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Electrostatics –

Part 4-4: Standard test methods for specific applications – Electrostatic classification of flexible intermediate bulk containers (FIBC)

Électrostatique –

Partie 4-4: Méthodes d'essai normalisées pour des applications spécifiques – Classification électrostatique des grands récipients pour vrac souples (GRVS)



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTROSTATICS –

**Part 4-4: Standard test methods for specific applications –
Electrostatic classification of flexible intermediate bulk containers (FIBC)**

FOREWORD

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International Standard IEC 61340-4-4 has been prepared by IEC technical committee 101: Electrostatics, in cooperation with ISO subcommittee 3: Performance requirements and tests for means of packaging, packages and unit loads, of ISO technical committee 122: Packaging.

This second edition cancels and replaces the first edition, published in 2005, and constitutes a technical revision.

The main changes with respect to the first edition are listed below:

- a) Adoption of a type classification system for FIBC based on four types: A, B, C and D.
- b) Guidance for safe use of FIBC in relation to hazardous areas and hazardous zones defined in IEC 60079-10-1 and IEC 60079-10-2 is added.
- c) Resistance to groundable points and electrical breakdown voltage measurements on FIBC shall be measured at low humidity only.

- d) Requirements for labelling FIBC are changed to improve clarity and ease of recognition by end users.
- e) Classification, performance requirements and guidance for safe use of inner liners in combination with FIBC are added.
- f) An informative annex giving guidance on test methods for quality control and inspection testing is added.

The text of this standard is based on the following documents:

FDIS	Report on voting
101/346/FDIS	101/353/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all the parts in the IEC 61340 series, published under the general title *Electrostatics*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

Flexible intermediate bulk containers (FIBC) are widely used for the storage, transportation and handling of powdered, flaked or granular material. Typically, they are constructed from woven polypropylene fabric in the form of cubic bags of about 1 m³ volume, although they can vary in shape and in size from 0,25 m³ to 3 m³. The fabric used may be a single layer, a multi-layer laminate, or a coated fabric. Untreated polypropylene is an electrical insulator, as is often the case with the products placed in FIBC. There is ample opportunity for the generation of electrostatic charge during filling and emptying operations and in unprotected FIBC high levels of charge can quickly build up. In such cases, electrostatic discharges are inevitable and can be a severe problem when FIBC are used in hazardous explosive atmospheres.

A hazardous explosive atmosphere can be generated when handling fine powders that create dust clouds or thin layers of powder, both of which can be ignited by electrostatic discharges. A hazardous explosive atmosphere can also be generated when using gases or volatile solvents. In these industrial situations there is clearly a need to eliminate incendive electrostatic discharges.

As with any industrial equipment, a thorough risk assessment should always be conducted before using FIBC in potentially hazardous situations. This part of IEC 61340 describes a system of classification, test methods, performance and design requirements and safe use procedures that can be used by manufacturers, specifiers and end-users as part of a risk assessment of any FIBC intended for use within a hazardous explosive atmosphere. However, it does not include procedures for evaluating the specific risks of electrostatic discharges arising from products within FIBC, e.g. cone discharges, from personnel or from equipment used near FIBC. Information on risks associated with cone discharges is given in Annex E.

CAUTION: The test methods specified in this standard involve the use of high voltage power supplies and flammable gases that may present hazards if handled incorrectly, particularly by unqualified or inexperienced personnel. Users of this standard are encouraged to carry out proper risk assessments and pay due regard to local regulations before undertaking any of the test procedures.

ELECTROSTATICS –

Part 4-4: Standard test methods for specific applications – Electrostatic classification of flexible intermediate bulk containers (FIBC)

1 Scope

This part of IEC 61340 specifies requirements for flexible intermediate bulk containers (FIBC) between 0,25 m³ and 3 m³ in volume, intended for use in hazardous explosive atmospheres. The explosive atmosphere may be created by the contents in the FIBC or may exist outside the FIBC.

The requirements include:

- classification and labelling of FIBC;
- classification of inner liners;
- specification of test methods for each type of FIBC and inner liner;
- design and performance requirements for FIBC and inner liners;
- safe use of FIBC (including those with inner liners) within different zones defined for explosion endangered environments, described for areas where combustible dusts are, or may be, present (IEC 60079-10-2), and for explosive gas atmospheres (IEC 60079-10-1);
- procedures for type qualification and certification of FIBC, including the safe use of inner liners.

NOTE 1 Guidance on test methods that may be used for manufacturing quality control is given in Annex C.

The requirements of this standard are applicable to all types of FIBC and inner liners, tested as manufactured, prior to use and intended for use in hazardous explosive atmospheres: Zones 1 and 2 (Groups IIA and IIB only) and Zones 21 and 22 (see Annex D for classification of hazardous areas and explosion groups). For some types of FIBC, the requirements of this standard apply only to use in hazardous explosive atmospheres with minimum ignition energy of 0,14 mJ or greater and where charging currents do not exceed 3,0 µA.

NOTE 2 0,14 mJ is the minimum ignition energy of a typical Group IIB gas or vapour. Although more sensitive materials exist, 0,14 mJ is the lowest minimum ignition energy of any material that is likely to be present when FIBC are emptied. 3,0 µA is the highest charging current likely to be found in common industrial processes. This combination of minimum ignition energy and charging current represents the most severe conditions that might be expected in practice.

Compliance with the requirements specified in this standard does not necessarily ensure that hazardous electrostatic discharges, e.g. cone discharges, will not be generated by the contents in FIBC. Information on the risks associated with cone discharges is given in Annex E.

Compliance with the requirements of this standard does not mitigate the need for full risk assessment. For example, metal and other conductive powders and toner powders may require additional precautions to prevent hazardous discharges from the powders.

NOTE 3 In the examples mentioned in the paragraph above, additional precautions may be necessary in the case of metal or other conductive powder because if the powder is isolated and becomes charged, incendiary sparks may occur, and in the case of toner powders, incendiary discharges may occur during rapid filling and emptying operations. Future IEC/TS 60079-32 [1]¹ gives guidance on additional precautions that may be necessary.

¹ Figures in square brackets refer to the bibliography.

Test methods included in this standard may be used in association with other performance requirements, for example when a risk assessment has shown the minimum ignition energy of concern is less than 0,14 mJ, charging currents are greater than 3,0 μ A, or the ambient conditions are outside of the range specified in this standard.

Compliance with the requirements specified in this standard does not necessarily ensure that electric shocks to personnel will not occur from FIBC during normal use.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60079-10-1, *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres*

IEC 60079-10-2, *Explosive atmospheres – Part 10-2: Classification of areas – Combustible dust atmospheres*

IEC 60243-1:1998, *Electric strength of insulating materials – Test methods – Part 1: Tests at power frequencies*

IEC 60243-2, *Electric strength of insulating materials – Test methods – Part 2: Additional requirements for tests using direct voltage*

IEC 60417-5019:2006, *Graphical symbols for use on equipment*. Available at: <<http://www.graphical-symbols.info/equipment>>"

IEC 61241-2-3, *Electrical apparatus for use in the presence of combustible dust – Part 2: Test methods – Section 3: Method for determining minimum ignition energy of dust/air mixtures*

IEC 61340-2-3, *Electrostatics – Part 2-3: Methods of test for determining the resistance and resistivity of solid planar materials used to avoid electrostatic charge accumulation*

ISO 7000:2004, *Graphical symbols for use on equipment – Index and synopsis*

ISO 21898, *Packaging – Flexible intermediate bulk containers (FIBCs) for non-dangerous goods*

ASTM E582, *Standard test method for minimum ignition energy and quenching distance in gaseous mixtures*

3 Terms and definitions

For the purposes of this document, the following terms and definitions, as well as those given in IEC 60079-10-1, IEC 60079-10-2 and ISO 21898, apply.

