Report
IB-18-8-0083/2
about non-standard BFM® connectors
for use in potentially explosive atmospheres

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1. Order

1.1	Customer:	BFM Global Limited, NZ-0749 Beach Haven, Auckland, New Zealand
1.2	Purchase order:	No. 300938 of 09.11.2018
1.3	Supplier:	IBExU Institut für Sicherheitstechnik GmbH, Freiberg, Germany

2. Origination, test procedure

The Test Report IB-18-8-0083/1 [1] describes the electrostatic testing of 4 BFM® standard connectors (Seeflex 060ES, LM3, Teflex and Teflex NP) and includes a summary of the test results for 4 other BFM® standard connectors (Seeflex 020E, Seeflex 040E, Seeflex 040AS and LM4), which have already been tested within the scope of individual reports. The test report IB-18-8-0083/1 [1] includes also the conclusions for the use of these BFM® standard connectors in explosive atmospheres, including an evaluation according to the current regulations / standards.
The testing and evaluation of the explosion protection aspects of various non-standard BFM® connectors have been carried out and documented in the Reports IB-16-8-071/1 [2] and IB-17-8-0027/1 [3]. The report at hand summarizes the relevant test results of these non-standard BFM® connectors and assesses them according to the current regulations / standards. The new BFM® standard connectors examined in [1] are included as well.

3. Assessment of the non-standard BFM® connectors

3.1 BFM® connectors with stainless steel rings embedded in the material

3.1.1 Design / geometry of the stainless steel rings

The BFM® connectors Seeflex 020E, Seeflex 040E, Seeflex 040AS, LM3, LM4 and Teflex can be equipped with stainless steel rings. These rings are completely embedded in the respective plastic material (see picture 1). There can be 1 to 10 rings in different dimensions and different spaces between the rings for BFM® connectors with diameters up to 500 mm.

Picture 1: BFM® connector with stainless steel ring

Each stainless steel ring represents an insulated electrical capacitance. Because these stainless steel rings are located in the free space between the connection points on the BFM® connectors, it can be assumed that the stainless steel rings have a lower electrical capacitance than the spring steel rings located at the ends (assumption: same area dimensions of the stainless steel rings and spring steel rings). However, due to the greater distance of the stainless steel rings from the clamping location of the BFM® connectors, any existing charges can worse dissipate to earth via the respective plastic material.

The following assessments of the usability of stainless steel rings apply to the following geometric dimensions / conditions:

- Dimension H (see picture 1) of the stainless steel rings should be limited as follows:
  - Diameter of BFM® connectors: < 200 mm: → H ≤ 25 mm
  - Diameter of BFM® connectors: ≥ 200 mm - ≤ 500 mm: → H ≤ 12.5 mm
- The distance between the individual stainless steel rings must be so large that the stainless steel rings cannot touch each other.

3.1.2 Use of the stainless steel rings in dust-explosion-hazardous areas

As long as the stainless steel rings of the non breathable materials Seeflex 020E, Seeflex 040E and Seeflex 040AS are permanently completely embedded in the respective plastic materials, they do not pose any hazard in the case of explosive dusts. In practice, however, it must be made sure that the plastic layer around the stainless steel ring is not worn to such an extent that the stainless steel ring is completely or partially uncovered. If this cannot be made sure, the above-mentioned Seeflex-BFM® connectors should only be used for dusts with Minimum Ignition Energy > 10 mJ (valid for diameters up to 500 mm).
For the breathable materials LM3, LM4 and Teflex, the stainless steel rings should only be used for dusts with Minimum Ignition Energy > 10 mJ, because the porosity of the materials allows electrostatic charging and spark discharge at the stainless steel rings.
The criteria mentioned apply both to *not* strongly charge-generating processes and strongly charge-generating processes. In the case of strongly charge-generating processes (here especially: pneumatic transport and free fall > 3 m), the restrictions of use for the respective BFM® standard connectors mentioned in [1] must always be considered.

