IBExU Institut für Sicherheitstechnik GmbH
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Test Report

IB-18-8-0083/1

about the electrostatic properties of BFM® standard connectors and their use in potentially explosive atmospheres

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Test Laboratory and Certification Body
as per IECEx-Scheme

Contents

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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

Within the scope of the Test Reports IB-10-8-058 [1], IB-12-8-052 [2], IB-13-8-029 [3], IB-13-8-085 [4], IB-15-8-038 [5] and IB-17-8-0044/1 [6], the electrostatic properties of various BFM® connectors have been determined and corresponding conclusions have been drawn regarding their use in potentially explosive atmospheres. The examinations were based on the regulations / standards in force at that time, which have now been replaced in part by new regulations / standards, e.g. TRBS 2153 [7] → TRGS 727 [8] or Technical Report CLC/TR 50404 [9] → Technical Specification IEC/TS 60079-32-1 [10] or EN 13463-1 [11] → EN ISO 80079-36 [12].

This test report provides a summary of the previous test results [1] to [6] and an assessment according to the current regulations / standards. In addition, four new BFM® connectors should be tested (see sect. 3) and assessed.

3. Testing of the new BFM® connectors Seeflex 060ES, LM3, Teflex and Teflex NP

3.1 Test samples

The BFM® connectors in standard sizes - diameter 100 to 650 mm, as special connector up to 1650 mm – are dust-tight, flexible connectors. The two ends of the connectors are each provided with a spring steel ring. These spring steel rings are completely enclosed by flexible material (see figure 1). The BFM® connectors are attached in BFM spigots with special profile.

The flexible materials of the BFM® connectors Seeflex 060ES, LM3, Teflex and PTFE are as follows:

- Seeflex 060ES: clear ether based thermoplastic polyurethane alloy with a white internal polyester scrim, pressure-resistant, thickness: 1.3 mm (± 10 %)
- LM3: white woven polypropylene, thickness: 0.5 mm
- Teflex (TFLX): dark brown pure woven Teflon PTFE, thickness: 0.5 mm
- Teflex NP (TFLX NP): black pure Teflon PTFE, thickness: 0.23 mm

The following test samples were supplied for the tests (delivered on 12.11.2018 and 26.11.2018):

a) BFM® connector 060ES: part: test sample, size: 200/600 060ES, batch: 203917, diameter: 200 mm, length: 600 mm; IBExU no.: EXel 0818/18
b) BFM® connector LM3: part: test sample, size: 200/600 LM3, batch: 203912, diameter: 200 mm, length: 600 mm; IBExU no.: EXel 0819/18
c) BFM® connector Teflex: part: test sample, size: 200/600 TFLX, batch: 203912, diameter: 200 mm, length: 600 mm; IBExU no.: EXel 0820/18
d) BFM® connector Teflex NP: part: test sample, size: 200/600 TFLX NP, batch: 203912, diameter: 200 mm, length: 600 mm; IBExU no.: EXel 0821/18
e) 2 separate test samples each of Seeflex 060ES, LM3, Teflex and Teflex NP (15 cm x 15 cm)
f) BFM spigot 304/200, material: stainless steel 304, inner diameter 200 mm

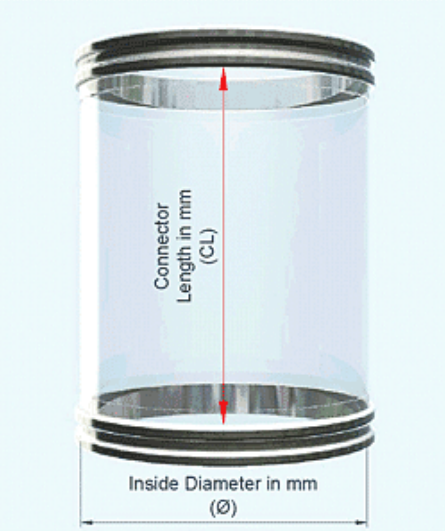

Figure 1: Illustrated BFM™ Flexible Connector below manufactured using Seeflex 040 material (Clear Urethane) (source: BFM homepage)

3.2 Measuring conditions

All measurements were carried out in a conditioned room with the following parameters:

- Test temperature: 21 - 22 °C
- Relative humidity: 25 - 26 %
- Before the tests: storage of the test samples for at least 24 hours under the specified conditions

3.3 Surface resistance

Test standards:	IEC 60093 [13], IEC 60167 [14], IEC 60079-32-2 [15]
Measuring instrument:	Tera Ohm-Meter F-H12.020 of comp. Knick Elektronische Messgeräte GmbH & Co. KG (test instrument no.: 0209)
Test electrode:	parallel electrodes acc. to [14], [15]
Electrode length l:	10 cm
Electrode distance a:	1 cm

Table 1: Measuring results at an instrument voltage of 500 V

Material	Surface resistance	Surface resistivity
Seeflex 060ES	$8.1 \cdot 10^{12}$ Ω	$8.1 \cdot 10^{13}$ Ω
LM3	$3.1 \cdot 10^{11}$ Ω	$3.1 \cdot 10^{12}$ Ω
Teflex	> 10^{14} Ω	> 10^{15} Ω
Teflex NP	$9.0 \cdot 10^{4}$ Ω	$9.0 \cdot 10^{5}$ Ω

3.4 Volume resistivity

Test standards: IEC 60093 [13], IEC 60079-32-2 [15]

Measuring instrument: Tera Ohm-Meter F-H12.020 of comp. Knick Elektronische Messgeräte GmbH & Co. KG (test instrument no.: 0209)

Test electrode: circular electrode

Electrode surface: 20 cm²

Table 2: Measuring results for the volume resistivity (instrument voltage for Teflex NP only 100 V, because greater fluctuations occurred in the read-out display at 500 V)

Material	Instrument voltage	Volume resistivity
Seeflex 060ES	500 V	$5.6 \cdot 10^{11}$ Ω·m
LM3	500 V	$1.6 \cdot 10^{10}$ Ω·m
Teflex	500 V	$4.6 \cdot 10^{13}$ Ω·m
Teflex NP	100 V	$2.4 \cdot 10^{7}$ Ω·m

3.5 Leakage resistance along the BFM® connector to the BFM spigot

Test standard: ISO 8031 [16]

Measuring instruments: Tera Ohm-Meter F-H12.020 of comp. Knick Elektronische Messgeräte GmbH & Co. KG (test instrument no.: 0209)

Insulation measuring instrument METRISO 1000D of comp. Gossen-Metrawatt (GMC-I Messtechnik GmbH) (test instrument no.: 0015)

Table 3: Measuring results for the leakage resistance

Material	Instrument voltage	Leakage resistance over a length of the BFM® connector of 600 mm
Seeflex 060ES	500 V	not determined
LM3	500 V	$> 10^{11}\ \Omega$
Teflex	500 V	not determined
Teflex NP	500 V	$3.5 \cdot 10^{4}\ \Omega$

3.6 Test for chargeability / dangerous discharges (transferred charge)

Test standard: DIN EN 60079-32-2 [15]

Measuring instrument: Coulombmeter HMG 11/02 of comp. SCHNIER Elektrostatik GmbH (test instrument no.: 0462)

Test execution:

The tests were carried out with different charging methods up to 10 times per method:

- Rubbing with a pure polyethylene cloth
- Rubbing with a cotton cloth
- Hitting with a leather glove
- Charging with a high voltage direct current source (U ≥ 30 kV)

After each charging of the test sample, the charge from a typical discharge is measured. This is done by discharging the test sample by slowly approaching a spherical electrode until a discharge occurs.

For the evaluation, the highest value from the charging methods is used [15].

The tests were performed on a separate test sample of the flexible material and with the BFM® connector in the mounting position. Because Teflex NP is not insulating, this material did not need to be tested here.