3.1

quenching

effect of solid objects acting as heat sinks in close proximity to gas

3.2

critical quenching distance

maximum separation distance between opposing electrodes below which quenching prevents ignition at a specified energy

NOTE For ignitions to take place, the gap between electrodes should be greater than the critical quenching distance.

3.3

flammable substance

substance in the form of gas, vapour, liquid, solid, or mixture of these, capable of propagating combustion when subjected to an ignition source

3.4

explosive atmosphere

mixture with air, under atmospheric conditions, of flammable substances in the form of gases, vapours, mists or dusts in which, after ignition has occurred, combustion spreads to the entire unburned mixture

3.5

hazardous explosive atmosphere

explosive atmosphere present in such quantities that precautions against ignition are required

3.6

minimum ignition energy

least electrical energy of a purely capacitive spark (i.e. no added inductance) required to ignite a dust, gas or vapour

3.7

charging current

quantity of charge per unit time flowing into FIBC

3.8

cone discharge

electrostatic discharge running outwards across the surface from the top of highly charged, insulating powder heaps in large containers

3.9

brush discharge

electrostatic discharge from a non-conductive, solid or liquid surface

3.10

spark

electrostatic discharge from an electrically isolated conductive object or surface

3.11

propagating brush discharge

highly energetic discharge from an insulating sheet, layer or coating on a conductive surface, or a material of high resistivity and high break down voltage with the two surfaces highly charged to opposite polarity

3.12

inner liner

integral or removable container which fits into the FIBC (synonymous with liner)

3.13

surface resistivity

equivalent to the surface resistance of a square area of material, having electrodes at two opposite sides

3.14

volume resistivity

equivalent to the volume resistance of a cube of material with unit length, having the electrodes at two opposite surfaces

3.15

type qualification testing

testing used to determine the type of FIBC as specified in 4.1 and to demonstrate that FIBC meet the requirements of Clause 7

3.16

quality control testing

testing designed to provide manufacturers and users with information that demonstrates all FIBC produced and delivered are substantially the same as the sample FIBC used to qualify the FIBC design

3.17

groundable point

point on FIBC designated by the manufacturer as a location to attach a grounding or earth bonding cable or other means of earthing FIBC

NOTE There may be one or more groundable points on each FIBC. Lift loops may also be designated as groundable points, but fortuitous earthing via lifting hooks should not be relied as these may be painted/coated, or covered with powder etc., and so may not guarantee an adequate earth path.

4 Classification

4.1 Principles of classification for FIBC

FIBC are classified according to one of four types: Type A, Type B, Type C and Type D. The types are defined by the construction of the FIBC, the nature of their intended operation and associated performance requirements.

An individual design of FIBC may only be classified as one single type; for example one FIBC cannot be simultaneously classified as both Type B and Type D, or as Type CD.

4.1.1 Type A

Type A FIBC are made from fabric or plastic sheet without any measures against the build up of static electricity. Any FIBC that does not meet the requirements specified in Clause 7, or which has not been tested against the requirements is classified as Type A.

4.1.2 Type B

Type B FIBC are made from fabric or plastic sheet designed to prevent the occurrence of sparks and propagating brush discharges.

4.1.3 Type C

Type C FIBC are made from conductive fabric or plastic sheet, or interwoven with conductive threads or filaments and designed to prevent the occurrence of incendiary sparks, brush discharges and propagating brush discharges. Type C FIBC are designed to be connected to earth during filling and emptying operations.

4.1.4 Type D

Type D FIBC are made from static protective fabric designed to prevent the occurrence of incendiary sparks, brush discharges and propagating brush discharges, without the need for a connection from the FIBC to earth.

4.2 Principles of classification and requirements for inner liners

4.2.1 Surface resistivity measurements for inner liners

Surface resistivity shall be measured according to IEC 61340-2-3. A minimum of ten measurements shall be made at points evenly distributed over the inner liner surface. All measurements shall be within the limits specified for the type of inner liner being tested.

4.2.2 Special cases

Inner liners made from materials that contain a conductive layer sandwiched between two insulating layers shall not be used in Type B or Type D FIBC. If such an inner liner is used in Type C FIBC, the conductive layer shall be securely bonded to earth. The thickness of the insulating layers shall be less than 700 μm , and the breakdown voltage measured between an electrode placed on each surface in turn and the conductive layer shall be less than 4 kV, measured according to 9.1 under the conditions specified in 8.2.

NOTE In order to avoid incendiary brush discharge, the thickness of any exposed insulating layers in contact with non-insulating layers is limited to a maximum of 700 μm .

4.2.3 Type L1

Type L1 inner liners are made from materials with surface resistivity on at least one surface less than or equal to $1,0 \times 10^7 \Omega$ (see Annex F), measured under the conditions specified in 8.2. of this standard. Type L1 inner liners may be used in Type C FIBC.

If the material is multi-layered, or if the material has one surface with surface resistivity greater than $1,0 \times 10^{12} \Omega$, the breakdown voltage through the material shall be less than 4 kV, measured according to 9.1 under the conditions specified in 8.2.

The thickness of any layer with surface resistivity greater than $1,0 \times 10^{12} \Omega$ on the inside (product side) of the inner liner material shall be less than 700 μm .

Permissible configurations and requirements for type L1 inner liners are summarized in Table 1.

Table 1 – Permissible configurations and requirements for Type L1 inner liners

Configuration	Parameters			
	Resistivity of inside surface ρ_I	Resistivity of outside surface ρ_O	Breakdown voltage V_B	Thickness d
1	$\rho_I \leq 1,0 \times 10^7 \Omega$	$\rho_O \leq 1,0 \times 10^7 \Omega$	No measurement required	No limit
2A	$\rho_I \leq 1,0 \times 10^7 \Omega$	$\rho_O \leq 1,0 \times 10^{12} \Omega$	No measurement required	No limit
2B	$\rho_I \leq 1,0 \times 10^{12} \Omega$	$\rho_O \leq 1,0 \times 10^7 \Omega$	No measurement required	No limit
3	$\rho_I \leq 1,0 \times 10^7 \Omega$	$\rho_O > 1,0 \times 10^{12} \Omega$	$V_B < 4 \text{ kV}$	No limit
4	$\rho_I > 1,0 \times 10^{12} \Omega$	$\rho_O \leq 1,0 \times 10^7 \Omega$	$V_B < 4 \text{ kV}$	$d < 700 \mu\text{m}$

4.2.4 Type L2

Type L2 inner liners are made from materials with surface resistivity on at least one surface between $1,0 \times 10^9 \Omega$ and $1,0 \times 10^{12} \Omega$ (see Annex F), measured under the conditions specified in 8.3. Type L2 inner liners may be used in Type B, Type C and Type D FIBC.

If Type L2 inner liners are used in Type C FIBC, the charging current shall not exceed 3 μA .

If the material is multi-layered, or if the material has one surface with surface resistivity greater than $1,0 \times 10^{12} \Omega$, the breakdown voltage through the material shall be less than 4 kV, measured according to 9.1 under the conditions specified in 8.2.

The thickness of any layer with surface resistivity greater than $1,0 \times 10^{12} \Omega$ on the inside (product side) of the inner liner material shall be less than 700 μm .

Permissible configurations and requirements for Type L2 inner liners are summarized in Table 2.

Table 2 – Permissible configurations and requirements for Type L2 inner liners

Configuration	Parameters			
	Resistivity of inside surface ρ_i	Resistivity of outside surface ρ_o	Breakdown voltage V_B	Thickness d
1	$1,0 \times 10^9 \Omega \leq \rho_i \leq 1,0 \times 10^{12} \Omega$	$1,0 \times 10^9 \Omega \leq \rho_o \leq 1,0 \times 10^{12} \Omega$	No measurement required	No limit
2	$1,0 \times 10^9 \Omega \leq \rho_i \leq 1,0 \times 10^{12} \Omega$	$\rho_o > 1,0 \times 10^{12} \Omega$	$V_B < 4 \text{ kV}$	No limit
3	$\rho_i > 1,0 \times 10^{12} \Omega$	$1,0 \times 10^9 \Omega \leq \rho_i \leq 1,0 \times 10^{12} \Omega$	$V_B < 4 \text{ kV}$	$d < 700 \mu\text{m}$

4.2.5 Type L3

Type L3 inner liners are made from materials with surface resistivity of greater than $1,0 \times 10^{12} \Omega$, measured under the conditions specified in 8.2. Type L3 inner liners may be used in Type B FIBC.