3.1.3 Use of the stainless steel rings in gas-explosion-hazardous areas and for hybrid mixtures

The following assessment results for internal and / or external gas-explosion-hazardous atmospheres and hybrid mixtures:

- - Zone 1 or 0: in general, use of stainless steel rings is not permitted

- Zone 2 without strongly charge-generating processes:
  - o Stainless steel rings are permitted for Seeflex 020E, Seeflex 040E and Seeflex 040AS; The plastic material layer around the stainless steel must not be worn to such an extent that the stainless steel ring is completely or partially uncovered.
  - o Use of stainless steel rings is not permitted for LM3, LM4 and Teflex
- Zone 2 with strongly charge-generating processes:
  in general, use of stainless steel rings is not permitted

3.2 BFM® connectors with plastic rings (nylon rods) embedded in the material

The plastic rings (nylon rods) of BFM® connectors are completely embedded in the respective plastic materials (see picture 2). There can be 1 to 10 rings in different dimensions and different spaces between the rings for BFM® connectors with diameters up to 1000 mm.

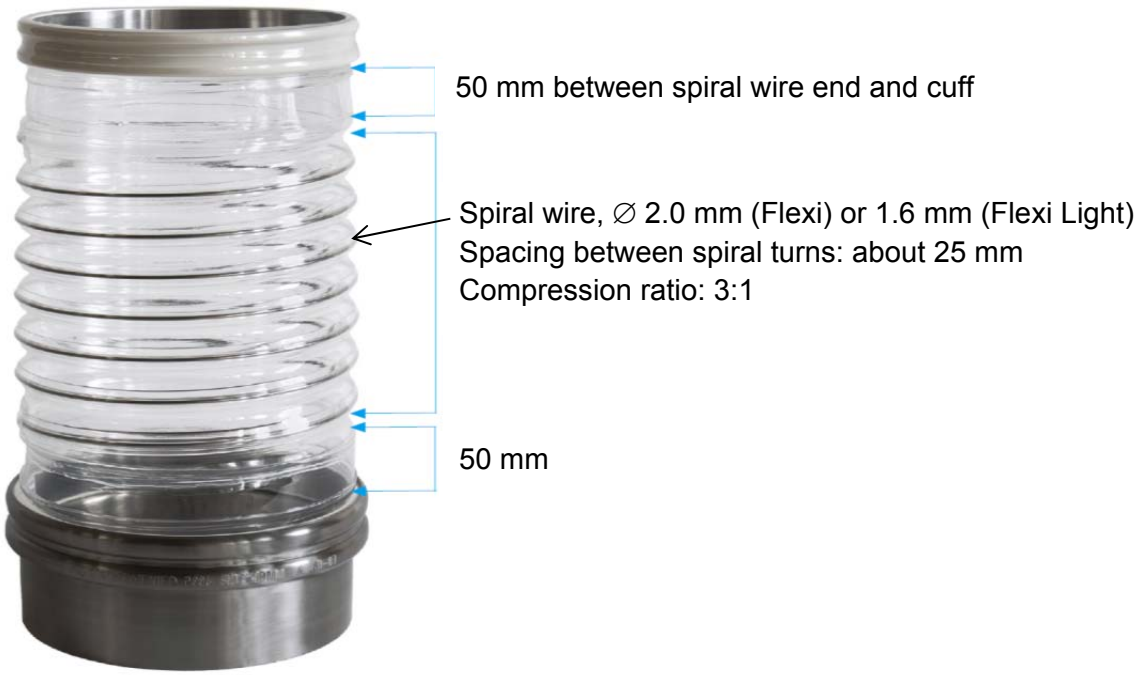
Picture 2: BFM® connector with plastic ring

Assessment: Nylon is usually electrically insulating and it therefore does not represent an electrical capacitance. Since the plastic rings are completely surrounded by Seeflex, LM3, LM4 or Teflex material, their resistance is not relevant. This means that there are no restrictions for use for these plastic rings.

3.3 BFM® Flexi- and Flexi Earthed-Connectors with spiral wire embedded in the material

3.3.1 Design of the BFM® Flexi- and Flexi Earthed-Connectors

The BFM® Flexi-Connector is provided with a thin spiral wire (corrosion-resistant steel) which is completely embedded in the plastic material (see picture 3). The plastic material consists of ether-based thermoplastic polyurethane and has a wall thickness of 0.6 mm (for diameters of 100-200 mm) or 0.7 mm (for diameters of 250-300 mm) [4] (variant Flexi Light with 0.4 mm wall thickness [5]). The wire length can vary and the diameter of the BFM® Flexi Connector is up to 300 mm. The spiral wire can be provided without (Flexi / Flexi Light) or with (Flexi-Earthed) earthing connections.



