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Avoidance of Ignition Sources Use of a Dust Filter without Inerting Measures for Dedusting Offgas Containing Combustible Dusts

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The avoidance of effective ignition sources is one essential measure in explosion prevention and protection following the zone classification of hazardous areas.
Because dust filters are not necessarily ‘equipment’ according to the ATEX-directive 2014/34/EU (former 94/9/EU, ATEX 95,…) it is in the responsibility of the plant manager / plant operator to assess the explosion hazards due to the handling of combustible dusts especially using dust filters.
In the paper a dust filter is described which is designed for the handling of combustible dusts with an explosion prevention concept based on the avoidance of potential ignition sources. Great importance is attached to the assessment of the different types of filtering systems (cartridges, cassettes, hoses, etc.) and filter media, e.g. different types of conductive cloths, which often contain “hidden” electrostatic ignition hazards appearing not until the system has been run for a certain time.
The potential ignition sources - especially those related to electrostatics - are discussed in detail and measures are presented to prevent malfunction and to maintain the initially safe status of the filter system over its whole lifetime.

1. Introduction

When handling larger amounts of dusts as it is commonly performed in the processing industries and preferably in the chemical industry the use of dust restraining systems is often required e.g. to prevent contamination of the environment. Especially the fines are collected and accumulated in the filter systems, and when combustible dusts are involved the filter systems are the crucial location in the matter of potential ignition sources, because the combustible fines are often very sensitive to especially electrostatic ignition sources.
To discuss different types of filter elements and filter media together with a possible interaction between the equipment used and the dust handling processes (conveying, dedusting) with regard to potential electrostatic ignition sources a simple set-up of a dust filter unit is described, which allows a detailed assessment of the relevant features. The requirements concerning the suitability of the filter elements and the filter media are discussed and determined in a separate chapter (chapter 7 “Assessment”).

2. Plant and Process

The dust filter unit which will be discussed here consists of a cylindrical or rectangular housing with an integrated conical duct for the release of the separated dust directly into a metal drum. The diameter of the housing does not exceed 1 m. All parts of the housing are made of stainless steel and are welded together except for the connection of the rotary valve which is flange-mounted. The inner side of the housing is not lined or coated. The housing is not heated and if any contains only equipment which is suitable for zone 20. The filter elements are inserted from outside and the fastening is outside as well - except for the cartridges. The dedusting of the filter elements is done time-controlled by pulsed air jets.

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Typical filter units of a two-step filtering system equipped with cassette filter elements (without dust rotary valve or dust collecting device) are shown in figure 1.

Figure 1: Filter units equipped with cassette filter elements

The dust is sucked through a metal piping system from several fixed aspiration points where combustible dusts are handled open, e.g. FIBC discharge stations, hoppers where bags are discharged, or orifices for individual cleaning operations with the help of conductive hoses equipped with special suction nozzles. The nozzles are equipped with sieves not allowing the suction of bigger (metal) parts or particles. The suction is performed by a ventilator positioned on the clean side of the filter unit. The off-gas is introduced into the filter housing tangentially to avoid abrasion of the filter media and to minimize electrostatic charging caused by direct impact of the dust-laden off-gas flow on the filter media.
Four types of filter elements are discussed, which guarantee a good cleanliness of the dust-laden off-gas after filtering down to very small particle sizes (below one micron), with regard to especially electrostatic ignition sources.

- Hoses or Pockets with Cages
- Cartridges (lamella)
- Panels (lamella)
- Cassettes

Hoses or pockets need cages to support the proper operation of the filter element. The cages are made of metal and inserted from the clean side into the hose or pocket. They are fixed on the clean side. There are a number of different systems to fix the cages and keep the system tight and in the correct position. Additionally the grounding of the metal cages has to be accomplished either integrated in the fixing system or separately. Because of the construction (cages) and the length of the hoses this type of filter element is swinging during normal operation caused by the dedusting air jets which interrupt the off-gas flow intermittently. This pulsating load makes the system not very robust (see discussion in 7.) against mechanical Failure compared to the other types of filter elements. A typical hose is shown in figure 2.
Cartridges have a robust housing consisting of metal plates for bottom and top and one inner cylindrical perforated metal sheet stabilizing the filter medium which is folded forming lamellae. Bottom, top, and the perforated sheet normally are joined together with hot-melt adhesive. When the filter medium is equipped with a conductive coating an electric contact is made between the bottom and the conductive layer by means of a small metal pin inserted between two lamellae. A typical cartridge is shown in figure 3.
Panels (or plates) have as the cartridges a folded filter medium, which in contrast to the cartridges forms a flat double layer. The mechanical stabilization is made by guiding rails made of metal at the both sides of the element. Bottom and top consist of a non-conductive polymer (usually polyurethane) which directly border the filter medium. When the filter medium is equipped with a conductive coating flexible grounding litz wires are led through the top polymer border. A typical filter panel is shown in figure 4.