Table 4: Results of the test of a separate test sample of 15 cm x 15 cm, test sample e) or in the mounting position of the BFM® connectors ∅ 200, test samples a), b) and c),
n. d. = not determined, because not required according to the other measured values
values printed in bold type: above the upper limit value of 60 nC (see Table 7)

Material	Test sample		Transferred charge Q in nC per individual test			
			Rubbing with pure polyethylene cloth	Rubbing with cotton cloth	Hitting with leather glove	High voltage direct current source
Seeflex 060ES	e)		*n. d.*	*n. d.*	*n. d.*	**72**; **66**; **101**; 47
	a)	inside	No charges measurable	No charges measurable	0; 15; 0; 0; 0; 0; 42; 0; 0; 23	0; 0; 0; 14; 0; 0; 18; 0; 0; 0
		outside	**75**; 28; 43; 34	**103**; 49; **85**; **129**	58; 42; 13; **89**	No charges measurable
LM3	e)		No charges measurable	No charges measurable	No charges measurable	No charges measurable
	b)	inside	No charges measurable	No charges measurable	No charges measurable	No charges measurable
		outside	No charges measurable	No charges measurable	No charges measurable	No charges measurable
Teflex	e)		20; 34; 31; 29	25; 20; 39; 33	49; 48; 50; 43	35; 32; 42; 32; 39; 34; 32; 32; 41; 38
	c)	inside	*n. d.*	**74**; 29; 36; 41	*n. d.*	No charges measurable
		outside	*n. d.*	36; 49; 30; 35	56; 60; **63**; 35	*n. d.*

4. Assessment of the measuring results, conclusions

4.1 Classification of the BFM® connectors according to resistance / conductivity

The current Technical Specification IEC/TS 60079-32-1 [10] shows partially other criteria with regard to conductive / dissipative materials compared to the former Technical Report CLC/TR 50404 [9] and the German technical rules (previously: TRBS 2153 [7], current: TRGS 727 [8]) (compare Table 5 and Table 6). However, the differences are insignificant for the classification of the tested BFM® connectors Seeflex 060ES, LM3, Teflex and Teflex NP. The resistance measurements carried out within the scope of the Test Reports

IB-10-8-058 [1], IB-12-8-052 [2] and IB-13-8-085 [4] also do not result in any changes in the classification according to IEC/TS 60079-32-1 [10].

Based on the determined surface resistances and volume resistivities, The BFM® connectors are classified as follows:

- Seeflex 060ES: insulating
- LM3: insulating
- Teflex: insulating
- Teflex NP: dissipative

Table 5: Definitions according to IEC/TS 60079-32-1 [10]

Object	Material	Enclosure
Unit	Volume resistivity	Surface resistance
Conductive	$< 10^5\ \Omega{\cdot}m$	$< 10^4\ \Omega$
Dissipative	$\geq 10^5\ \Omega{\cdot}m$ to $< 10^9\ \Omega{\cdot}m$	$\geq 10^4\ \Omega$ and $< 10^{11}\ \Omega$ at (23 ± 2) °C and (25 ± 5) % r.H.
Insulating	$\geq 10^9\ \Omega{\cdot}m$	$\geq 10^{11}\ \Omega$

Table 6: Definitions according to CLC/TR 50404 [9], TRBS 2153 [7] and TRGS 727 [8]

Substance, material or object	Volume resistivity	*or*	Surface resistance
Conductive	$\leq 10^4\ \Omega{\cdot}m$		$\leq 10^4\ \Omega$
Dissipative	$> 10^4\ \Omega{\cdot}m$ to $< 10^9\ \Omega{\cdot}m$		$> 10^4\ \Omega$ and $< 10^9\ \Omega$ (at 23 °C and 50 % r.H.) *or* $> 10^4\ \Omega$ and $< 10^{11}\ \Omega$ (at 23 °C and 30 % r.H.)
Insulating (Non-conductive)	Substance or material, that is neither conductive nor dissipative		

4.2 Chargeability / Hazardous discharges

With regard to the use of BFM® connectors of insulating material for gas explosion hazards, the charges measured during the chargeability test in sect. 3.6 are relevant. The limit values of the transferred charges listed in Table 7 are applying.
The test of LM3 did not show any transferred charges. The two other insulating materials Seeflex 060ES and Teflex showed transferred charges of > 60 nC in some tests, which restricts the use of these BFM® connectors for flammable gases / vapors accordingly (see sect. 4.4).