Picture 3: BFM® Flexi-Connector with spiral wire

3.3.2 Assessment of the BFM® Flexi Earthed-Connectors

In the case of BFM® Flexi Earthed-Connectors, the earthing connections on the two end points must be earthed (e.g. connection to the upstream and downstream BFM spigot, which effects potential bonding between the upstream and downstream apparatus). In this

case, there are no restrictions for use with regard to the spiral wire. The use of BFM® Flexi Earthed-Connectors is then restricted only by the plastic material, which is identical to the Seeflex 020E or Seeflex 040E BFM® connectors [1].

3.3.3 Assessment of BFM® Flexi-Connectors (+ Flexi Light)

Within the scope of the Report IB-17-8-0027/1 [3], the electrical capacitance of the spiral wires of 1 m long BFM® Flexi- / Flexi-Earthed Connectors with diameters of 100 mm, 200 mm and 300 mm has been measured. In addition, the leakage resistance between the spiral wire and the BFM spigot has been tested.
Without earthing of the spiral wire, the leakage resistance of the spiral wire is in the range of 10^{12} Ω [3]. The spiral wire thus represents an electrically insulated capacitance for the BFM® Flexi and Flexi Light Connectors, which can discharge by spark discharges.
According to the electrical capacitances measured in [3] and the estimated possible charging energies of the spiral wires, the following assessment of the use of the BFM® Flexi- and Flexi Light-Connectors results according to the current regulations / standards:

a) Dust explosion hazard at *not strongly charge-generating p*rocesses (free fall with hose lengths up to 3 m): Use is permitted with the following restrictions:
   - Hose length up to 1 m: Minimum Ignition Energy of the dust > 10 mJ
   - Hose length > 1 m up to 3 m: Minimum Ignition Energy of the dust > 30 mJ

   (Minimum Ignition Energy values are valid for BFM® connectors with diameters up to 300 mm)

b) Dust explosion hazard at *strongly charge-generating p*rocesses (pneumatic transport or free fall with hose lengths > 3 m): Use is only possible, if the following 3 conditions are fulfilled at the same time:
   - Max. length of the BFM® Flexi-Connector is 20 cm
   - No transport of dusts with high (> 10^{10} Ω·m) resistivity
   - No use of very dry transport air with rel. humidity < 25 %

c) Gas explosion hazard: use is not permitted

3.4 Kevlar cover over the BFM® standard connectors

For enclosing with woven Kevlar [6], the assessment in [2] remains valid:
Kevlar (aromatic polyamide: aramide) is an electrically insulating material. From a safety-related point of view, there are no restrictions for the use of Kevlar as a cover in explosive dust atmospheres. However, picture 4 shows metallic rings / connectors at the two ends of the Kevlar cover. These should be earthed or included in the equipotential bonding. Otherwise, restrictions for use in external potentially explosive zones would be necessary in accordance with the respective electrical capacitance (measurements would be necessary for this purpose).

Picture 4: Kevlar cover over BFM® standard connector

For use of Kevlar covers in a gas zone outside, additional tests and measurements for chargeability / hazardous discharges at the Kevlar would be required or the maximum permissible surface area of the Kevlar covers would have to be limited according to the gas zone and explosion group as per Table 3 in [7] / Table 1a in [8].

4. Bibliography

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[2] Report IB-16-8-071/1 about modifications to BFM® Connectors in regard to a use in potentially explosive atmospheres (Bericht IB-16-8-071/1 zu Modifikationen an BFM® Verbindungen hinsichtlich des Einsatzes in explosionsgefährdeten Bereichen), IBExU Institut für Sicherheitstechnik GmbH, Freiberg, 27.07.2016

[3] Report IB-17-8-0027/1 about BFM® Flexi Connectors with spiral wire in regard to a use in potentially explosive atmospheres (Bericht IB-17-8-0027/1 zu BFM® Flexi-Verbindungen mit Spiraldraht hinsichtlich des Einsatzes in explosionsgefährdeten Bereichen), IBExU Institut für Sicherheitstechnik GmbH, Freiberg, 02.11.2017

[4] BFM Global Limited: Product spec sheet: Flexi Connector, October 2017

[5] BFM Global Limited / WALTER Gerätebau GmbH: Technisches Datenblatt: BFM® Flexi Light Verbindung, 04.09.2017

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