standards develop, there have been changes in test procedures and aspects of classification with technical advances. For example, in the past there used to be five application categories, but nowadays only three dust classes still exist. The availability of equipment which has been evaluated according to different test procedures leads to confusion in practical usage. For the operator or supervisory staff the classification system (L,M,H) clearly indicates which item of equipment is suitable for which dust class. To ensure greater clarity the IFA (formerly BGIA) has developed a table which describes classification by various testing principles, based on the suitability of equipment according to its intended purpose.

### New dust class rating for dust removal machines

<table>
<thead>
<tr>
<th>Suitable for dry, non-combustible dusts which are hazardous to health</th>
<th>DIN EN 60335-2-69 Anh. AA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dust class</td>
<td>Maximum degree of permeability</td>
</tr>
<tr>
<td>with WEL &gt; 1 [mgm⁻³]</td>
<td>At least L (M, H)</td>
</tr>
<tr>
<td>with WEL &gt; 0.1 [mgm⁻³]</td>
<td>At least M (H)</td>
</tr>
<tr>
<td>with WEL &lt; 0.1 [mgm⁻³]</td>
<td>H</td>
</tr>
</tbody>
</table>

Carcinogenic hazardous substances as per GefStoffV (Ordinance on Hazardous Substances) §11, TRGS 905, TRGS 906 (Technical rules for Hazardous Substances)

- H | < 0.005%

Asbestos as per TRGS 519

- H + Certified for use as per TRGS 519 | < 0.005%

Additional certification for combustible dusts of all dust explosion classes (except dusts with extremely low minimum ignition energy MIE < 1 mJ)

- At least L also incl. Zone 22

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Fig. 8. Dust classification

1. Dust classes L, M and H refer to the entire item of equipment.
2. The relevant classifications are determined according to WEL (value for maximum permissible concentration at the workplace).
3. After establishing the dust class, the maximum degree of permeability of the filter category is determined:

   - **Filter category G**: Degree of permeability ≤ 0.5% (dust class L) - tested as per DIN EN 60335-2-69 Anh. AA
   - **Filter category C**: Degree of permeability ≤ 0.1% (dust class M) - tested as per DIN EN 60335-2-69 Anh. AA
   - **Filter category K1**: Degree of permeability ≤ 0.005% (dust class H) - tested as per DIN EN 60335-2-69 Anh. AA

The degree of permeability is determined using test dust as per DIN EN 60335-2-69, Ann. AA.
Safe removal of dust as a hazardous substance

By extraction, using EOB (= deduster for portable operation)

- to extract dust at source with a deduster
- on all machines and equipment creating dust when machining and processing materials
- air speed inside hose min. 20 m/sec.
- monitoring of air volume flow in extraction line with signalling

By vacuuming, using IS (Industrial vacuum cleaner)

- to remove settled dust with an industrial vacuum cleaner on and in machines and production systems, for cleaning floors, large areas, walls and ceilings.
Potentially explosive atmospheres are created when air mixes with combustible dusts (hazardous dusts - Dust-Ex) or combustible gases or vapours / mists (hazardous gases - Gas-Ex). There must also be an active source of ignition which can ignite this combustible atmosphere.

**Avoidance of explosions**

Effective preventative explosion protection for uncontrolled and accidental explosions, often with disastrous consequences, involves eliminating one of the three above conditions. Combustible dust can be vacuumed up without risk provided that the use of a suitable industrial vacuum cleaner does not entail any source of ignition.

**Protective measure:**

Reliably avoid at least ONE of the three conditions
The three conditions

1 Air/Oxygen

The amount of oxygen present in the air can only oxidise a certain volume of combustible material. If the proportion of combustible material is too low, combustion will only be sluggish or stop altogether. The situation is similar if the proportion of combustible material is too high for the amount of oxygen available in the air.

Is it possible to prevent the occurrence of "air / oxygen"?

Yes, it is possible to eliminate AIR. BUT this involves a very complex design along with high costs.

Inertisation

Inertising areas is a process whereby the oxygen in the air, reactive / potentially explosive gases or mixture of gases are displaced from an area by the introduction of inert gases or vapours. Inertisation performed for fire and explosion protection (e.g. at industrial chemicals warehouses or production plants) involves displacing the oxygen in the air by introducing inert gas (for example argon, nitrogen, carbon dioxide) in order to avoid a potentially explosive atmosphere. In the case of fire protection this is also known as active fire prevention through permanent inertisation.
The three conditions

2 Combustible dusts/gases

Combustible materials can take the form of a gas, fluid or solid.
Combustible solid substances in the form of dust, fibres or lint can react with the oxygen in the air and result in disastrous explosions.
The amount of energy necessary to cause an explosion in combination with air is generally greater than with gases or vapours. Once encouraged to catch alight, the energy released by the combustion reaction results in high temperatures and pressures.
One major factor here is not only the chemical properties of the solid substance but also the particle size of the solid substance and its overall surface area, which increases with the degree of fineness. (See figure 12.)