Table 7: Permissible transferred charges depending on gas zone and explosion group [8], [10] (limit values for Zone 0 are not yet included in the former regulations [7] and [9])

Explosion Group	Permissible max. transferred charge at	
	Zone 0	Zone 1 and 2
II A (or I)	25 nC	60 nC
II B	10 nC	25 nC (former 30 nC)
II C	No measurable discharge	10 nC

The two ends / fastening points of the BFM® connectors are each provided with a spring steel ring, which is embedded in the flexible plastic material. The following conclusions can be drawn from a test for hazardous charges of the spring steel rings in the event of excessive wear of the plastic material and the measurement of the electrical capacitance of these spring steel rings in [1] and [5]:
In the case of electrically insulating BFM materials, the flexible material before the spring steel ring shall not be worn to such an extent that the spring steel ring is completely or partially uncovered. If this cannot be made sure, these BFM® connectors may not be used for flammable gases and only for dusts with a Minimum Ignition Energy > 10 mJ.

4.3 Use of BFM® connectors in hazardous dust areas

The BFM® connectors tested here and in [1] to [6] can be used without restriction in *not* strongly charge-generating processes both in Zone 20 inside and in Zone 21 outside (Note: Zone 20 is not usual on the outside). From an electrostatic point of view, there is no restriction with regard to the minimum ignition energy of the dust or dust group, because no incendive charges / discharges are possible.

For pneumatic transport (strongly charge-generating process), the leakage resistance at each point on the inner wall of the BFM® connector must be less than 100 MΩ = 10^8 Ω as required in IEC/TS 60079-32-1 [10] (measured according to ISO 8031 [16]). As the values in Table 3 in sect. 3.5 show, the Teflex NP BFM® connector with a length of 600 mm meets this condition (leakage resistance = $3.5 \cdot 10^4$ Ω). The leakage resistance increases admittedly with increasing length. But with the typical (maximum) lengths of the BFM® connectors up to 6 m, the leakage resistance of Teflex NP will certainly remain below the permissible value.

The LM3 BFM® connector has a significantly higher leakage resistance of > 10^{11} Ω over a length of 600 mm. Similar high leakage resistances are expected for Seeflex 020E and Seeflex 040E, as these two materials with $2.0 \cdot 10^{11}$ Ω [2] have a similar surface resistance as LM3 with $3.1 \cdot 10^{11}$ Ω. The resistances of Seeflex 020E and Seeflex 040E are only slightly above the limit value for a conductive material. Therefore, in [3] these BFM® connectors up to a relatively short length of 200 mm have also been approved for pneumatic transport, provided that there is no explosive gas atmosphere present. Considering the current limit value of the leakage resistance of < 10^8 Ω [10], the BFM® connectors LM3, Seeflex 020E and Seeflex 040E may only be used for pneumatic transport if the following conditions are fulfilled:

- Max. length ≤ 200 mm
- No explosive gas atmosphere is present.
- Only transport of dusts with low (< 10^6 Ω·m) or middle (< 10^{10} Ω·m) resistivity
- Avoidance of very dry transport air with rel. humidity < 25 %

The materials Seeflex 040AS and LM4 tested in [4] or [1] with surface resistances $1.6 \cdot 10^9$ Ω or $2.5 \cdot 10^{10}$ Ω are dissipative. However, even with these BFM® connectors, an exceeding of the leakage resistance of < 10^8 Ω permitted according to IEC/TS 60079-32-1 [10] can be expected after a relatively short length. For this reason, Seeflex 040AS and LM4 should only be used for pneumatic transport up to the (standard) length of the BFM® connectors of 200 mm. The simultaneous presence of flammable gases / vapours is only permitted if no dusts with a high (>10^{10} Ω·m) resistivity are transported and if very dry transport air with a relative humidity of < 25 % is avoided.
The Seeflex 060ES and Teflex BFM® connectors tested here have very high resistances and may generally not be used in strongly charge-generating processes.

Note: The pneumatic transport of bulk solids or the discharge of bulk solids (free fall) through the BFM® connectors with a drop height of more than 3 m are considered to be strongly charge-generating processes. Dedusting with a low dust concentration of typically < 1-2 g/m³ with Zone 22 or no zone or a free fall of ≤ 3 m does not represent a strongly charge-generating process [8].