Figure 2: Hoses for dust filter elements

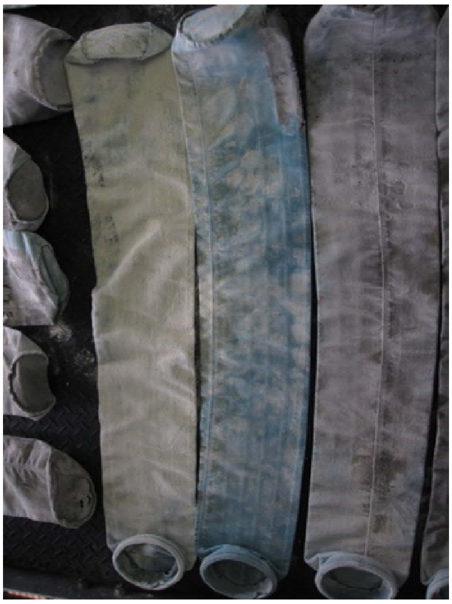

Figure 3: Cartridges - mounted in a filter housing

Figure 4: Panel with grounding leads

Figure 5: Cassette with separate grounding connection

Cassettes consist of an open-plan filter pad which is folded in a way that sheets are formed. Between respectively two sheets a separator made of metal foil (mostly made of alumina) is placed to enlarge the filter area. This compound is fitted into a rectangular housing. As a rule each cassette contains 98 separators which are bonded electrically. For grounding reasons the cassette is equipped with a grounding strip, which contacts the housing of the filter unit when the cassette is inserted. A typical filter cassette is shown in figure 5.

As filter media normally needle felt made of polyester or polypropylene, special fleece material, membranes made of PTFE, or compounds, e.g. fiber glass fabric reinforced with polyester, are used. The untreated material as a rule is electrostatically non-conductive. In many cases the filter media are coated or equipped with special membranes to achieve a better dedusting behavior. In some cases the coating or the material is

conductive or equipped with an antistatic agent to prevent electrostatic charging - provided that the coating resp. material has sufficient contact to ground.
The filter unit as described above can be utilized as a dust separator e.g. on top of a silo. In this case the refeed of the separated and probably highly charged dust has to be assessed carefully in terms of a possible cone discharge in the silo if applicable.

3. Properties of the dusts handled

The combustible dusts aspirated from the dust filter unit are thermally resistant up to 120 °C, they are not subject to self-heating or self-igniting processes, they do not show thermic decomposition and do not deflagrate (according to the respective testing standards).
The minimum ignition energy of the dusts handled normally is more than 3 mJ, but it cannot be excluded, that in single cases dusts with minimum ignition energies below 3 mJ will be present.
The median value of the dusts normally does not exceed 300 µm.
In the plant no flammable liquids are handled including cleaning operations.

4. Explosive Mixtures - Zoning

Because of the open handling of the dusts inside the whole system of hoses, piping, and the raw gas side (upstream flow before entering the filter elements) in the housing of the filter unit explosive mixtures of dust in air can occur occasionally. So, this continuous gas phase is determined as a hazardous area zone 21. (The dedusting operation will not lead to zone 20 conditions, i.e. a continuous or frequently occurring explosive mixture of combustible dust in air, because the dedusting cycle is accordingly long and not every air jet will lead to an explosive atmosphere).
The clean side is not determined as a hazardous area, when this area is inspected regularly concerning layers of fines which have passed the filter elements and if applicable these layers are removed, and the filter media will not tend to a spontaneous malfunction which cannot be foreseen. Spontaneous malfunction of robust systems can be avoided by means of preventative maintenance and repair.
Outside the housing no hazardous area is determined either, because the filter unit is accordingly tight and there are no foreign sources which can provide explosive mixtures of dust in air.

5. Ignition Sources

Inside the dust-loaded area of the housing ignition sources others than those caused by electrostatic charging processes have not to be taken into account because the lack of e.g. hot surfaces which can start an ignition of a dust cloud or a dust layer or installation leading to a relevant input of energy into the system. Mechanical sparks of e.g. foreign parts which have been sucked in do not have enough kinetic energy because their size/mass is limited by the sieves in the suction nozzles.
In the concerned area the following electrostatic ignition sources are assessed:

5.1 Brush Discharges

Brush discharges can come from charged non-conductive surfaces or dust clouds. According to the IEC 60079-32-1 Electrostatic Hazards (2013) and the German guidelines on the avoidance of ignition hazards due to static electricity TRBS 2153 (2009) they cannot ignite explosive mixtures of combustible dust in air. So have not to be taken into account.

