

# Electrostatic Ignition Hazards Associated with Dissipative Dust Filters

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**Abstract.** In present guidelines and codes of practice it is strongly recommended to use dissipative filter media in dust separators, if the minimum ignition energy of the powder is below 3 mJ and/or a hybrid mixture may be present. Despite being in compliance with this rule and despite the filter media passed the relevant tests, burnt product was found in a dust separator of pharmaceutical production. Extensive investigations have shown that the demands made in the present standards on dissipative filter clothes are not sufficient to prevent ignition of deposited powder and ignition of an explosive atmosphere. Proposals for additional tests and requirements are presented in the paper.

## 1. Introduction

In the relevant guidelines to avoid ignition hazards due to static electricity TRBS 2153 [1] and IEC/TS 60079-32-1 [2] the use of dissipative filter media is strongly recommended in dust separators, as soon as the minimum ignition energy of the powder is below 3 mJ and/or hybrid mixtures cannot be excluded. The dissipative properties of textile filter media are usually determined according to the standard DIN 54345-5 [3]. Sometimes the measurements are also performed according to the standard DIN EN 1149-Part 1 [4] though this standard is really intended for personal protective clothing.

Despite being in compliance with the present guidelines and despite the filter media installed in the dust separator passed the relevant tests, burnt product was found in a dust separator used in pharmaceutical production. The product being processed had a high resistivity of more than  $10^{13} \Omega \cdot m$  and low minimum ignition energy of less than 3 mJ. Solvent vapors or hybrid mixtures have not been present. Extensive investigations outlined in the following have shown that the demands made in the present standards on dissipative filter clothes are not sufficient to prevent ignition of deposited powder and/or ignition of an explosive atmosphere in dust separators.

## 2. Investigations and results

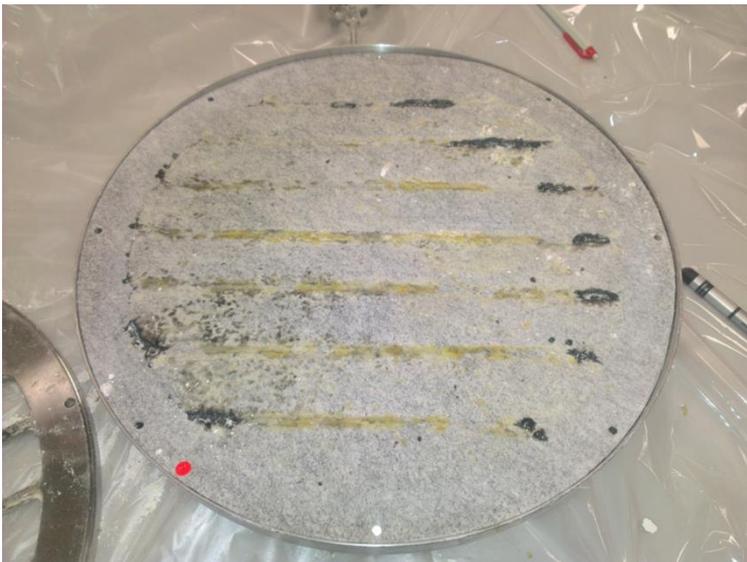
In DIN 54345-5 [3] the resistance between two metal electrodes of length 50 mm and variable distance between 10 and 300 mm put on top of the textile filter media is measured. In DIN EN 1149-Part 1 [4] the resistance between to concentric circular electrodes with a gap of about 10 mm put on top of the textile filter media is measured. In both cases the homogeneity of electrical conduction through the whole filter media with a large contact surface of the electrodes with the filter media is determined. Most dissipative or conductive filter media are made dissipative or conductive by incorporation of very thin metal or carbon loaded filaments. Due to the large contact area of the electrodes in the test arrangements the electrical current between the electrodes flows along a huge number of conductive filaments as explained above. Thus, the electric current flowing through one single filament remains



rather moderate, particularly if a voltage of 100 V is applied as recommended in the standards. In practice the current is accumulated all over the area of the filter cloth and flows to earth through the contact points with earth. Depending on the geometry and installation of the filter cloth the contact area with earth may be small. Particularly if the filter is purged the filter cloth may become detached from the supporting earthed metal grid and the contact area with earth may become very small. Exactly at this moment the current density all over the filter area will be highest due to the separation process between powder particles and filter cloth surface.

Based on new investigations [5] the charging current density due to contact and separation of powder particles in pneumatic transfer systems and dust separators may reach  $1 \text{ mA/m}^2$ . Thus, from a filter cloth area of  $0.1 \text{ m}^2$  a total current of  $100 \text{ }\mu\text{A}$  has to be discharged to earth.

If in a filter assembly the charging current generated over the whole surface is lead to earth through a few small contact points, a high current will flow through a few very thin conductive filaments. Under these conditions the thin conductive filter filaments may start to glow. This phenomenon was observed in a dust separator in pharmaceutical production. Fortunately this phenomenon was observed before leading to a dust explosion. The resulting scorch marks on the filter cloth are shown in figure 1. The scorch marks are exactly in the region, where the filter cloth was in contact with the supporting earthed structure of the filter housing.