For the BFM® connectors tested in [1] to [6], shorter drop heights of 1 m (Seeflex 020E [5], Seeflex 040E [3], LM4 [3]) or 2 m (Seeflex 040AS [4]) have been permitted for free fall. According to the current regulations, these BFM® connectors can now be used up to a drop height of 3 m [8]. This also applies to all BFM® connectors tested here.
The drop height of 3 m corresponds to the length of the BFM® connector, provided that above the BFM® connector there is no free fall through an insulating plastic pipe or similar. In this case, the length of the insulating plastic pipe must be subtracted from the 3 m of the BFM® connector. For free fall through an upstream, short (< 1 m), earthed metal pipe, its length does not need to be considered (higher speed of fall of dust particles in the BFM® connector, but also discharging of the particles in the wall area of the metal pipe).

4.4 Use of BFM® connectors in potentially explosive gas atmospheres and for hybride mixtures (always) without strongly charge-generating processes

The dissipative materials Seeflex 040AS, LM4 and Teflex NP can be used in all potentially explosive gas atmospheres (Zone 0, 1 and 2 inside / outside) without limiting the surface area of the BFM® connector.
The insulating LM3, for which no transferred charges could be measured (see sect. 3.6), may be used in Zones 1 and 2 without limiting the surface area of the BFM® connector.
A limitation of the surface area of the BFM® connector is required for the insulating materials Seeflex 020E, Seeflex 040E, Seeflex 060ES and Teflex, because transferred charges occurred during the tests for chargeability / hazardous discharges.
Table 8 lists the suitability / restrictions of the individual BFM® connectors. Dust explosion-hazardous zones were also included, as these partly have influence on the applicability of the BFM® connectors. For example according to sect. 3.2.1 in [8] for insulating materials, Zone 2 then requires suitable measures (in the sense of restrictions on the surface of the BFM® connectors) if experience has shown that incendive discharges occur. In sect. 6.7.5 in [11] or [12] is the following stipulated in the case that an equipment in intended use can cause frequent ignitable discharges during normal operation: the area limitations for Zone 1 are to be applied for Zone 2 and the area limitations for Zone 0 are to be applied for Zone 1. These requirements were included in Table 8 for the existing dust-explosion-hazardous Zones 20 and 21 for the following reasons:

- The frequent or occasional presence of an explosive dust atmosphere in Zones 20 or 21 also increases the risk of charging the insulating BFM materials compared with Zone 22.
- It is not known under which conditions the BFM® connectors are intended to be installed. Charges must be expected, for example, due to induction phenomena or installation close to ionizers and electrostatic spraying devices. In normal operation, such charging can possibly lead to frequent ignitable discharges.
- A hybrid mixture of combustible gas and dust results in an increased hazard.

In Table 8, no distinction was made between a gas/dust-explosion-hazardous zone inside and outside, since charging on the inner surface as a result of the dust movement general-

ly leads to a similar charging on the outer surface. However, a Zone 0 or 20 in the outer area is not usual.

In the presence of strongly charge-generating processes, the respective restrictions of use according to sect. 4.3 always apply additionally.

Table 8: Suitability / restrictions of the BFM® connectors depending on the potentially explosive zones in not strongly charge-generating processes

Gas zone inside and/or outside	Dust zone inside and/or outside	Permissible BFM surface[1] for Explosion Group		
		II A (or I)	II B	II C
Seeflex 040AS, LM3, LM4 and Teflex NP				
0, 1, 2	20, 21, 22	No restrictions [3]		
Seeflex 020E and Seeflex 040E				
0	20, 21, 22	100 cm²	50 cm² [2]	8 cm² [2]
1	20, 21	No restrictions [3]	50 cm² [2]	8 cm² [2]
	22	No restrictions [3]	200 cm²	40 cm² [2]
2	20, 21	No restrictions [3]	200 cm²	40 cm² [2]
	22	No restrictions [3]		
Seeflex 060ES and Teflex				
0	20, 21, 22	100 cm²	50 cm² [2]	8 cm² [2]
1	20, 21	100 cm²	50 cm² [2]	8 cm² [2]
	22	200 cm²	200 cm²	40 cm² [2]
2	20 oder 21	200 cm²	200 cm²	40 cm² [2]
	22	No restrictions [3]		

Annotations:

[1] Permissible projected BFM surface corresponds to the product of diameter and length [12] of the BFM® connector.