The breakdown voltage through the material shall be less than 4 kV, measured according to 9.1 under the conditions specified in 8.2.

Permissible configurations and requirements for Type L3 inner liners are summarized in Table 3.

Table 3 – Permissible configurations and requirements for Type L3 inner liners

Configuration	Parameters			
	Resistivity of inside surface ρ_i	Resistivity of outside surface ρ_o	Breakdown voltage V_B	Thickness d
1	$\rho_i > 1,0 \times 10^{12} \Omega$	$\rho_o > 1,0 \times 10^{12} \Omega$	$V_B < 4 \text{ kV}$	No limit

4.3 Combination of FIBC and inner liners

The inclusion of an inner liner in FIBC does not change the type classification of the FIBC. For example, Type A FIBC with Type L1 inner liners are still Type A FIBC and are subject to all the restrictions on use of Type A FIBC.

The requirements for breakdown voltage for FIBC and inner liners shall be applied separately. For Type B, Type C and Type D FIBC with inner liners for which there is a breakdown voltage requirement, two sets of breakdown voltage measurement shall be required: one set on the FIBC material and one set on the inner liner material. For example, if a Type B FIBC is fitted

with a Type L3 inner liner, the breakdown voltage of the FIBC material shall be measured on its own and shall be less than 6 kV and a separate breakdown voltage measurement shall be made on the inner liner material and it shall be less than 4 kV.

5 Safe use of FIBC

The requirements and specifications that FIBC must meet and the ways in which they are used depend on the nature and sensitivity of any explosive atmosphere present during filling and emptying. The final goal for the construction of FIBC is to exclude incendiary discharges from the FIBC fabric during their intended use. FIBC constructed in compliance with the requirements specified in this standard do not necessarily ensure that hazardous electrostatic discharges, e.g. cone discharges, will not be generated by the contents in FIBC. Information on the risks associated with cone discharges is given in Annex E.

The igniting ability of electrostatic discharges, i.e. sparks, brush discharges and propagating brush discharges, is different for each type of discharge. The necessity of their exclusion and thus the requirements and specifications for FIBC depend on the intended use of the FIBC. The conditions in which each type of FIBC shall be used is shown in Table 4.

Table 4 – Use of different types of FIBC

Bulk product in FIBC	Surroundings		
	Non-flammable atmosphere	Dust zones 21-22 ^b (1 000 mJ ≥ MIE > 3 mJ) ^a	Gas zones 1-2 ^b (Explosion groups IIA/IIB) ^b or dust zones 21-22 ^b (MIE ≤ 3 mJ) ^a
MIE > 1 000 mJ	A,B,C,D	B,C,D	C,D ^c
1 000 mJ ≥ MIE > 3 mJ	B,C,D	B,C,D	C,D ^c
MIE ≤ 3 mJ ^d	C,D	C,D	C,D ^c
NOTE 1 Additional precautions are usually necessary when a flammable gas or vapour atmosphere is present inside the FIBC, e.g. in the case of solvent wet powders.			
NOTE 2 Non-flammable atmosphere includes dusts having a MIE > 1 000 mJ.			
^a Measured in accordance with IEC 61241-2-3, capacitive discharge circuit (no added inductance).			
^b See Annex D for explanation of hazardous areas, zones and explosion groups.			
^c Use of Type D shall be limited to explosion groups IIA/IIB with MIE ≥ 0,14 mJ.			
^d See Annex E for explanation of the 3 mJ limit in relation to cone discharges.			

The ability to safely use FIBC in hazardous explosive atmospheres may change if an inner liner is installed in the FIBC. Combinations of FIBC and inner liner that can be used safely in hazardous explosive atmospheres are shown in Table 5. In addition to the separate requirements for FIBC and inner liners, there are requirements that certain combinations of FIBC and inner liner shall meet. These requirements are also shown in Table 5.

Table 5 – Inner liners and FIBC: combinations that are permissible and not permissible in hazardous explosive atmospheres

FIBC	Inner liner		
	Type L1	Type L2	Type L3
Type B	Not permissible	Permissible	Permissible
Type C	Permissible ^a	Permissible	Not permissible
Type D	Not permissible	Permissible ^b	Not permissible

^a To ensure the inner liner is properly earthed, the resistance from at least one side of the inner liner to the groundable points on the FIBC shall be less than $1,0 \times 10^7 \Omega$, measured according to 9.3 under the conditions specified in 8.2.

^b Combination of FIBC and liner shall meet the requirements of 7.3.2 tested under the conditions specified in 8.3.

Additional precautions:

Type A FIBC shall not be used in hazardous explosive atmospheres, irrespective of the type of liner used.

Liners shall not be removed from emptied FIBC in hazardous explosive atmospheres.

Isolated conductive objects (e.g. tools, bolts, clips, etc.) should not be stored on, attached to, or even temporarily placed on any type of FIBC during filling and emptying operations. Even with Type C FIBC, the rough nature of some FIBC materials may prevent conductive objects placed on the FIBC from contacting the conductive elements in the fabric of the FIBC.

In accordance with general safety guidance (see future IEC/TS 60079-32), all conductive objects within a hazardous explosive atmosphere shall be properly earthed.

Precautions should be taken to prevent the contamination of any FIBC with substances (e.g. water, rust, oil, grease, etc.) that might create an ignition hazard or impair charge dissipation.

6 Labelling

FIBC for which claims of compliance with this standard are made, shall be durably marked by means of a permanently attached label, or other means, with at least the following information:

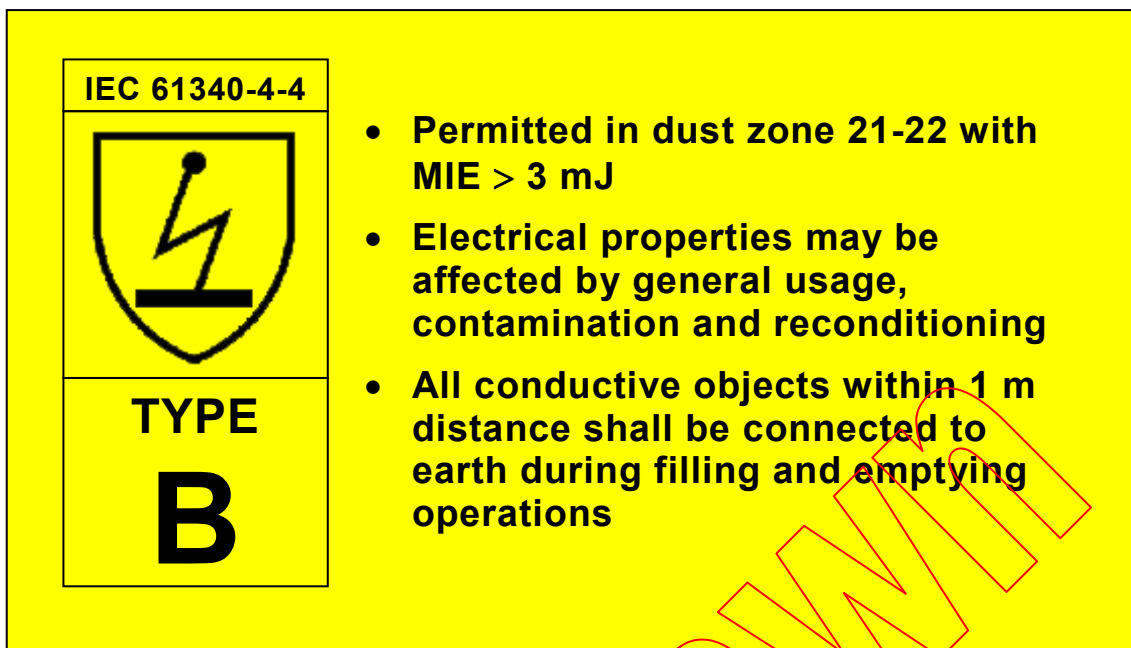
- a) the number of this standard, i.e. IEC 61340-4-4;
- b) the type of FIBC, i.e. Type B, Type C or Type D (the type designation shall be emphasized so that it is easily readable at a glance);

NOTE Type A FIBC are not required to be labelled.

