Reducing the fire risk in dust extraction systems, and increasing system functionality

Fires in dry filtration systems may be unavoidable in certain applications. To keep the pitfall of needless downtime to a minimum, a variety of solutions for fire protection in dust extraction systems are available.
The difference between fire and explosion protection is the available response time to minimize the damage created. During an explosion, the threat to personnel and the environment is immediate; however, in the event of a fire, there is a window of time remaining to move to safety or to extinguish the fire. The following illustration demonstrates the difference.

**Legal Directives and Standards**

In the absence of any response time, explosion protection is clearly regulated by law with ATEX Directives. However, clear-cut legal requirements do not exist for fire protection. Feasible measures are outlined in the following standards and directives. Their implementation, however, is dependent on the operator’s own requirements or those of the property insurer.

- **DIN EN ISO 13953:2016-07**: Machine safety - fire protection
- **VDI 2263 page 6**: Dust fires and explosion protection in dust extraction installations
- **VDS 3445**: Fire protection in dust extraction installations
- **TRGS 800**: Fire protection measures

**Responsibility lies with the operator**

Whenever fire protection measures are requested by the operator or their insurer, Keller Lufttechnik always conforms to VDI guideline 2263-6 which specifically applies to dust extraction systems. Since there is no mandatory regulation regarding fire protection measures, the responsibility for fire protection lies with the operator. The applicable measures can be determined in a hazard assessment according to the German Industrial Safety Regulation (BetrSichV). Keller Lufttechnik can only suggest fire protection measures, but they are not mandatory for the operator.
A fire load in a dust extraction system can exist due to the following conditions:

**Fire loads in dust extraction systems**

Filter elements consist of natural, synthetic or organic material (paper, cotton, needle felt and plastic granulate) and are therefore classified as combustible. Basically, a fire load exists. The thermal value, e.g. for polyester is 6.3 kWh/kg.

Secondary flammable sources such as oily air, aerosols or other foreign matter leave residues in the filters and ductwork, which easily ignite.

The fire load increases by the dust accumulation in the filter if the material separated is also flammable. The combustion factor can vary between CF 1 and CF 6 depending on the type of dust (see table below).

**Dust combustibility**

The combustibility factor defines the flammability of dusts. The type of reaction in dust extraction installations can be critical because of the air flow, e.g. smoldering fires can reignite.

<table>
<thead>
<tr>
<th>Combustion factor CF</th>
<th>Type of reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF 1</td>
<td>No burning</td>
</tr>
<tr>
<td>CF 2</td>
<td>Brief ignition and rapid extinguishing</td>
</tr>
<tr>
<td>CF 3</td>
<td>Localized burning or smoldering without spreading</td>
</tr>
<tr>
<td>CF 4</td>
<td>Spreading of a smoldering fire</td>
</tr>
<tr>
<td>CF 5</td>
<td>Spreading of open flames</td>
</tr>
<tr>
<td>CF 6</td>
<td>Flash fires</td>
</tr>
</tbody>
</table>
Fire hazard due to ignition sources

The fire load only becomes a fire hazard in the presence of an ignition source, which can be internal or external. There is a distinction between internal and external ignition sources.

**Ignition sources**

- **Internal ignition sources inside systems**
  - Hot surfaces
  - Static electricity

- **External ignition sources**
  - Operational ignition sources
    - Mechanically generated sparks, e.g. during grinding processes
    - Flames and hot gases, e.g. thermal spraying, welding
    - Hot particles, e.g. glowing sparks from machine tools
  - Ignition sources resulting from an error
    - Exothermic reactions, incl. spontaneous ignition of dusts, e.g. dust accumulation in Big Bags
    - Mechanically generated sparks, e.g. machine tool failures

**Internal ignition sources inside systems**

These include hot surfaces of electrical equipment and static electricity. Internal ignition sources can be avoided with simple initiatives. No additional measures are required insofar as the external entry of ignition sources can be precluded.

**External ignition sources**

External ignition sources are generated during extraction processes. There is a distinction between ignition sources resulting from an error or during normal operation (see diagram).

Unintentional ignition sources originate from exothermal reactions which can lead to a self ignition of dusts. A very classic example therefore is the accumulation of dust inside Big Bags. Mechanically generated sparks, e.g. because of a tool rupture, can also become a source of ignition.

Operational ignition sources are caused, as an example, by flames and hot gases originating during thermal spraying or welding. Also included in operational ignition sources are mechanically generated sparks from grinding processes or hot particles, such as energized sparks off machine tools.
Taking appropriate protective actions

Protective measures in accordance with VDI 2263-6

In order to adopt appropriate protective measures, Keller Lufttechnik adheres to VDI 2263-6 which specifically applies to dust extraction systems. The chart indicates the appropriate protective measure (A, B, C).

