ATEX GUIDELINES FOR EXPLOSION PROTECTION IN EXHAUST AIR SYSTEMS

RISK OF EXPLOSION

Explosions can occur anywhere that combustible gases, fumes, particulate or dust are stored or transported. Under certain circumstances an explosive combination is created when exposed to air. This could result in an explosion if an ignition source exists.

Typical explosive environments are found in the chemical and pharmaceutical industries, refineries, fuel storage facilities, and in painting/surface coating businesses. However, companies transporting and treating dust-creating bulk solids such as corn, animal feed or other organic products are also vulnerable. A large number of guidelines and standards ensure the minimization of explosion risks in such areas.

STANDARDIZED GUIDELINES EU-ATEX 95/ATEX 137

Numerous national guidelines concerning explosion protection are currently standardized throughout Europe. Since July 1, 2003, the utilization of the new guidelines on the application of council directive 94/9/EC (ATEX 95, formerly 100 a) and directive 1999/92/EC (ATEX 137, formerly 118 a) is viewed as a requirement. ATEX 95 (abbreviation for the French “Atmosphère Explosible”) sets product guidelines that apply to all manufacturers. ATEX 137 guideline establishes the requirements for workplaces and are relevant for operators.

EUROPEAN DIRECTIVE ATEX 137 FOR THE OPERATOR

The aim of this regulation is to improve the safety and wellbeing of workers potentially at risk in explosive environments. Essentially, ATEX 137 places the following obligations on the employer:

- Detection of explosion risk/Detection of physical dust characteristics such as ignition temperature, minimum ignition energy, lower explosion limit, KStT-values etc.
- Zone division depending on the explosion risk
- Labeling dangerous areas
- Determine which protective measures to implement
- Operating instructions for employees
- Creating an explosion prevention document which contains all available data and effective measures
EUROPEAN DIRECTIVE ATEX 95 FOR THE MANUFACTURER

The regulation affects protection systems and all systems located in potentially explosive environments. Included are electronic and non-electronic systems which possess their own possible sources of ignition.

The following requirements are imposed on the manufacturer:

- Performance of a risk evaluation of the product
- Clarification of intended use and operating conditions
- Classification into system categories

<table>
<thead>
<tr>
<th>Category</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of safety</td>
<td>very high</td>
<td>high</td>
<td>normal</td>
</tr>
<tr>
<td>Application in zone</td>
<td>0,1 or 2</td>
<td>20, 21 or 22</td>
<td>1 or 2</td>
</tr>
<tr>
<td>Environment</td>
<td>G</td>
<td>D</td>
<td>G</td>
</tr>
</tbody>
</table>

- Labelling on a printed plate
- EC-type evaluation by an authorized agency if an electrical system belongs to category 1 or 2, a non-electrical system into category 1 or if it is a matter of a protective measure.

LABELING ACCORDING TO ATEX 95

Ex II 3 GD T135°C

Max. surface temperature 135°C
Atmosphere: gas or dust
System category: 3
System Group: Group II denotes use above ground; Group I means use underground
Model certified according to ATEX 95

The labeling of the system according to ATEX 95 is necessary only if it vents into an explosive setting. If an explosive environment exists only inside the extraction system, labeling is not necessary. However, various system components can be affected such as fans, switchgear, engines for rotary valves, sensors and level indicators or differential pressure measuring systems.
CLASSIFICATION BY ZONES

Zones are divided into the following classifications:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Gas/ Mist/ Vapors</th>
<th>Dust</th>
<th>Likelihood /Duration of explosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>20</td>
<td></td>
<td>Constant, long period or frequent risk</td>
</tr>
<tr>
<td>1</td>
<td>21</td>
<td></td>
<td>Occasional risk</td>
</tr>
<tr>
<td>2</td>
<td>22</td>
<td></td>
<td>No risk during normal operation (rarely or short-lived)</td>
</tr>
</tbody>
</table>

Guidelines VDI 2263-6 and BGR 104 make recommendations for zone divisions in extraction systems. The dirty air duct can be categorized as a non-explosive zone (n.e.B.) with proper operation and corresponding flow speeds (normally > 20 m/s). Since for example, subsequent to a retrofitting, dust can accumulate in many spaces, so the dirty air duct classification as zone 22 is safer.

CLASSIFICATION OF THE CLEAN AIR ROOM

There have been many attempts at classifying the clean air room from “no zone” to “zone 21”. For example, currently the clean air room of SINBRAN rigid body filters is classified as n.e.B. Since this could increase labor for the operator, KL normally designs the clean air room for zone 22 which offers added safety in the event of a defective filter element.