- c) the symbol ISO 7000-2415 (2004-01) on Type B, Type C and Type D to indicate protection from static electricity;
- d) for Type B, the phrase “permitted in dust zone 21-22 with MIE > 3 mJ”;
- e) for Type C, the phrase “permitted in dust zones 21-22 and gas zones 1-2 (explosion groups IIA/IIB)”;
- f) for Type D the phrase “permitted in dust zones 21-22 and gas zones 1-2 (explosion groups IIA/IIB with MIE ≥ 0,14 mJ) and where charging currents ≤ 3 μA”;
- g) for Type C the phrase “FIBC shall be properly earthed according to manufacturer’s instructions”;
- h) for Type D, the phrase “FIBC does not require earthing”;
- i) for Type B, Type C and Type D the phrase “electrical properties may be affected by general usage, contamination and reconditioning”;
- j) for Type B and Type D the phrase “all conductive objects within 1 m distance shall be connected to earth during filling and emptying operations”;
- k) certifying authority and certificate number (only for FIBC certified by independent certifying authorities).

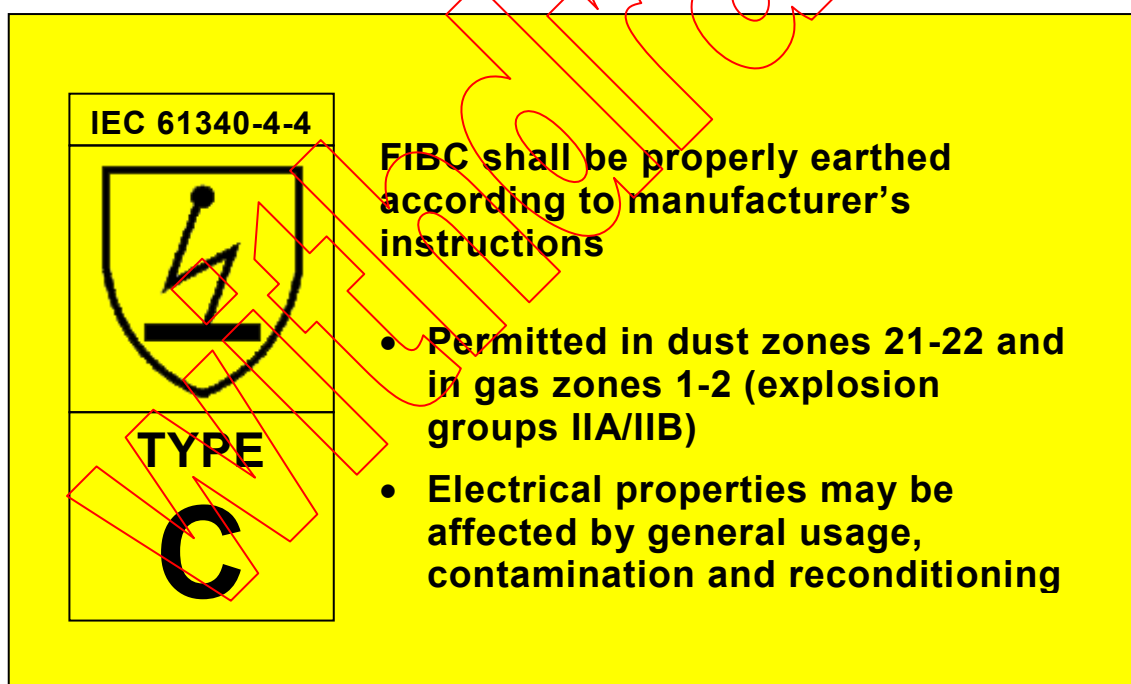
The designated earth bonding points on Type C FIBC shall be labelled or marked with the earth symbol (IEC 60417-5019 (2006-08)), as shown for example in Figure 4. The background colour for labels or marking shall be yellow and the lettering shall be black. The label or marking may be incorporated into another label or marking as may be required for other purposes.

Examples of suitable labels for each type of FIBC are shown in Figures 1 to 3.



IEC 2802/11

Figure 1 – Example of a label for Type B FIBC



IEC 2803/11

Figure 2 – Example of a label for Type C FIBC

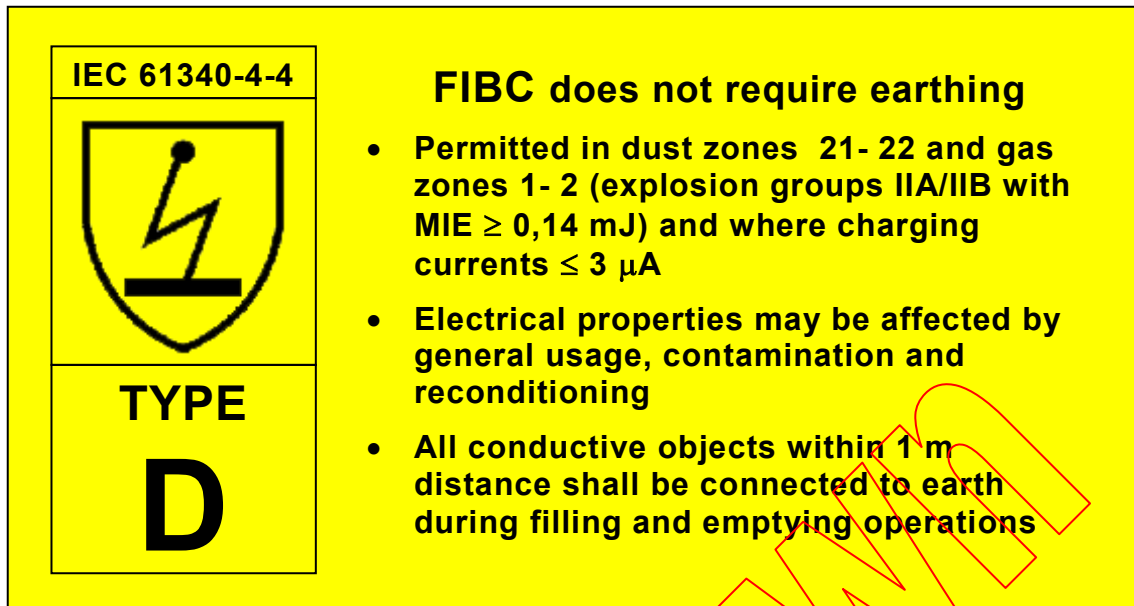
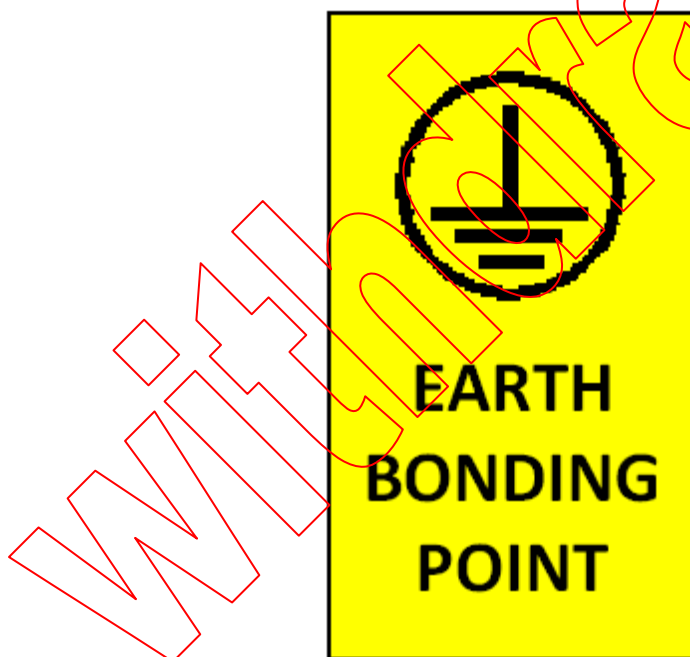


Figure 3 – Example of a label for Type D FIBC

IEC 2804/11



IEC 2805/11

Figure 4 – Example of a label for Type C FIBC designated earth bonding points

FIBC shall not be labelled or marked in any way that conflicts with the requirements of this standard, or in any way that could cause confusion as to its classification or use restrictions (e.g. “Type CD” is not permitted). No additional lettering or symbols shall be appended to the type designation (e.g. “Type D+” is not permitted).