Detection of dust burning characteristics

- Operational ignition sources existent?
  - no
  - yes
    - Dusts with CF > 1 existent?
      - no
        - Increased availability or environmental protection requirements, or potential threat to neighboring structures?
          - no
            - Type A
          - yes
            - Type B
      - yes
        - Type C

Determining the appropriate protective measure in conformity with regulation VDI 2263-6.

Overview of protective measures

- **Protective measure type A**
  - No operational ignition sources
  - No fire protection measures

- **Protective measure type B**
  - Operational ignition sources
  - Dust non-combustible (CF = 1)
  - Fire prevention measures

- **Protective measure type C**
  - Operational ignition sources
  - Dust combustible (CF > 1)
  - Fire prevention measures (see B)
  - Measures for limiting damage

Protective measure type A

No fire protection measures are required for type A, since there are no operational sources of ignition.
### Preventive fire protection

**Protective measure type B**

For protection type B, three ranges can be selected.

- **Spark pre-separation**
  - The threat of introducing ignition sources is reduced by using a spark preseparator. Ignition sources are diverted in different ways to minimize their energy. A residual risk remains.
  - Examples of spark pre-separators are cyclone separators, impact separators or cascading separators.

- **Spark detection and extinguishing**
  - Single sparks are extinguished with water (except for light metals).
  - Minimum length of ductwork between detection point and extinguishing must be maintained (usually 6 m).

- **Solid matter inertization**
  - Solid matter inertization offers the possibility to generate a non-combustible dust mixture out of combustible dust with the addition of limestone powder via a dosing device (DOS-K1 or DOS-K2).
  - This reduces the threat of combustion.
  - The mixing ratio is lower than in explosion protection. (As a rule, 1:1 or 1:2).
  - An auxiliary protective layer is formed on the filter elements utilizing a dust/powder mixture.

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- **Cascading separator**
  - Separation of coarse particles. Welding wires. Low-wear.
  - Energy dispersal through contact with deflector plates. Not suitable for larger volumes of dust.

- **Impact separator**
  - Separation of ignition sources and particles > 10 µm

- **Cyclone separator**
  - Separation of coarse particles. Welding wires. Low-wear.
Limiting damage in case of a fire

Protective measure type C

The following graphic indicates measures for damage control in the event of a fire. The individual components are described on the following pages.

Measures for limiting damage in case of a fire

- **Fire detection**
  - Downtime monitoring
  - Operational control

- **Manual fire extinguishing**
  - Easy extinguishing
  - Extinguishing by third parties

- **Semi-stationary extinguishing device**
  - Not all components are fixed
  - Effective only after introducing an extinguishing agent

- **Stationary extinguishing device**
  - All components are stationary detecting, reporting, and fighting fires in initial stages of development.
  - Manually triggered:
    - Argon
    - D-powder
    - ABC-powder
  - Automatically triggered:
    - Extinguishing system

### Examples of fire detection

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downtime detection</td>
<td>Temperature detectors in the clean air zone&lt;br&gt;Temperature monitoring in the hopper as an option</td>
<td><img src="image1.png" alt="Downtime detection" /></td>
</tr>
<tr>
<td>Detection during operation</td>
<td>Infrared spark detector in the clean air pipe</td>
<td><img src="image2.png" alt="Detection during operation" /></td>
</tr>
<tr>
<td>Fire alarm</td>
<td>Evaluation engineering UE-01&lt;br&gt;Fan shutdown&lt;br&gt;Compressed air lock&lt;br&gt;Visual and acoustic alarms and strobe light warnings at the system, with signalling to continuously occupied spaces</td>
<td><img src="image3.png" alt="Fire alarm" /></td>
</tr>
</tbody>
</table>
Fire detection and manual firefighting

A simple extinguishing opening offers an alternative to manually extinguish a fire by third parties (e.g., fire department). The blind cover over the extinguisher opening needs only to be moved aside. Firefighting commences directly after the fire ignition/fire detection, by either an ABC extinguisher or by the firefighters. A 12 kg ABC powder extinguisher can be sufficient as standard equipment for organic dust, since the extinguishing powder is distributed internally and suffocates the fire. The fire extinguisher is not permanently fastened onto the filter system.

For manual firefighting (ABC powder extinguisher).

For stationary extinguishing systems with manual extinguishing, connection of an Argon or D-powder canister is possible. It is securely attached for safe fire extinguishing.