The VDI 2263-6 does not differentiate between the filter and the clean air duct in classifying the clean air room. However, Keller Lufttechnik has found that even with dust passing through a defectively installed filter element, with eventual dust accumulation in the clean air room, the dust deposits were not necessarily hazardous. This depends on the air flow in the clean air duct. The varying zone division between the clean air room and the clean air duct is further explained (zone 22/no zone).
COMBUSTION AND EXPLOSION CHARACTERISTICS OF DUST

System operators have the opportunity to examine dust specimen at various test institutes concerning combustion and risk of explosion. A rough estimation of explosion characteristics can be accessed via the GESTIS-DUST-EX database at www.dguv.de/bgia/de/gestis/expl/index.jsp.

For comparison:
A spark discharged between two conductive components which are separated from each other (such as through paint/seal isolated flanges) can create an ignition energy of approx. 1,000 mJ. A cluster discharged within an isolated material (eg., non-conductive filter element) creates ignition energies of approx. 2 mJ.

**Ignition Temperature:**
temperature at which dust ignites. The maximum surface temperature may only be 2/3 of the ignition energy.

For example, inside a fan motor: the lowest allowable ignition temperature = 202,5 °C.

**KST-value** = speed of pressure increase = increase of the red curve

**Pmax** = maximum explosion excess pressure which would be created in a closed case.

**BRIEF LISTING OF COMBUSTION AND EXPLOSION CHARACTERISTICS**

<table>
<thead>
<tr>
<th>BZ = Combustibility</th>
<th>Combustibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not flammable</td>
<td>BZ 1</td>
</tr>
<tr>
<td>Localized flame; quickly extinguished</td>
<td>BZ 2</td>
</tr>
<tr>
<td>Localized burning or smoldering, without spreading</td>
<td>BZ 3</td>
</tr>
<tr>
<td>Spreading of smoldering flames</td>
<td>BZ 4</td>
</tr>
<tr>
<td>Spreading of open flames</td>
<td>BZ 5</td>
</tr>
<tr>
<td>Full conflagration</td>
<td>BZ 6</td>
</tr>
</tbody>
</table>

**UEG =** lower explosion limit = minimum dust concentration level for the dust-air combination to become explosive. The minimum volume is usually at 30 g/m³.

**MZE =** Minimum Combustion Energy

<table>
<thead>
<tr>
<th>MZE ≥ 10 mJ</th>
<th>Normal flammability</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 mJ &lt; MZE &lt; 10 mJ</td>
<td>Highly flammable</td>
</tr>
<tr>
<td>MZW &lt; 3 mJ</td>
<td>Extremely flammable</td>
</tr>
</tbody>
</table>
Keller Lufttechnik prepares a hazard analysis for each dust collection system. The operator can use it as an explosion protection document. With explosion parameters that are set by the customer, and with zone classifications, it is feasible to determine the necessary protective measures.

Vario dust collection system with integrated motor-impeller unit, discharge into a 50-L container. Protective measures: averting ignition with a back pressure flap on the dirty air side.

All possible protective measures are described on the following pages
PROTECTIVE PROCEDURES

Protective measures must be chosen in the following priority:

1. Prevention of an explosive environment
2. Avoidance of sources of ignition (combustion)
3. Specific explosion protection

AVOIDANCE OF AN EXPLOSIVE ATMOSPHERE

Protective measures can be set in place with the use of wet scrubbers or the use of solid inertisation.

When using solid inertisation, the separator is supplied with inert material such as limestone powder. The mixture ratio must be such that the combination of inert material/explosive dust/air cannot set off an explosion. The exact ratio must be according to established principles (see testing institutes on the last page).

– The ratio of inert material should be > 50 Gew-%

→ Without specifying the dust, a weight ratio of inert material to dust of ≥ 9:1 must be assumed. Due to the large quantities of inert material required, this process is economically feasible only with low volumes of dust.
**PREVENTING COMBUSTION**

Avoiding sources of ignition can be undertaken for systems at risk for explosion, even if specific protective measures are already in place. The only way explosion/combustion can be prevented is if the following conditions are met:

- minimal dust ignition energy is > 10 J;
- no mixed compounds, e.g., explosive dust with sufficient volume of explosive gases/fumes;
- no risk of spontaneous combustion;
- intake of ignition sources into the filtration system must be prevented.

A spark detection and extinguisher system could help to achieve one protective measure in some instances.