It is the responsibility of FIBC manufacturers to ensure the sample(s) tested are representative of the production FIBC to which labels shall be attached.

Type B FIBC labels shall not be made from material with surface resistivity less than $1,0 \times 10^9 \Omega$, measured according to IEC 61340-2-3 under the conditions specified in 8.2 of this standard.

Type C FIBC labels greater than 100 cm² in area, or greater than or equal to 700 µm in thickness shall not be made from material with surface resistivity greater than $1,0 \times 10^{12} \Omega$, measured according to IEC 61340-2-3 under the conditions specified in 8.2. Type C FIBC labels made from materials with surface resistivity less than $1,0 \times 10^7 \Omega$, measured according to IEC 61340-2-3 under the conditions specified in 8.2 can be used, provided the resistance to groundable point measured according to 9.3 is less than the limit specified in 7.3.1. Type C FIBC labels made from materials with surface resistivity between $1,0 \times 10^9 \Omega$ and $1,0 \times 10^{12} \Omega$, measured according to IEC 61340-2-3 under the conditions specified in 8.3. can be used.

Type D FIBC labels greater than 100 cm² shall be subjected to ignition testing according to 9.2 and shall meet the requirements specified in 7.3.2.

7 Requirements for FIBC

7.1 General remarks

A FIBC intended for use in the presence of a flammable material or in a hazardous explosive atmosphere shall not itself produce incendiary discharges. The absence of incendiary discharges shall be verified for at least the smallest and largest sizes of FIBC of a particular design by meeting one of the requirements listed in 7.2 and 7.3 when tested as manufactured, prior to usage.

Quality control test methods described in Annex C shall not be used as a substitute for type qualification test methods specified in Clause 9.

NOTE Compliance with the requirements of this standard may not extend to FIBC that have been contaminated or degraded through use, or are used contrary to manufacturers' recommendations. Where it is intended that FIBC be used for multiple fill/clean/empty cycles, it is recommended that tests be conducted according to Clause 9 to verify that FIBC comply with the requirements of Clause 7 after the required number of use cycles.

Type qualification certificates based on this standard shall be supported by a test report including the information specified in Clause 10. Unless otherwise specified or agreed by interested parties, a type qualification certificate for a FIBC design shall be valid for a period of three years from the date of issue.

7.2 Requirements for dust environments with ignition energies greater than 3 mJ (apply to Type B FIBC, Type C FIBC and Type D FIBC)

To ensure propagating brush discharges cannot occur across the walls of a FIBC intended for use in the presence of combustible dusts but in the absence of flammable vapours or gases, it shall be constructed from materials having an electrical breakdown voltage of less than or equal to 6 kV when tested according to 9.1. The materials used to construct inner baffles, other than mesh or net baffles, shall also meet these requirements.

7.3 Requirements for vapour and gas atmospheres and for dust environments with ignition energies of 3 mJ or less

7.3.1 Type C FIBC

A Type C FIBC intended for use in the presence of flammable vapours or gases, or combustible dusts with ignition energies of 3 mJ or less (see Annex E) shall have a resistance to groundable point of less than $1,0 \times 10^7 \Omega$ (see Annex F) when tested according to 9.3. Additionally, the FIBC shall be constructed entirely from conductive material or at least shall contain fully inter-connected conductive threads or tapes with a maximum spacing of 20 mm if the threads or tapes are in a stripe pattern, or 50 mm if they are in a grid pattern.

For FIBC constructed of multi-layer materials, the inside or outside surface of the FIBC shall have a resistance to groundable point of less than $1,0 \times 10^7 \Omega$ when tested according to 9.3. If the inside layer does not have a resistance to groundable point of less than $1,0 \times 10^7 \Omega$,

then the material shall also meet the requirements specified in 7.2. All layers of multi-layer materials shall remain in firm contact during filling and emptying operations.

The materials used to construct inner baffles, other than mesh or net baffles, shall also meet these requirements and shall be included in the tests conducted according to 9.3.

7.3.2 Type D FIBC

A Type D FIBC intended for use in the presence of flammable vapours or gases, or combustible dusts with ignition energies of 3 mJ or less (see Annex E) shall not cause any ignition when tested according to 9.2.

Additionally, for Type D FIBC made from material that has an insulating layer (e.g. coating film or lamination) on the inside of the container, the material shall meet the requirements specified in 7.2. All layers of multi-layer materials shall remain in firm contact during filling and emptying operations.

For the purposes of type qualification testing where a range of outlet sizes are available for a particular design, ignition testing according to 9.2 shall be carried out on test FIBC with an outlet size that is the smaller of a) 400 mm, or b) the maximum outlet size for the design under test.

The materials used to construct inner baffles, other than mesh or net baffles, shall be the same as the materials used to construct the major panels of the FIBC.

8 Atmosphere for conditioning, calibrating and testing

8.1 Conditioning time

Conditioning time shall be at least 12 h prior to testing and test samples shall be free hanging to allow sufficient air circulation. When tests are to be conducted in accordance with 9.2, pellets shall be circulated at intervals during this period to ensure adequate conditioning.

8.2 Electrical breakdown voltage and resistance to groundable point testing

Test samples and apparatus shall be conditioned, calibrated and tested under conditions of $(23 \pm 2) ^\circ\text{C}$ and $(20 \pm 5) \%$ relative humidity.

8.3 Ignition testing

Test samples and apparatus shall be conditioned, calibrated and tested under conditions of

- a) $(23 \pm 2) ^\circ\text{C}$ and $(20 \pm 5) \%$ relative humidity;
- b) $(23 \pm 2) ^\circ\text{C}$ and $(60 \pm 10) \%$ relative humidity.

9 Test procedures

9.1 Electrical breakdown voltage

Breakdown voltage shall be determined in accordance with IEC 60243-1 and IEC 60243-2. The method used is specified in 9.1 of IEC 60243-1:1998, the short-time (rapid-rise) test. The test shall be conducted with unequal electrodes under the application of direct voltage at a rate of rise of 300 V/s. The maximum output current of the DC power supply shall be 1 mA.

For multi-layer materials, all layers shall be tested together and the test specimens shall be positioned so that the high-voltage electrode is in contact with the surface of the material that is normally on the inside of the FIBC.

An example of a voltage/time graph for materials showing distinct breakdown is shown in Figure A.1. For certain materials used in the construction of FIBC there may be some conductivity which will prevent a sudden breakdown occurring. Typically such materials will cause a reduction in the rate of voltage rise as charge leaks through the material. An example is shown in Figure A.2. Materials of this nature will not give rise to propagating brush discharges and shall be deemed to meet the requirements of 7.2.

If the output current of the DC power supply reaches 1 mA before the electrode voltage reaches 6 kV, the material under test shall be deemed to meet the requirements of 7.2.

