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REPORT

Declaration for safe use of Filcoflex flexible connections of types PU-UF1 and PU-UF3 in areas containing explosive dust air mixtures

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INBUREX Consulting
Gesellschaft für
Explosionsschutz und
Anlagensicherheit mbH
August-Thyssen-Str. 1
D-59067 Hamm

Phone: +49 (0) 23 81 27 16 10
Fax: +49 (0) 23 81 27 16 20
E-mail: infos@inburex.com
Internet: www.inburex.com

Geschäftsführer:
Dr. Bernd Broeckmann
Dr. Klaus Hermann
Dipl.-Ing. (FH) Jörg Meistes
Sitz der Gesellschaft: Hamm
Amtsgericht Hamm HRB 1523

1 General Information

Report No.	EX/11590/17
Classification	Confidential
Title	Declaration for safe use of Filcoflex flexible connections of types PU-UF1 and PU-UF3 in areas containing explosive dust air mixtures
Author	Gerard van Laar, M. Sc.
Summary	In this report the safe application of certain types of flexible joints manufactured by Filcoflex inside dust hazardous areas and containing explosive dust mixtures, has been assessed. The materials PU-UF1 and PU-UF3 can be safely used in relation to static hazards for flexibles with maximum length of 1000 mm of pure flexible inside dust hazardous environments containing dust mixtures with dusts with minimum ignition energies larger than 1 mJ. They shall not be used in case of flammable gases and vapors.
Client	Filcoflex BV Veerweg 19 5171 PW Kaatsheuvel The Netherlands
Contact Person	Werner van Loon Tel +31 (0) 416 764 764 Email: werner@filcoflex.com
Contractor	INBUREX GmbH, Hamm
Section	Brand- und Explosionsschutz
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Signatures	

Gerard van Laar, M. Sc.
Senior Consulting Scientist

Dipl.-Ing. (FH) Jörg Meistes
Managing Director

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1. Introduction

Flexible connections are often used in the process industry for transport of powders and granules. In the transport through those flexible connections static charging may occur that under certain conditions may lead to hazardous static discharges. Those discharges might lead to ignition of potential explosive mixtures both in and outside the flexible and thus lead to dust explosions.

This document describes the potential ignition risks due to flexible connections and assesses whether the Filcoflex flexibles using PU-UF1 and PU-UF3 materials can be safely used inside hazardous dust areas containing explosive dust air mixtures.

2 Hazards when using flexibles

When product flows through flexibles, both the product and the flexibles might become charged electrostatically. The charge on the flexibles when they are ***not conductive or not static dissipative*** will tend to accumulate on the flexibles. At a certain point the field strength on the flexibles can become so high that spontaneous electrostatic discharges occur:

- Corona discharges which are ***not hazardous*** for dusty products.

- Brush discharges which are ***not hazardous*** for dusty products as long as we are dealing with pure dusts with MIE>1 mJ (minimum ignition measured without induction).

- Propagating brush discharges in case of extreme charging. Because of the internal charging due to product transfer the outside of the flexible might also become charged by counter charge: bipolar charge. This means that at the inside e.g. the charge has become -20 kV but at the outer side +20 kV. If the potential difference becomes higher than the break down voltage of the flexible material, finally a so-called propagating brush discharge can develop. Such discharges can reach 1 J and thus are ***hazardous*** for most dusty and combustible products.

- Flexibles in general are not conductive, so cannot lead to spark discharges.

Note, that when the flexibles charge they also cause an electrostatic field radiating to the outside. This charge may affect non-grounded conductive objects by charging through influention.

In standard EN 13463-1 for non-electrical equipment for use in potentially explosive atmospheres the use of plastic materials is in fact not limited in size or surface except if propagating brush discharges are possible. Then additional demands for the materials are necessary.

With regard to TRBS 2153, respectively IEC 60079-32-1, materials or objects can be classified:

- According to their **surface resistance** at test conditions of 23 (±2)°C and 25 (±5)% relative humidity as ***conductive*** (<10^4 Ohm), as ***dissipative*** (10^4 Ohm up to 10^{11}Ohm) or as ***insulating*** (>10^{11} Ohm).
- According to their **volume resistance** at test conditions of 23 (±2)°C and 25 (±5)% relative humidity as ***conductive*** (<10^4 Ohmm), as ***dissipative*** (10^4 Ohmm up to 10^9 Ohmm) or as ***insulating*** (>10^9 Ohmm).

So, summarizing, insulating or dissipative flexibles only may become a hazard when very high charging occurs that under certain conditions may lead to *propagating brush discharges*.

Such high charging can generated easily by pneumatic transport but also can be expected in metal chutes with flexibles where product falls through at high flow rates (more than 2 m/s) e.g. at emptying big bags, in longer chutes after blenders which are emptied etc.

In pneumatic transport the minimum length of a flexible at which charge levels become so high that propagating brush discharges can be triggered can be as small as 100 mm for extreme cases, but in general will be more than 300 mm.

Regarding chutes there is some expert discussion about the minimum height at which the charging levels can become so high that propagating brush discharges can be generated, but at the moment is regarded as a minimum height of 3 m.

In flexibles used for sieves in general these flow rates are not very high since the fall height is small and also less charging expected.

The diameter of flexibles is hardly influencing static charging levels on the flexible materials since the speed and mass flow rates influence charging of the flexible.