Sparks are detected inside the duct ahead of the filter and are extinguished immediately by water spray. However, piping measuring at least 6 meters between spark detection and dosing is necessary. Extinguishing may not be reliable for larger sources of flame such as burning components. An evaluation must be made on an individual basis if additional constructive measures are required. Spark detection and flame extinguishing are common solutions for retrofitting existing systems without extensive explosion protection measures.

**ATEX SYSTEMS**

A basic prerequisite for an avoidance of ignition sources is the utilization of systems with the corresponding ATEX system category depending on the zone division (see page 3).

Below are some examples:

1. Solenoid valves in the clean air room: ATEX category 3D
2. Fans/motors in the clean air room: ATEX category 3D
   Terminal box in the clean gas room: ATEX category 1D
3. Level sensors in the dirty air room: ATEX category 1D
   Rotary valves and screw-conveyors including gear motors: ATEX category 1D
   Gear motors of rotary gate valves and screw-conveyors: ATEX category 3D

**Reducing Potential**

To avoid sparks created by electrostatic discharges, it is absolutely essential to ground conductive components inside explosive areas (bleeder resistor < $10^6$ Ohm).

For dust which easily ignites (<10 mJ), the use of conductive filter elements is imperative.
CONSTRUCTIVE EXPLOSION PROTECTION

Constructive explosion protection measures which limit the extent of an explosion are required if an explosion in the dust collection system cannot be prevented. Various conditions must be taken into consideration in selecting construction explosion protection measures, such as:

- Dust characteristics and pressure increase ($K_{ST}$-value) and maximum explosion excess pressure $P_{max}$
- Filter dimensions
- Indoor/outdoor installation with possible safety zones in front of pressure release mechanisms
- Dust toxicity
- etc.

Explosion pressure surge resistance

Sturdier filter housing is required at all protection points since an explosion cannot be ruled out. Keller Lufttechnik performed explosion tests for its filter housings at the German FSA (Research Centre for Applied System Safety and Industrial Medicine) to determine the pressure surge resistance. Depending on the application it is possible to design the housings with a pressure surge resistance of 0.2 bar or 0.4 bar excess pressure.

SERIES OF EXPLOSION TESTS AT FSA ON TYPES OF FILTER HOUSINGS

The impact of a slanted pressure relief was also tested.
Pressure relief - burst panels

In outdoor installations or alongside outer walls, it is feasible to use burst panels as an explosion pressure relief to cover a large safety zone. In the event of an explosion, the burst panels open at 0.1 bar excess pressure and the explosion pressure is discharged to the outside. The filter housing must be able to withstand a pressure surge that is capable of reaching a selected explosion pressure limit. (The standard at Keller Lufttechnik is 0.2 - 0.4 bar.)

Characteristics

- Low cost
- Also function with gases and metal dusts
- A variety of installation directions are possible
- Pressure relief indoors is not allowed
- Pressure relief into fire and explosion prone areas is prohibited.
- Practically maintenance-free (in the winter, snow must be removed manually from horizontal installations of >50 cm; small quantities of snow are not a concern.)
- A safety zone outside the flame range must be marked in front of the burst panels
- Individuals are not allowed outside the safety zone. Adjacent buildings must also be protected against explosions and flames.

Technical data on Keller's standard burst panels.

- Response excess pressure: 0.1 bar
- Effective relief surface area on each burst panel: 0.535 m²
- Height: 586 x 920 mm
- Resistant to vacuums up to 50 mbar standard version, alternatively up to 200 mbar
- Allowed for K₅T-values to 300 bar x m/s
Pressure relief - Q-Box

The Q-Box can be used for flameless explosion pressure relief for indoor applications, or within a limited marked safety zone.

Characteristics

- Minimal $K_{ST}$ value: 200 bar x m/s
- Response excess pressure: 0.1 bar
- For dust with a minimum combustion energy level (MIE) > 3 mJ
- Safe distance: 5 m for people; 0.5 m for objects/walls
- Fits standard burst panels - suitable for retrofits
- The ratio between the relieved volume and the volume of the room must be at least 1:15
- Stainless steel version available for outdoor installations
- Practically maintenance-free
- Control is included
- Can be used following an explosion after replacing the burst panel.
Pressure Relief Valves EVN

Relief valves EVN for a flameless explosion pressure relief can be used at a filter installation in the workroom or at a limited possibility to mark a security area.