9.2 Ignition testing

9.2.1 Apparatus

Apparatus other than that specified below may be used, provided that it satisfies the same functional requirements and is shown to give the same results.

9.2.1.1 Ignition probe

The ignition probe is a cylinder made from rigid non-conductive material such as polycarbonate or acrylic with an internal diameter of (70 ± 5) mm and an internal length of (100 ± 5) mm (see Figure 5). The material used for constructing the probe shall be of sufficient thickness and strength to withstand repeated ignition without cracking, distorting or otherwise failing.

One end of the cylinder is closed apart from a central port to allow the inflow of the flammable gas. The size of the inlet port is not critical but shall be large enough to allow the required flow rate to be achieved without excessive pressure build-up. A suitable flame arrestor shall be installed in the gas supply line as close as possible to the ignition probe.

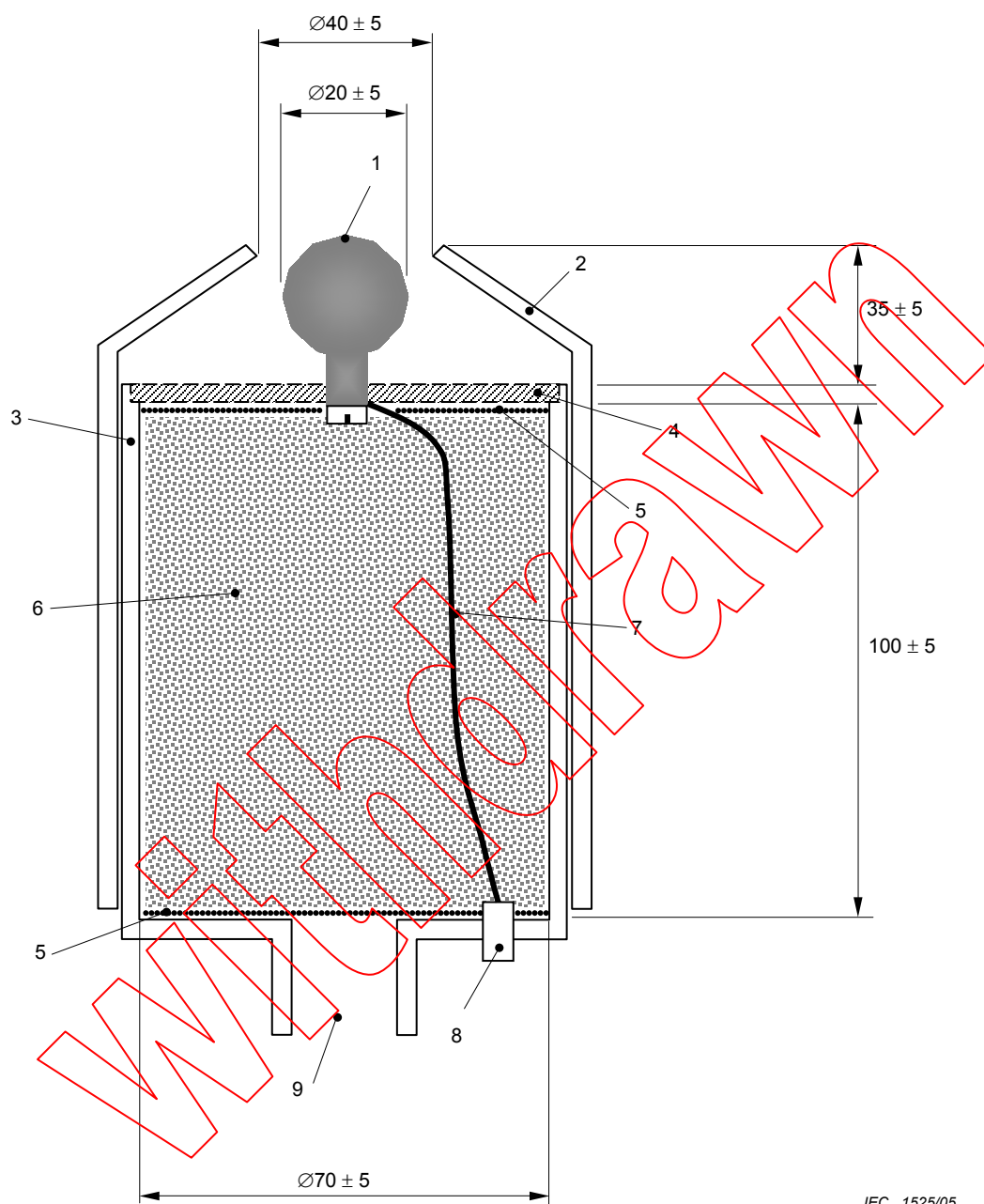
A metal plate is fitted to the other end of the cylinder to form a fixing base for the discharge electrode (see Figure 6). The metal plate is drilled with holes, (5 ± 1) mm in diameter to allow the uniform flow of gas through it and around the discharge electrode.

A spherical metal electrode of diameter (20 ± 5) mm is mounted centrally to the metal plate. The electrode, metal plate and any other metal or conductive material in the ignition probe are connected to a common point earth via a low impedance ($<10 \Omega$) connection. The earth point shall be the common point earth for local structures and equipment to the FIBC such as conductive parts of the FIBC test rig. The common earth point may be connected to the electricity supply earth. The connection between the electrode, the metal plate and the earth connector shall be sufficiently robust to withstand physical and thermal impacts. The electrical continuity between the discharge electrode and the earth connector shall be checked prior to use.

The ignition probe is filled with glass or porcelain beads, nominally 1 mm to 2 mm in diameter, which are retained by a fine metal gauze or mesh at either end of the main cylinder. The beads assist in the mixing of the gases and also contribute to preventing propagation of any flame back through the probe.

An adjustable shroud made from insulating material is fitted to the cylinder to direct gas over the discharge electrode and into the region in front of the discharge electrode where electrostatic discharges take place. The opening in this shroud is (40 ± 5) mm.

Dimensions in millimetres



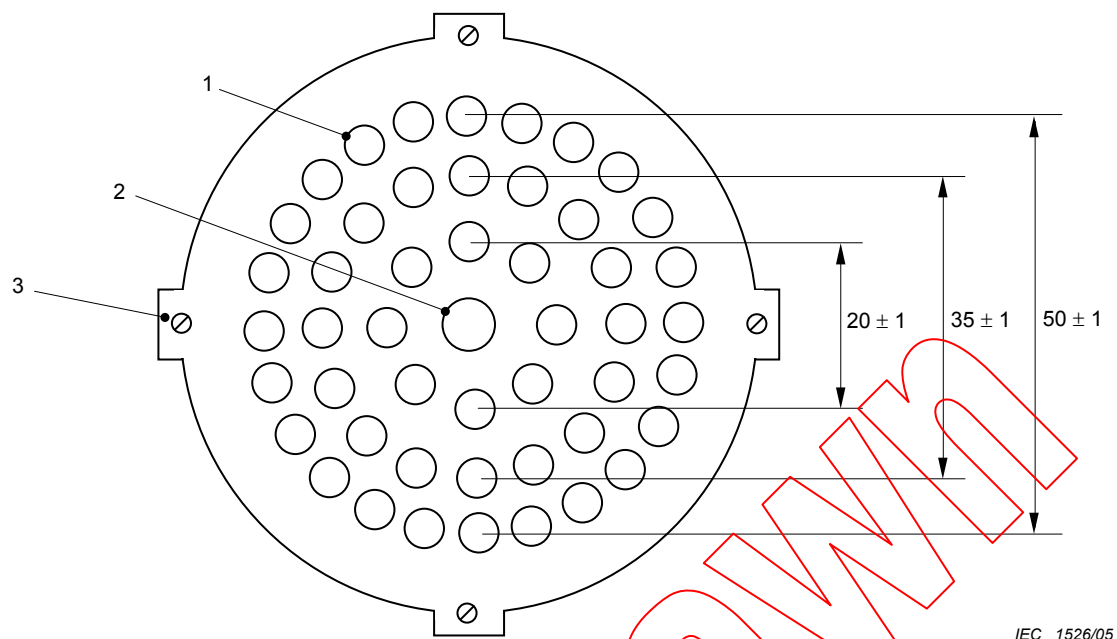
IEC 1525/05

Key

- | | |
|---|--|
| 1 discharge electrode | 5 fine metal mesh or gauze (e.g. copper) |
| 2 adjustable shroud made from insulating material (e.g. polycarbonate or acrylic) | 6 beads (e.g. glass or porcelain), 1–2 mm diameter (nominal) |
| 3 cylinder made from insulating material (e.g. polycarbonate or acrylic) | 7 robust earth connection |
| 4 perforated metal plate (2 mm nominal thickness) | 8 earth connector |
| | 9 inlet port for flammable gas |