**Figure 1.** Scorch marks on the filter cloth of a dissipative filter material from a dust separator in pharmaceutical production

In further investigations, the filter media were earthed at the rim and contacted at different locations on the surface with the pointed electrode of a megohmmeter. Immediately after the contact the filter medium surface began to glow at the contact point with the pointed electrode. In addition glowing was observed at the earthing contact, which was achieved with an alligator clip. With an applied voltage of 1000 V the total electrical current flowing from the megohmmeter to the earthing alligator clip was typically between  $70 \text{ }\mu\text{A}$  and  $100 \text{ }\mu\text{A}$ . Photographs of this experiment are shown in figures 2 and 3. In case the pointed electrode was slid across the surface a luminous tracer could be observed, which left behind a trace with burnt surface spots. Several video clips showing such luminous tracers have been recorded.



**Figure 2.** Glowing spot on the filter medium when contacted by the pointed electrode of a megohmmeter.



**Figure 3.** Zoomed in region of figure 2 with the glowing spot. The glowing spot around the earthing contact at the location of the alligator clip becomes also visible.

Since already at moderate electrical currents of  $70 \mu\text{A}$  to  $100 \mu\text{A}$  such glowing spots have been observed and former experiments [5] have shown that such currents are realistic in dust separators, the hypothesis, that the total electrical current integrated over the whole area of the filter cloth during the separation process between the powder and the filter cloth surface has been responsible for the scorch marks on the filter cloth as shown in figure 1, was strongly supported.

In additional experiments it was shown, that neither glowing spots nor traces of burnt material could be observed, if the electrical current in the circuit with the megohmmeter was below  $30 \mu\text{A}$ .

### 3. Proposal for additional tests

To prevent phenomena as described above the density and interconnection of the conductive filaments in filter media must be increased and improved.

In order to identify and prevent the phenomena described in this paper the following tests have proven to be very useful and reliable in addition to a measurement of the surface resistance or surface resistivity according to the standards mentioned above:

The filter cloth is laid on an insulating surface. An alligator clip is fixed to the rim of the filter cloth. The alligator clip is connected via a  $\mu\text{A}$ -meter to the earth port of a megohmmeter. A test tip is connected to voltage port of the megohmmeter. The measuring voltage is set to  $1000 \text{ V}$ . An electrical contact between the test tip and the filter cloth surface is applied at 5 different locations. In addition the test tip is slid across the surface of the filter cloth. These measurements are repeated with 4 different earthing points.

The tests must be performed in the dark and the following observations and measurements must be made:

- Occurrence of glowing spots at the test tip
- Occurrence of glowing spots at the earthing clip
- Measurement of the electrical current

Based on the observations and measurements listed above the following two different safe kinds of filter media construction types have to be distinguished:

1. The surface resistance or surface resistivity of the dissipative filaments in the filter medium is rather high. The surface resistance or surface resistivity meets however the requirements specified in the relevant guidelines [1, 2]. In this case the electrical current stays rather low - also in case of a very local contact of the earthing point. In this case all of the following requirements must be met:
  - a) The surface resistance is below  $10^8 \Omega$ .
  - b) No glowing spots are observed at the test tip. The very weak spark, which may occur due to the contact of the test tip at 1000 V and the dissipative structure of the filter medium, is tolerated.
  - c) No glowing spots are observed at the earthing clip.
  - d) The current stays below 20  $\mu\text{A}$ .
  
2. The resistance of the dissipative filaments in the filter medium is rather low. The density of the dissipative filaments in the filter medium is rather high or the conductive cross section of the dissipative filaments is sufficiently high that also in case of a punctual contact now glowing of a single filament occurs. In this case all of the following requirements must be met:
  - a) The surface resistance is below  $10^8 \Omega$ .
  - b) No glowing spots are observed at the test tip. The very weak spark, which may occur due to the contact of the test tip at 1000 V and the dissipative structure of the filter medium, is tolerated.
  - c) No glowing spots are observed at the earthing clip.
  - d) The current is not relevant.

Note: If it would only be stated that the resistance to earth from any point on the filter material shall be less than  $10^6 \Omega$  as mentioned in IEC/TS 60079-32-1 [2], sub-clause 13.2.2 - where it is explained that if the charging current is 100  $\mu\text{A}$  or higher, the resistance to earth should be less than  $10^6 \Omega$  - glowing filter filaments could still occur, since already one or a few very thin metallic filter filaments will accomplish a resistance below  $10^6 \Omega$  but may start to glow at a current of 100  $\mu\text{A}$  or higher.

Though the tests described in this paper may appear to be rather empirical lacking any quantitative scientific background they have proven to be very useful and applicable to many different kinds of filter clothes and - most important - filter clothes, which have passed these tests, no longer provoked burned product.

#### 4. References

- [1] TRBS 2153 Technische Regel Betriebssicherheit 2153 „Vermeidung von Zündgefahren infolge elektrostatischer Aufladungen“, Germany, June 2009.
- [2] IEC/TS 60079-32-1, Technical Specification EXPLOSIVE ATMOSPHERES – Part 32-1: Electrostatic hazards, Guidance, Edition 1.0, 2013-08.
- [3] DIN 54345-5 Elektrostatisches Verhalten: Bestimmung des elektrischen Widerstandes von Streifen aus textilen Flächengebilden (Juli 1985).
- [4] DIN EN 1149-Part 1 Schutzkleidung - Prüfverfahren für die Messung des Oberflächenwiderstandes.
- [5] Fath W, Blum C, Glor M and Walther C D *Journal of Electrostatics* **71** 377-382.