Characteristics

- Response excess pressure: 0.05 bar
- Allowed for $K_{ST}$-values up to 300 bar x m/s
- Also usable for gases/fumes
- Relief into zone 22 is permissible
- Can be used further after an explosion following an inspection
- Practically maintenance-free
- The increase of pressure in the place of installation shall be considered
- No flame discharge or any discharge into the workplace is allowed, however, within a marked security area of 2.5 m maintenance staff can remain during operation
**Explosion Suppression**

Through explosion suppression, an explosion is prevented within 50 milliseconds by means of detection and addition of an extinguishing powder. A dynamic pressure sensor is installed in the dirty air room, and an infrared sensor is installed at the dirty air inlet (to detect slow explosions). The tanks in which the extinguishing agents are stored are controlled via the control center.

**Characteristics**

- Allowed for $K_{ST}$-values up to 500 bar x m/s
- Ideal for installation in the workplace or in the vicinity of toxic dusts
- Explosion decoupling possible by means of an extinguishing agent can be achieved with minimal effort, since both detection and control are readily available.
- Cannot be used for pure metal dust
Design to withstand maximal explosion pressure

No additional relief or suppression measures are required in the design of the filter housing for maximum explosion pressure, which is normally 10 bar. However, there are considerably stricter requirements for pressure surge resistance, and decoupling measures.

- Ideal for installation on the factory floor and where high $K_{ST}$-values are required.

![Round filter designed for explosion surge resistant for 10 bar](image-url)
Explosive Decoupling

Filtration systems with constructive explosion protection must generally be decoupled.

Specific installation distances should be established. See example below for back pressure flap.

**Dirty air pipe**

Most common decoupling measures:

- **Back pressure flap**
  (decoupling of flame and pressure)

- **Pressure relief chimney**
  (pressure decoupling)

- **Extinguishing agent lock**
  (flame decoupling)

- **Fast-closing slider**
  (decoupling of flame and pressure)

Specific installation distances have to be taken into consideration - Example back pressure flap

The ductwork between ProFlap and explosion protected housing/filter shall have the same pressure surge protection (normally at least 2 mm sheet thickness, welded).
Clean Air Ducting

Most commonly used decoupling measures:

- **Filter elements** (Flame resistance - not considered as a protective measure):
  For rigid filter elements such as SINBRAN or filter tubes with a support frame, some flame decoupling can be assumed. The duct on the clean air side has to resist the excess explosion pressure; however, it should not collapse. An inadequately installed duct can create a hazardous situation.

  The ducting must be directed into a safe zone.

Disposal

Most commonly used decoupling measures:

- **Disposal tank:**
  Must be pressure resistant at the direct openings into disposal tanks.

- **Rotary valves** (for decoupling flames and pressure):
  Rotary valves must be installed according to ATEX 95 (flashback and pressure surge protected).

- **Flap valve** (for decoupling flames and pressure):
  Flap valves must be installed according to ATEX 95 (flashback and pressure surge protected).
Additional information for explosion protection

Standards and technical specifications
EN 1127-1  Explosion protection - Basic principles and systems engineering
EN 13463  Non-electrical systems in explosion endangered areas
EN 14460  Explosion resistant systems
EN 14491  Systems for pressure relief of dust explosions
VDI 2263  Dust fires and dust explosions
VDI 3673  Pressure relief of dust explosions
EN 14986  Explosion protection measures at fans
BGR 104  Explosion protection measures
BGR 109  Guidelines to avoid the danger of dust explosions at grinding, brushing and polishing of aluminium and its alloys (former ZH 1/23)
BGR 132  Guideline "static electricity" (former ZH 1/200)
BGR 204  Handling with magnesium (former ZH 1/328)

Noted bodies/Test institutes to detect dust characteristics/Experts:
Institute for Research and Testing of the German Social Accident insurance
www.bgia.de

German Research Association for applied system safety and industrial medicine (FSA) - Service provider and inspecting authority concerning guideline 94/9/EC
www.fsa.de/

Physical-technical federal agency (German PTB) - Explosion protection
http://www.explosionsschutz.ptb.de/hp.htm?186,34

DEKRA EXAM GmbH
www.bg-exam.de/

IBExU Institut für Sicherheitstechnik GmbH - European notified body for the ATEX directive
www.ibexu.de/

TÜV Product Service GmbH (TÜV=German Technical Inspection Agency)
www.tuev-sued.de

BAM - Federal Institute for Materials Research and Testing
www.bam.de

FTZU - Physical-Technical Testing Institute
www.ftzu.cz

FireEX Consultant, GmbH, Richard Siwek