5.2 Propagating Brush Discharges

Propagating brush discharges can come from highly charged non-conductive foils/coatings or baking-on situated on conductive (metal) surfaces. In the housing including the filter elements this scenario is not existent because the thickness of the non-conductive coatings is too high or the breakdown voltage is too low (filter media), see e.g. IEC 60079-32-1.

5.3 Cone and Lightning like Discharges

The physical dimensions of the housing are too small (diameter ≤ 1 m) for the occurrence of cone discharges. A mathematical estimation of the equivalent energy of a potential cone discharge acc. IEC 60078-32-1 shows a value below 1 mJ which is lower than the minimum ignition energies of the handled dusts. Lightning like discharges cannot occur either because the volume of the housing is far below 100 m^3, see e.g. TRBS 2153.

5.4 Spark Discharges

Independent of the type of filter element it has to be hindered, e.g. by means of the sieves in the suction nozzles, that conductive parts are sucked in which can lead to spark discharges, which can ignite explosive mixtures of dust in air even those of very low minimum ignition energies. A mathematical estimation of the energy stored on such a small conductive part shows that - provided that the maximum Voltage the small part can keep will not exceed 20 kV - the maximum capacitance must be below about 5 to 10 pF.

6. Explosion Prevention and Protection Concept

The explosion prevention and protection concept consists in avoiding effective ignition sources according to the determined zone.

7. Assessment of the Filter Elements

As far as the other ignition sources including electrostatic brush, propagating brush, cone, and lightning like discharges have been examined here only electrostatic spark discharges have to be assessed, which are related to the special properties of the four types of filter elements. To avoid spark discharges all conductive (metal) parts must be grounded properly and long-lasting. Generally, to achieve a safe and proper operation of the filter elements it is necessary to check the filter elements before mounting in terms of integrity especially bonding, and after mounting for proper grounding, and inspect the filter elements periodically during their lifetime on-site.

7.1 Hoses and Pockets

The main problem concerning the hoses is the long-lasting proper grounding of the conductive cages, because the mechanical stress caused by the swinging due to the dedusting process together with the size and structure of the elements often leads to damage of the fixation. Although there are many types of fixations only a few are suitable. In addition the grounding is concerned in the same way, because normal screws will loosen and normal wires will break. Other details which can lead to the loss of grounding are: Use of split cages with unfavourable connections, use of cages with loose (not welded) bottom plates, use of cages without rigid top plate (grounding can fail because of infiltration of dust at the top isolating the hole cage). Concerning the filter media non-conductive hoses equipped with grounding litz wires often are not inserted properly, so that the (additional?) grounding path is ineffective. “Conductive” hoses must be checked/tested before use, because e.g. incorporated metal particles can segregate and so called isolated “conductive islands” can be formed leading to spark discharges or to smouldering fires. Interwoven conductive threads may have no electric contact to each other, see figure 6. A safe and proper grounding and fixation of the cage can be achieved using a bayonet mount on the clean side.

7.2 Cartridges

The cartridges are less critical compared to the hoses, because the construction is much more robust. Bonding problems occur when the electric contact between the conductive parts (bottom, perforated cylindrical sheet, and the top) is missing due to a fault during manufacturing when the hot-melt adhesive isolates the metal parts. Often the electric contact between the metal pin and the surface of the conductive coating is poor or not given. A check of each cartridge before use is necessary.
Another problem can occur when the fixation and grounding and bonding of the cartridge are carried out on the raw gas side inside the filter housing because normal nuts and bolts can loosen, see figure 7.

Figure 6: Isolated conductive threads

Figure 7: Cartridges - Mount on the raw gas side

So self-locking screws must be used.

7.3 Panels

Bonding problems with panels can occur, when the Panels contain reinforcement devices which are not in contact with grounding litz wires.

7.4 Cassettes

As with the other types of filter media the bonding of the conductive parts must be checked. Each metal separator of each cassette to be used must be checked before mounting. This can easily be done with a normal multimeter.

8. Conclusions

Cassettes, cartridges, and panels can be used as filter elements in dust filter units as described, when the conditions given in the assessment are fulfilled, especially the check of each filter element in terms of potential electrostatic ignition sources before mounting, the grounding check after mounting, and a periodic inspection on-site. This holds even for plants where the handling of dusts which are very sensitive to ignition cannot be excluded.

Hoses and pockets are less suitable because of their lesser robustness against the mechanical stress during operation, especially the checks on-site can hardly be performed reliably, because the crucial parts (cage, fixation) are hidden respectively difficult to access, e.g. in filter units with a large number of filter elements.

However, the avoidance of ignition sources as the sole measure of explosion prevention and protection requires a detailed assessment of all concerned details. This holds especially for potential electrostatic ignition sources.

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