[2] BFM® connectors are not applicable, since the area criterion is already exceeded with smallest available connector (e.g.: 100 mm diameter and 80 mm length = 8000 mm² (80 cm²) projected BFM surface).

[3)] No restrictions for the surface of the BFM® connector is required due to the results of the tests for chargeability / hazardous discharges.

Notes:

- *When transporting dusts / bulk solids in the presence of flammable gases / vapours, the choice of suitable BFM® connectors can prevent ignitable discharges from the BFM® connectors, but not discharges from the transported product [8].*
- *High charges are also possible when transporting non-explosive bulk solids, which can lead to ignition of flammable gases / vapors. The requirements of Table 8 must be applied for the presence of a gas zone and non-explosive bulk solids.*

The area limitations in Table 8 derived from [8] and [10] have been doubled because the BFM® connectors are surrounded by grounded metal on two sides [17].

5. Summary

For BFM Global Limited, the electrostatic properties of 4 BFM® connectors (Seeflex 060ES, LM3, Teflex and Teflex NP) were examined and conclusions were drawn for their use in potentially explosive atmospheres.

For various previously tested BFM® connectors (Seeflex 020E, Seeflex 040E, Seeflex 040AS and LM4), a summary of the test results including the evaluation according to the current regulations / standards was also made.

The materials of these standard BFM® connectors are electrically dissipative to insulating. Accordingly, there are partly different restrictions for the usage of these BFM® connectors in potentially explosive dust or gas atmospheres or with hybrid mixtures. Teflex NP has the clearly lowest ohmic resistance values and can therefore be used for all relevant applications.

Annex 1 shows a summary overview of all BFM® connectors evaluated here including their ranges of application / restrictions of use. All data apply to BFM® connectors with diameters up to 1650 mm.

6. Bibliography

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[16] ISO 8031:2009-10: Rubber and plastics hoses and hose assemblies - Determination of electrical resistance and conductivity [DIN EN ISO 8031:2010-04: Gummi- und Kunststoffschläuche und Schlauchleitungen - Bestimmung des elektrischen Widerstands und der elektrischen Leitfähigkeit (ISO 8031:2009); Deutsche Fassung EN ISO 8031:2009]

[17] U. v. Pidoll: Bewertung der Zündfähigkeit elektrostatischer Entladungen
VII Fachtagung: Maßnahmen des Brand- und Explosionsschutzes – Mittel zur Anlagen- und Arbeitssicherheit, Merseburg, 24.09.2003

Properties of BFM® connectors (diameter up to 1650 mm) and ranges of application in hazardous zones

BFM® connector			**Seeflex 020E**	**Seeflex 040E**	**Seeflex 040AS**	**Seeflex 060ES**	**LM3**	**LM4**	**Teflex**	**Teflex NP**
Material			Ether based thermoplastic polyurethane	Ether based thermoplastic polyurethane	Ether based thermoplastic polyurethane with antistatic infusion	Ether based thermoplastic polyurethane with a polyester scrim	100% woven polypropylene	100% woven polyester	100% woven Teflon PTFE	100% Teflon PTFE
Thickness			0.35 mm	0.9 mm	0.9 mm	1.3 mm	0.5 mm	0.5 mm	0.5 mm	0.23 mm
Surface resistance [1]			$2.0 \cdot 10^{11}\ \Omega$	$2.0 \cdot 10^{11}\ \Omega$	$1.6 \cdot 10^{9}\ \Omega$	$8.1 \cdot 10^{12}\ \Omega$	$3.1 \cdot 10^{11}\ \Omega$	$2.5 \cdot 10^{10}\ \Omega$	$> 10^{14}\ \Omega$	$9.0 \cdot 10^{4}\ \Omega$
Transferred charge [2]			< 60 nC	< 60 nC	n. r. [3]	> 60 nC	No charges measurable	n. r. [3]	> 60 nC	n. r. [3]
Dust zone / Gas zone / Explosion Group [7]			Use of BFM® connectors **without** strongly charge-generating processes [4]							
20, 21, 22 (without Gas)			yes	yes	yes	yes	yes	yes	yes	yes
20, 21, 22	0	IIA o.I	100 cm² [6]	100 cm² [6]	yes	100 cm² [6]	yes	yes	100 cm² [6]	yes
		IIB	50 cm² [6]	50 cm² [6]	yes	50 cm² [6]	yes	yes	50 cm² [6]	yes
		IIC	8 cm² [6]	8 cm² [6]	yes	8 cm² [6]	yes	yes	8 cm² [6]	yes
20, 21	1	IIA o.I	yes	yes	yes	100 cm² [6]	yes	yes	100 cm² [6]	yes
		IIB	50 cm² [6]	50 cm² [6]	yes	50 cm² [6]	yes	yes	50 cm² [6]	yes
		IIC	8 cm² [6]	8 cm² [6]	yes	8 cm² [6]	yes	yes	8 cm² [6]	yes
22	1	IIA o.I	yes	yes	yes	200 cm² [6]	yes	yes	200 cm² [6]	yes
		IIB	200 cm² [6]	200 cm² [6]	yes	200 cm² [6]	yes	yes	200 cm² [6]	yes
		IIC	40 cm² [6]	40 cm² [6]	yes	40 cm² [6]	yes	yes	40 cm² [6]	yes