Diagram of fire detection

1  Separate compressed air locking device
2  Shut-off valve, incl. voltage- and pressure-free return, securely closing
3  Container temperature monitoring (as an option)
4  Electronic evaluation
5  PFC for customer
6  Signal light
7  Manual extinguishing (as an option)
8  Maximum heat sensor
9  Infrared spark detection (no zone)
Semi-stationary extinguishing device

Semi-stationary extinguishing devices are extinguishing systems that are not permanently installed in all components. Extinguishing is effective only after introducing an extinguishing agent. Firefighting commences immediately after fire materializes. An example would be by water extinguishing. Stationary water sprinkler systems with extinguishing nozzles are installed in areas where rapid fire propagation is assumed. The effectiveness of fire extinguishing is enhanced by utilizing additives such as a film-forming foaming agent (AFFF).

Example: Connection and nozzle of water sprinkler system
Argon extinguishing recommended for aluminum dust

Argon extinguishing can be accomplished with a 20 L or 50 L extinguishing canister provided by the customer. Connection of an Argon extinguisher is by means of a pressure reducer and a hose directly at the adapter plate of the system. A return valve prevents flames from escaping in the event of an explosion. Extinguishing is complete with the emptying of the entire Argon canister. A shut-off valve or a vertically installed pipe prevents the release of Argon from the system.

D-powder extinguishing

D-powder is used mainly for supplementary extinguishing of metal fires. Extinguishing powder is especially suitable for extinguishing fires in the hopper area or tank. The extinguishing powder blankets the site of the fire by suffocating flames and sparks. D-powder is recommended only as an auxiliary extinguishing method, since it cannot extinguish fire sufficiently. Extinguishing is initiated manually after fire detection using an attached stationary extinguishing nozzle. 12 kg D-powder extinguishing agent can be ordered directly from Keller Lufttechnik.

Stationary gas extinguishing device at pressure relief

The burst disk should be attached as illustrated to prevent an unauthorized leak of extinguishing gas.
The standard design is suitable for both unprotected systems and for explosion protected systems (zone 22 in the clean air zone) in which the infrared sensor is installed in the clean air pipe (no ex-zone).

The advantage of automatic extinguishing is that all components are stationary. Also, extinguishing agent is stored on-site and manual extinguishing is not required. Fire detection in a continuously manned space is possible. We recommend this type once the combustion risk exceeds factor three.

1. Separate compressed air locking (as an option)
2. Shut-off valve incl. voltage- and pressure-free return, securely closed
3. Container temperature monitoring (as an option)
4. Electronic evaluation
5. PFC for customer
6. Signal light
7. Manual extinguishing
8. Maximum heat sensor
9. Infrared spark detection (no zone)
10. Shut-off valve incl. voltage- and pressure-free return, leakage 3 %
Suitable extinguishing agent

<table>
<thead>
<tr>
<th>Fire load/extinguishing agent</th>
<th>Sample applications</th>
<th>ABC</th>
<th>Argon</th>
<th>D-powder</th>
<th>H₂O</th>
<th>CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter elements (low volume organic dust particles, disposal via rotary valve)</td>
<td>GFC/CFC processing</td>
<td>X</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Paper dust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filter elements + larger volume of organic dust particles (disposal via tank)</td>
<td>Laser cutting of organic substances</td>
<td>X</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>GFC/CFC processing paper dust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filter elements, lesser amount of dust in the filter (disposal via rotary valve), type of dust: metals (no light metals)</td>
<td>Thermal spraying</td>
<td>0</td>
<td>X</td>
<td>-</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Filter elements, larger volume of dust in the filter (tank disposal), type of dust: metals (no light metals)</td>
<td>Laser cutting of metals</td>
<td>0</td>
<td>X</td>
<td>(X)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Grading of steel, brass</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blasting of steel, brass</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filter elements, small amounts of dust in the filter (disposal via rotary valve), type of dust: light metals</td>
<td>Aluminum processing with MQL</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Grading of Aluminum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blasting of Aluminum</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Filter elements, larger volume of dust in the filter (tank disposal), type of dust: light metals</td>
<td>Aluminum processing with MQL</td>
<td>-</td>
<td>X</td>
<td>(X)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Grading of Aluminum</td>
<td></td>
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</tr>
</tbody>
</table>

X = recommended  O = possible  - = not possible  (X) = recommended as supplement

The extinguishing method must be approved by fire protection management.

Quantities of extinguishing agent

<table>
<thead>
<tr>
<th>VARIO without burst channel (full capacity of KLR-bran/cartridges/single hopper)</th>
<th>Dirty air flow (m³)</th>
<th>Number of Argon extinguishing bottle(s) 20 L</th>
<th>Number of Argon extinguishing bottle(s) 50 L</th>
</tr>
</thead>
<tbody>
<tr>
<td>VARIO 1</td>
<td>0.8</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>VARIO 2</td>
<td>1.8</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>VARIO 3</td>
<td>2.8</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>VARIO 4</td>
<td>3.3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>VARIO 5</td>
<td>6.1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>VARIO 6</td>
<td>8.1</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>