Figure 5 – Ignition probe

Dimensions in millimetres



IEC 1526/05

Key

- 1 perforation (5 ± 1) mm diameter
- 2 mounting hole for discharge electrode
- 3 screw for securing plate to body of ignition probe

Figure 6 – Perforated metal plate for use in ignition probe**9.2.1.2 Gas control and mixing apparatus**

The flammable gas is generated by mixing ethylene (minimum 99,5 % purity) with air. The air used shall contain $(21,0 \pm 0,5)$ % oxygen and $(79,0 \pm 0,5)$ % nitrogen. The gas control and mixing apparatus is used to direct the gas in the appropriate proportions to the ignition probe (see Figure 7).

The volume concentrations of gas used are shown in Table 6.

Table 6 – Volume concentrations of flammable gas mixture

Gas	Composition	Volume concentration %	Minimum ignition energy mJ	Critical quenching distance mm
Ethylene	$\geq 99,5$ % C_2H_4	$5,4 \pm 0,1$	$0,14 \pm 0,01$	$1,8 \pm 0,1$
Air	$(21,0 \pm 0,5)$ % O_2 $(79,0 \pm 0,5)$ % N_2	$94,6 \pm 0,1$		

The control of the gas mixture within the specified tolerances shall be checked using, for example, an infra-red ethylene gas analyser sampling the gas mixture supply line.

If a gas mixture other than that specified in Table 6 is used, the minimum ignition energy of the gas mixture shall be verified using the ASTM E582 method to be $(0,14 \pm 0,01)$ mJ.

NOTE 1 If a gas other than ethylene is used, the critical quenching distance may be different to that specified in Table 6.

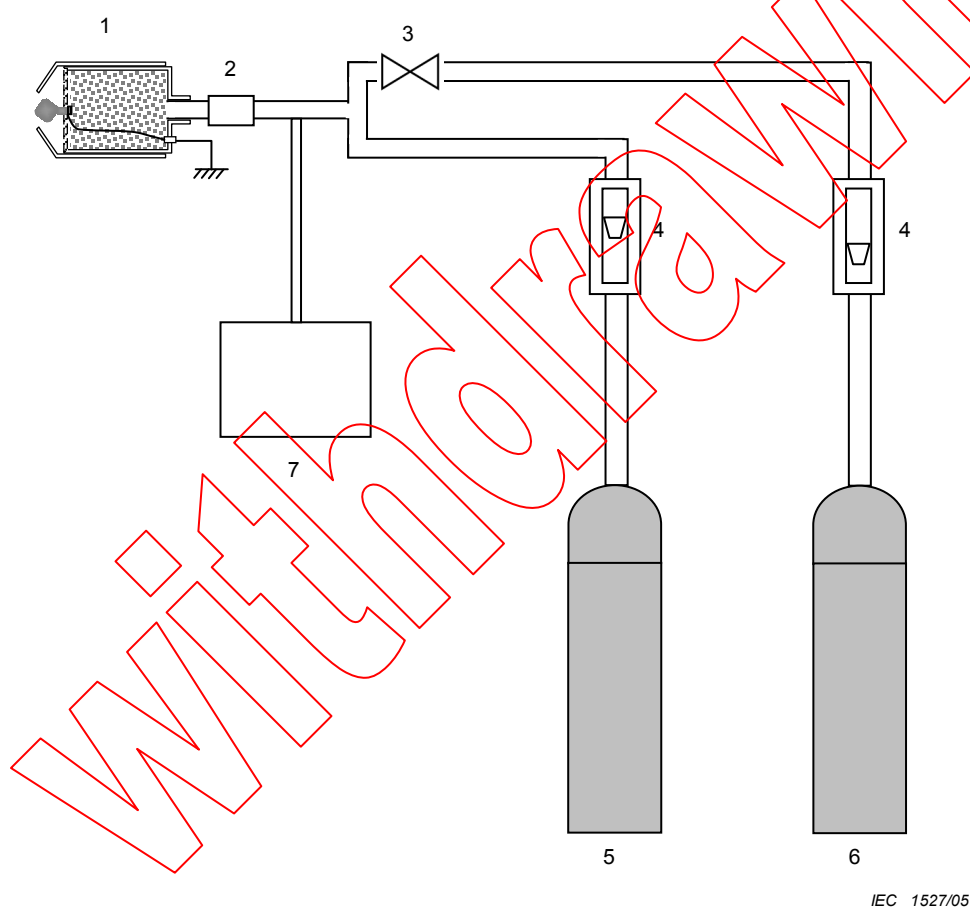
It is convenient to use compressed gas cylinders for the gas supply, but other sources of supply may be used. A pre-mixed cylinder of $(21,0 \pm 0,5)$ % oxygen and $(79,0 \pm 0,5)$ % nitrogen may be used in place of air. If necessary, molecular sieve filters shall be used to

ensure the gases have low moisture content. This is particularly important, for example, when using air directly from a compressor. Gases of at least 99,5 % purity shall be used.

NOTE 2 "Breathing air" has a wider tolerance of oxygen concentration than is specified in Table 6 and should not be used. Some molecular sieves may absorb ethylene so it is important to position the sieve filter before the gas reaches monitoring equipment.

Each gas supply is controlled and monitored using flowmeters and valves. The combined flow-rate of all gases through the ignition probe shall be $(0,21 \pm 0,04)$ l/s.

A fast action shut-off valve is used to stop the flow of ethylene when ignition occurs. The shut-off valve shall stop the supply of ethylene whilst leaving the air to flow freely to provide cooling and drying of the ignition probe after ignition has occurred. The type and location of the shut-off valve shall be selected as appropriate to the specific design of the overall apparatus.



Key

- 1 ignition probe
- 2 flame arrestor
- 3 ethylene shut-off valve
- 4 flowmeters
- 5 air or oxygen/nitrogen mixture
- 6 ethylene
- 7 ethylene analyser

Figure 7 – Gas control and mixing apparatus (schematic)

9.2.1.3 Re-circulating FIBC filling rig

A rigid steel framework, or other suitable support, is used to hold test FIBC so that they can be filled with charged product (see Figure 8). To minimize the influence of the steel framework on the electrostatic fields associated with the charged FIBC, any support framework around the sides of the FIBC shall be at least 1 m away it.

Test FIBC are filled with polypropylene pellets (see Annex B) with a volume resistivity of at least $1,0 \times 10^{12} \Omega\text{m}$. The pellets shall be homopolymer without fillers, pigments, antistatic additives, etc. Other materials may be used only after it has been determined that they produce equivalent results and do not generate cone discharges.

NOTE 1 One way of checking the equivalence of different pellet materials is to carry out the procedures specified in 9.2.2 to establish that the voltage applied to the corona charging unit generates the same charging current.

One means of circulating pellets is to position a hopper immediately below the test FIBC to collect the pellets and feed them to a conveyor where they are transported to the filling chute and loaded back into the test FIBC. Other means of circulating pellets may be equally suitable. The filling rate shall be $(1,1 \pm 0,1)$ kg of product per second.