BFM® connector			**Seeflex 020E**	**Seeflex 040E**	**Seeflex 040AS**	**Seeflex 060ES**	**LM3**	**LM4**	**Teflex**	**Teflex NP**
20, 21	2	IIA o.I	yes	yes	yes	200 cm² [6]	yes	yes	200 cm² [6]	yes
		IIB	200 cm² [6]	200 cm² [6]	yes	200 cm² [6]	yes	yes	200 cm² [6]	yes
		IIC	40 cm² [6]	40 cm² [6]	yes	40 cm² [6]	yes	yes	40 cm² [6]	yes
22	2	IIA o.I	yes	yes	yes	yes	yes	yes	yes	yes
		IIB	yes	yes	yes	yes	yes	yes	yes	yes
		IIC	yes	yes	yes	yes	yes	yes	yes	yes
			Use of BFM® connectors **with** strongly charge-generating processes [4]							
20, 21, 22 (without Gas)			yes up to 20 cm length [5]	yes up to 20 cm length [5]	yes up to 20 cm length [5]	no	yes up to 20 cm length [5]	yes up to 20 cm length [5]	no	yes
20, 21, 22	0, 1, 2	IIA o.I	no	no	yes up to 20 cm length [5]	no	no	yes up to 20 cm length [5]	no	yes
		IIB	no	no		no	no		no	yes
		IIC	no	no		no	no		no	yes

Explanations:

1) Surface resistance according to IEC 60079-32-2:2015 determined at 500 V and a relative humidity in the range of 25-30 %
2) Maximum value of the transferred charge according to IEC 60079-32-2:2015 determined at a relative humidity in the range of 25-30 %
3) n. r. = not relevant, as dissipative material (dissipative)
4) Strongly charge-generating processes, here especially: pneumatic transport and free fall > 3 m
5) Can be used if no dust with a high (> 10^{10} Ω·m) resistivity is transported and very dry transport air with a relative humidity < 25 % is avoided
6) Permissible maximum projected BFM surface area: corresponds to the arithmetic product of diameter and length of the BFM® connector
7) Dust zone / gas zone as well as hybrid mixture possible both inside and outside (zone 0 or 20 in the outside area, however, is not usual) / explosion group for gases (subdivision into dust groups not necessary, as information applies to all dust groups IIIA, IIIB and IIIC)

Notes:

- *In the case of electrically insulating BFM materials, the flexible material before the spring steel ring shall not be worn to such an extent that the spring steel ring is completely or partially uncovered. If this cannot be made sure, these BFM® connectors may not be used for flammable gases and only for dusts with Minimum Ignition Energy > 10 mJ.*
- *When transporting dusts / bulk solids in the presence of flammable gases / vapours, the choice of suitable BFM® connectors can prevent ignitable discharges from the BFM® connectors, but not discharges from the transported product.*
- *High charges are also possible when transporting non-explosive bulk solids, which can then lead to ignition of flammable gases / vapours. In the presence of a gas zone and non-explosive bulk solids, the requirements of the above table must therefore be applied correspondingly.*