<table>
<thead>
<tr>
<th>Overall surface area</th>
<th>Active source of ignition</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compact cube of wood...</td>
<td>6cm²</td>
<td>e.g. very strong flame</td>
</tr>
<tr>
<td>...Broken up into shavings</td>
<td>approx 600cm²</td>
<td>e.g. single flame</td>
</tr>
<tr>
<td>...Deposited as fine dust</td>
<td>Depending on particle size approx. 6,000 to 60,000cm²</td>
<td>e.g. spark, hot surfaces</td>
</tr>
<tr>
<td>...Suspended as fine dust</td>
<td>Depending on particle size approx. 6,000 to 60,000cm²</td>
<td>e.g. sparks, stat. discharge, sources of ignition with low ignition energy</td>
</tr>
</tbody>
</table>

Fig. 12. Combustion behaviour of a wooden cube

Is it possible to eliminate "combustible dusts/gases"?

No, the occurrence of an explosive dust/gas atmosphere cannot be ruled out. BUT, regular removal (vacuuming or extraction) of combustible dusts with a suitable vacuum cleaner will minimise the risk of explosion.
Numerous sources of ignition can occur with technical equipment and systems:

**Hot surfaces** are the result of thermal dissipation losses occurring with the normal operation of systems and components.  
**Examples:** coils, resistors or lamps, equipment surfaces which become hot, brakes or overheated bearings.  
**Sparks are produced mechanically** for example with grinding and cutting equipment which cause sparks during operation and are prohibited at hazardous locations.  
**Examples:** Rusty hammers and chisels used on light metals, metal forks of fork-lift trucks (friction sparks). Electric sparks can also be produced through static electricity. The stored energy can be discharged as sparks and so act as a source of ignition.  
**Examples** for the occurrence of a static charge:  
Transmission belts made of synthetic materials, housings of portable equipment, synthetic clothing, unrolling films of paper or synthetic materials, plastic piping, cleaning equipment with plastic housings.

**Is it possible to avoid sources of ignition?**

**NO, not in principle**  
Careless handling of sources of ignition by the operator  
**BUT** explosion-proof RUWAC vacuum cleaner are not a source of ignition as they are designed to be "free of an ignition source".

**Dust extractors:** used on machines which do not produce sparks  
**Industrial vacuum cleaners:** used ONLY to remove settled dust (cleaning floors)
Hazardous locations

European directive 94/9/EC (ATEX), which came into force for all EC member states on 30.06.2003, forms the basis for the application of the ATEX directives. Even if a machine is explosion-proof, this does not necessarily mean that it can be used everywhere. Varying standards apply to explosion protection, so ATEX specifies various categories and levels of risk here:

**Zone 0 / 20**
A place in which an explosive atmosphere is present continuously or for long periods or frequently. Equipment must remain safe even in the case of faults which occur rarely. Two independent design safety measures are required.

**Zone 1 / 21**
A place in which an explosive atmosphere is likely to occur occasionally. Safety must be guaranteed even if faults occur frequently.

**Zone 2 / 22**
A place in which an explosive atmosphere is not likely to occur but if it does occur, will persist for a short period only. The equipment offers the required degree of safety when in normal use.

![Fig. 14, Definition of zones](image)

**Equipment group I (mining - firedamp)**

<table>
<thead>
<tr>
<th>Category</th>
<th>Requisite level of protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category M1</td>
<td><strong>The very high level of protection</strong> must be ensured in the event of two faults occurring independently at the same time.</td>
</tr>
<tr>
<td>Category M2</td>
<td>Must be switched off if a potentially explosive atmosphere occurs.</td>
</tr>
</tbody>
</table>

**Equipment group I (other hazardous locations)**

<table>
<thead>
<tr>
<th>Category</th>
<th>Atmosphäre G (Gas)</th>
<th>Atmosphäre D (Dust)</th>
<th>Requisite level of protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 1</td>
<td>Zone 0</td>
<td>Zone 20</td>
<td><strong>The very high level of protection</strong> must be ensured in the event of two faults occurring independently at the same time.</td>
</tr>
<tr>
<td>Category 2</td>
<td>Zone 1</td>
<td>Zone 21</td>
<td><strong>The high level of safety</strong> must be ensured in the event of a single fault</td>
</tr>
</tbody>
</table>
| Category 3| Zone 2             | Zone 22             | - in normal operation  
- standard safety requirements |

![Fig. 15, Definition of equipment groups](image)

**Example of faults occurring in Zone 1, Zone 21**

An industrial vacuum cleaner, equipped with conductive wheels and a plug with a protective conductor.