When using conductive or dissipative flexibles ***in all cases*** ignition sources by static charging is prevented, provided that all those parts are earthed well.

When inside the flexible ***non-earthed*** metal reinforcement rings are imbedded, these rings may charge in case of transport through those flexibles and may lead to spark discharges breaking through the flexible material. The potential energy of those rings will depend upon the ring diameter and built-up voltage: in practice a ring with diameter of 200 mm may create sparks with estimated potential energy of less than 5 mJ assuming the voltage is 30 kV. This energy level will increase proportional with its diameter.

When using plastic reinforcement rings, only brush discharges are expected.

3 ATEX114 and flexible connections

Since flexible connections do not contain an inherent energy source or contain moving parts, they do ***not*** fall under ATEX114 and thus need no certificate when used inside zoned area. Of course in the same way as e.g. in simple piping they still can lead to ignition sources when used in a process, due the flowing product when e.g. parts are not grounded well or non-conductive parts are used etc.

In the case here the flexibles may give rise to corona, brush and propagating brush discharges when non-conductive or dissipative but only in combination with the product flowing through it. In case of imbedded non-earthed metal reinforcement rings, also sparking can be expected.
Such cases fall under the Machine Directive and a manufacturer shall indicate that their product is safe for its expected use e.g. by a test report that the material used is conductive or dissipative.

4 Can Filcoflex type PU-UF1 and PU-UF3 be used safely inside dust explosion hazardous areas?

4.1 Description of Filcoflex flexibles of type PU-UF1 and PU-UF3

The flexible connections are made out of poly-urethane based flexible materials. The several connecting PU parts are plastic welded to ensure a high strength. The thickness of the flexible is 1 mm. The materials PU-UF1 and PU-UF3 are tested and approved for direct contact with food and drugs following all European guidelines and FDA.

The PU material has been tested for conductive properties and also has been tested whether possible propagating brush discharges are possible. The results are given in the following table.

Product	**Surface resistance (DIN EN 1149-1) (Ω)**	**Volume resistance (DIN EN 1149-2) (Ωm)**	**Propagating brush discharges possible?**
PU-UF1	$5\ 10^{12}$	$3\ 10^{11}$	No
PU-UF3	$2\ 10^{12}$	$2\ 10^{11}$	No

Note that propagating brush discharge testing has been done on a sheet sample of 200x200 mm, 300x300 mm and finally 465x465 mm, using test voltages up to 70 kV. In all cases no propagating brush discharges could be triggered.

From the data of the table it can be concluded that the material as such is not conductive and not dissipative, but that it was impossible to create propagating brush discharges, even at extreme high charging levels during the testing.

High charging, however, may lead to corona and brush discharges. Only for combustible dusts with minimum ignition energy of less than 1 mJ, flammable vapours and gases brush discharges might be a hazard.

Finally the ready product using PU-UF1 or PU-UF3 as flexible material for the connection types FSC, FDM and KLB25 have been tested under real explosion conditions to find out at what maximum explosion pressure the flexibles still can be applied. It turns out that the flexibles can withstand up to 1.5 barg under real explosion conditions.

4.2 Can Filcoflex flexibles using type PU-UF1 and PU-UF3 materials be used safely inside dust explosion hazardous areas?

At the testing it was impossible under the given conditions to create the hazardous propagating brush discharges even at dimensions as large as 465x465 mm. When extrapolating the found results propagating brush discharges also are not expected at larger dimensions of the flexibles e.g. flexibles with diameter of 1 m and/or length of 1 m. Also other types of static discharges are not deemed to be harmful. This means that at and inside this type of flexible no hazardous static discharges are expected and thus these types of materials can be safely used for the flexibles inside dust explosion hazardous atmospheres and containing explosive mixtures. Of course when using metal reinforcement rings these rings shall be earthed well.

These materials can be applied for all dusty combustible products with a minimum ignition energy of more than 1 mJ.

In case of environments where flammable gases and vapors are possible, these materials shall not be applied.

5 Documentation

Documentation used:

(1)	Test report WJI TL5808/10 and EX/5303, 26th. October 2010. Tests of different types of flexible connector systems under real conditions for Filcoflex B.V., Kaatsheuvel, The Netherlands.
(2)	Test reports WJI, No. -1 and -3, TL5488/10, 10th. April 2012. Determination of the safety characteristics of PU-UF1 and PU-UF3 (1 mm) for Filcoflex B.V., Kaatsheuvel, The Netherlands.
(3)	Test reports WJI, TL11590/17, 9 May 2017. Determination of the safety characteristics of PU-UF1 and PU-UF3 (1 mm) for Filcoflex B.V., Kaatsheuvel, The Netherlands.
(4)	Filcoflex Product catalogue 2014
(5)	IEC/TS 60079-32-1 Ed. 1.0: 2013-08. Technical Specification. Explosive atmospheres Part 32-1: Electrostatic hazards, guidance.
(6)	ATEX 114: Directive 2014/34/EU of the European Parliament and the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to Equipment and Protective Systems intended for use in Potentially Explosive Atmospheres (recast).
(7)	ATEX 2014/34/EU Guidelines: Guide to application of the directive 2014/34/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the law of the Member States relating to Equipment and Protective systems intended for use in Potentially Explosive Atmospheres, April 2016.
(8)	EN 13463-1: Non-electrical equipment for use in potentially explosive atmospheres - Part 1: Basic method and requirements, 2009.