The polypropylene pellets will naturally become charged by triboelectric action, but additional charge shall be injected by the incorporation of high-voltage corona points inside the filling pipe (see Figure 9). An insulating shroud surrounding the corona-charging unit prevents direct contact with the FIBC. A high-voltage DC power supply is used to control the corona-charging unit, which shall maintain the average charging current at $(3,0 \pm 0,2) \mu\text{A}$ with the instantaneous maximum not exceeding $4,0 \mu\text{A}$ and the instantaneous minimum not less than $2,0 \mu\text{A}$. The polarity of charge shall be negative. The corona charging unit shall not introduce charge into the FIBC under test when no pellets are flowing.

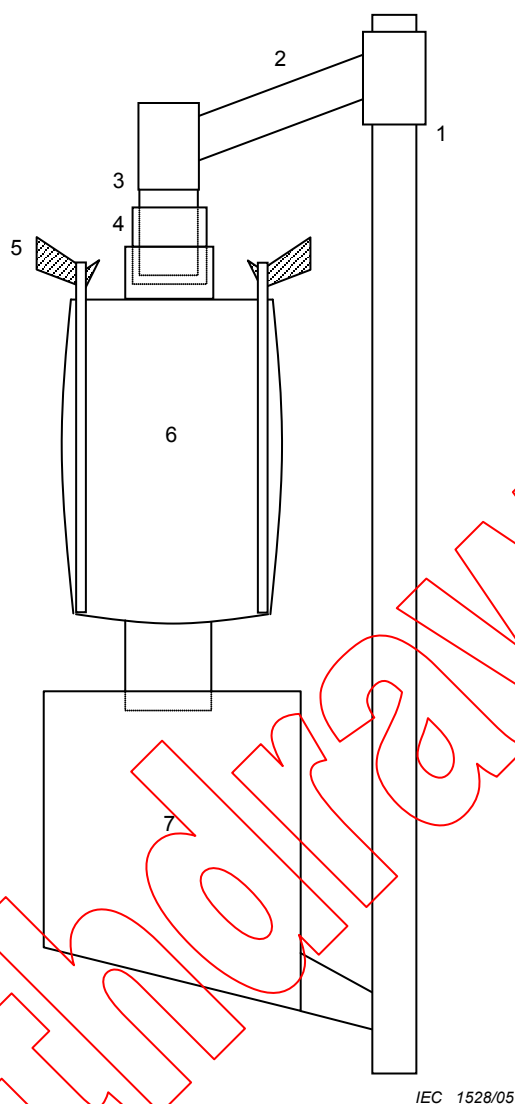
NOTE 2 It is recommended that pellets be changed regularly. It is not possible to specify intervals for changing pellets, but as a guide they should be changed whenever there are obvious signs of contamination, physical degradation, when the level of tribocharging is significantly reduced, or when there is an obvious build-up of fines.

All sections of the test FIBC, including the discharging spout, shall be accessible for approach with the ignition probe.

Depending on the design of the filling rig and its location, it may be necessary to provide a working platform to support the test apparatus and personnel.

For FIBC that are not required to be earthed during normal use, insulation shall be inserted between the lifting loops and the support points on the metal framework, such that the resistance to earth shall be at least $1,0 \times 10^{12} \Omega$.

All metal support framework, working platforms and any other conductors, including personnel, within 1 m of the test FIBC, shall be earthed, irrespective of the type of FIBC being tested.

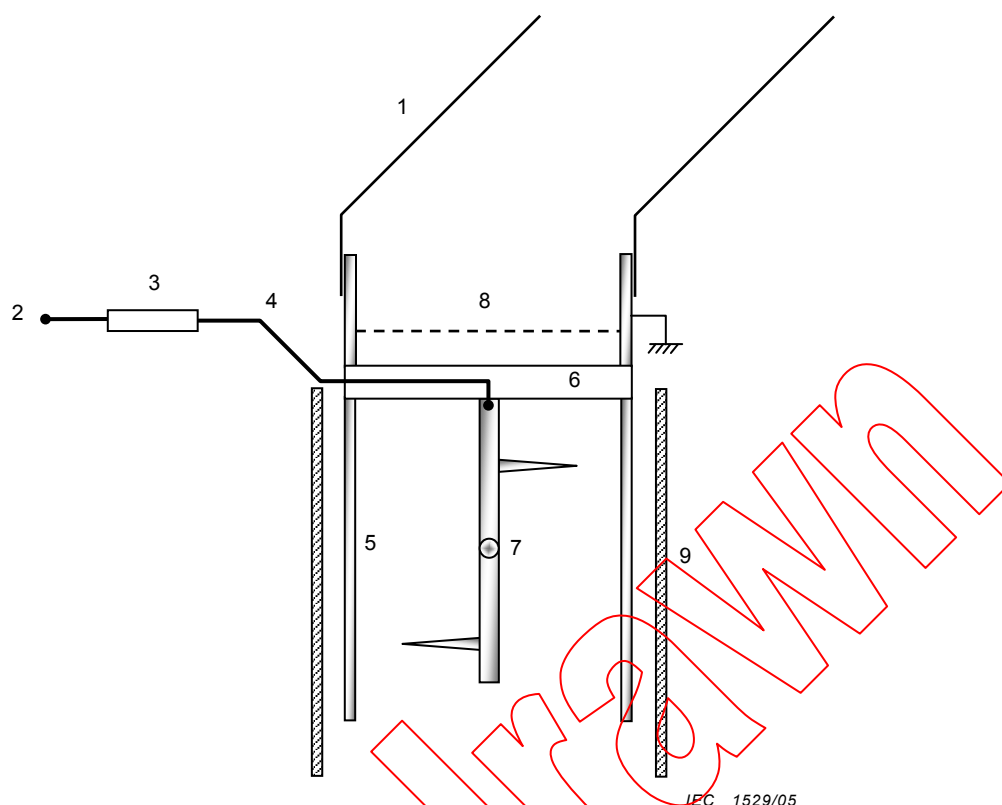


Key

- 1 means of conveying pellets
- 2 transfer pipe
- 3 corona charging unit
- 4 insulating shroud
- 5 means of supporting FIBC
- 6 FIBC
- 7 collecting hopper

NOTE This figure shows an example of a rig for FIBC with four lifting loops; other designs may be required when testing, for example, single-point liftable FIBC.

Figure 8 – FIBC filling rig (schematic)



Key

- 1 transfer pipe
- 2 input from high-voltage DC power supply (negative polarity)
- 3 decoupling resistor $\sim 10^7 \Omega$
- 4 insulated high-voltage connecting lead
- 5 earthed metal cylinder
- 6 insulating rod (e.g. PTFE)
- 7 metal rod carrying an array of pointed corona electrodes
- 8 earthed metal mesh to prevent damage to the corona array from large objects (mesh size > pellet size)
- 9 insulating shroud to prevent FIBC contacting corona charging unit

Figure 9 – Corona charging unit (schematic)

9.2.1.4 Charge measuring apparatus

The charge measuring apparatus comprises two main parts: a Faraday pail for collecting charged pellets and a means of measuring the charge flowing into the Faraday pail. It is convenient to use a conductive FIBC as a Faraday pail. The FIBC shall be constructed entirely from conductive material or at least shall contain fully inter-connected conductive threads or tapes with a maximum spacing of 20 mm, if the threads or tapes are in a stripe pattern, or 50 mm if they are in a grid pattern. The resistance to groundable point of the FIBC shall be less than $1,0 \times 10^7 \Omega$ when measured according to 9.3.

An electrometer is used to measure the charge flowing into the conductive FIBC. The electrometer shall either have an average, minimum and maximum function or shall have a suitable signal output from which the average, minimum and maximum charging current can be determined by means of a suitable instrument (e.g. digital multimeter, oscilloscope, data logger, etc.).