One fault: Wheels standing on synthetic flooring

**Consequence**: no longer conductive **BUT** conductivity continues to be assured by the protective conductor.

Other fault: Protective conductor is ineffective.

**Consequence**: no longer conductive **BUT** conductivity continues to be assured by the conductive wheels.
The authorisation of equipment for use in hazardous (explosive) areas.

Equipment for use in hazardous areas depending on the level of risk.

Three-phase current/Compressed air
Vacuum cleaner

- no
- yes

Vacuum cleaner manufactured according to:
EN 60335 -1
EN 60335 -2-69 Ann. AA (L, M, H)

EXPLOSIVE DUST

Zone 21
Zone 22 with dust with ignition energy \( \geq 1\text{mJ} \)
Zone 22 with dust with ignition energy \(< 1\text{mJ} \)
Zone 22 with combustible dust

Classification
II 2 D
IP 65
II 3 D
IP 54
II 3 D and other measures
IP 65

Classification
II 1G
Above ground II / Category 1 / Gas G
II 2 G
Above ground II / Category 2 / Gas G
II 3 G
Above ground II / Category 3 / Gas G

EXPLOSIVE GAS

Zone 1 with non-combustible dust
Zone 1 with combustible dust
Zone 1 with combustive and combustible dust
Zone 1 and Zone 21

Classification
II 2 G
IP 54
II 2 G / 3 D
IP 54
II 2 G / 3 D
IP 65
II 2 G / 2 D
IP 65

Zone 22 corresponds to former type 1 (B1)

Fig. 16, System of ATEX classification
Significance and application of zoning for potentially explosive locations

Hazardous locations are divided up into zones. This system takes into account occurrence of the different hazards caused by potentially explosive atmospheres and provides for explosion protection catering for the given circumstances both in terms of safety and economic efficiency. In the European Community a standard definition of zones can be found in Directive 94/9/EC (initially known as Atex 95).

Hazardous places are subdivided into zones according to the frequency of occurrence and duration of potentially explosive atmospheres. This categorisation gives rise to the extent of measures required according to Annex II Part A of Directive 1999/92/EC in conjunction with Annex I of Directive 94/9/EC.

IMPORTANT!
The level of risk in the individual zones is absolutely identical. It is the frequency of the possibility of explosion that forms the basis for the zone categorisation!

When using vacuum equipment to remove dry, combustible dust deposits from potentially explosive (EX) areas, certain risks must be taken into account.

Hazardous areas (Dir. 1999/92/EC)

Zone 20:
A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is present continuously, or for long periods or frequently.

Zone 21:
A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is likely to occur in normal operation occasionally.

Zone 22:
A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is not likely to occur in normal operation but, if it does occur, will persist for a short period only.
How can I find out about "my" substance?

The Gestis Substance Database contains information about the safe handling of hazardous materials and other chemical substances at the workplace: www.dguv.de/ifa/de/gestis/stoffdb/index.jsp

Click first on the menu item "GESTIS STAUB-EX" (GESTIS-DUST-EX)...

On the page "GESTIS STAUB-EX" click on "Datenbank öffnen" (Open database)...

Once the database window has opened, enter your search term and click on "suchen" (search) (for example "Weizenmehl" (wheat flour)).

The various substances (flours) will then be displayed with data about the median value, explosibility and minimum ignition energy. If you click on a substance...

...you will see details such as particle sizes, KST value etc. for this substance. If you click on one of the terms listed (e.g. "ExFähigkeit" (Explosibility)), a page will...

...appear showing detailed information such as the dust explosion classes.
Typ DS 1220 M, 2,6m²

Housing: GRP, insulating (red)

Push handle: insulated

CEE plug: IP67 (only with combustible, conductive dusts)

Castors

Motor circuit-breaker

Push handle: insulated

High-performance fan

Bag filter

Castors

Deflector: aluminium

Typ DS 1220 M, 2,6m², Zone 22,

High-performance fan

Bag filter

Deflector: Bronze or V2A

Fig. 18, DS 1220 M

Fig. 19, DS 1220 M, Dust-Ex
DustEx - II 3 D

Housing: GRP, conductive (black)
Motor: three-phase current
CEE plug: IP67 (only with combustible, conductive dusts)
Push handle: insulated
Castors

Typ DS 1220 M, 2,6 m², GasEx - II 2 G / II 3 D

Housing: GRP, conductive (black)
Motor: three phase current, gas explosion-proof
Push handle: conductive
Motor circuit-breaker: gas explosion-proof version
Exhaust air diffuser: conductive
High-performance fan
Bag filter, conductive
Deflector: bronze or V2A
Castors: conductive

Fig. 20, DS 1220 M, Gas-Ex