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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 STANDARD

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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.

This third edition cancels and replaces the second edition, published in 2012, and Amendment 1:2014. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) in light of experimental evidence, the maximum resistance to ground limit for Type C FIBC, and corresponding resistance limits for inner liners used in Type C FIBC has been increased from $1,0 \times 10^7 \Omega$ to $1,0 \times 10^8 \Omega$;
- b) the classification of Type L1 inner liners has been revised and extended to include Type L1C inner liners made from multi-layer materials with a conductive internal layer;

- c) a labelling requirement to include a reference to IEC TS 60079-32-1 for guidance on earthing has been added.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
101/546/FDIS	101/555/RVD

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

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

A list of all 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 document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
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- replaced by a revised edition, or
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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, for example 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 document 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 document 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 can be created by the contents in the FIBC or can 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, inner liner, labels and document pockets;
- design and performance requirements for FIBC, inner liners, labels and document pockets;
- 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 can 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 can be used for manufacturing quality control is given in Annex C.

The requirements of this document 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 document 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 represents a realistic minimum ignition energy for a Group IIB gas or vapour atmosphere. 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.

FIBC are not normally used in Zone 0 or Zone 20. If FIBC are used in Zone 0 or Zone 20, the requirements of this document are applicable, together with additional requirements that are beyond the scope of this document to define.

The volume contained within FIBC can be designated as Zone 20, in which case the requirements of this document are applicable.

Solids containing residual solvent can result in a hazardous explosive atmosphere within FIBC, possibly resulting in the volume being designated as Zone 1 or Zone 2; in which case the requirements of this document are applicable.

Compliance with the requirements specified in this document does not necessarily ensure that hazardous electrostatic discharges, for example cone discharges, will not be generated.

contents in FIBC. Information on the risks associated with cone discharges is given in Annex E.

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

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

Test methods included in this document can 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 µA, or the ambient conditions are outside of the range specified in this document.

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

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 – Explosive dust atmospheres*

IEC 60243-1:2013, *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, *Graphical symbols for use on equipment* (available at: <http://www.graphical-symbols.info/equipment>)

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

ISO/IEC 80079-20-2, *Explosive atmospheres – Part 20-2: Material characteristics – Combustible dusts test methods*

ISO 7000, *Graphical symbols for use on equipment – Registered symbols* (available at: <http://www.graphical-symbols.info/equipment>)

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

¹ Numbers in square brackets refer to the Bibliography.

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 terms and definitions given in IEC 60079-10-1, IEC 60079-10-2 and ISO 21898 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

multi-layer material

material comprised of more than one layer, the combination of which can be formed by coextrusion, coating, laminating or any other process that permanently bonds all layers together

3.2

quenching

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

3.3

critical quenching distance

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

Note 1 to entry: For ignitions to take place, the gap between electrodes is greater than the critical quenching distance.

3.4

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

3.5

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

3.6

hazardous explosive atmosphere

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

3.7

minimum ignition energy

MIE

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

3.8

charging current

quantity of charge per unit time flowing into FIBC

3.9**cone discharge**

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

3.10**brush discharge**

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

3.11**spark**

electrostatic discharge from an electrically isolated conductive object or surface

3.12**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 breakdown voltage with the two surfaces highly charged to opposite polarity

3.13**inner liner
liner**

integral or removable container which fits into the FIBC

3.14**surface resistivity**

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

3.15**volume resistivity**

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

3.16**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

3.17**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

3.18**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

4 Classification

4.1 Classification for FIBC

4.1.1 Principles of classification

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 shall not be simultaneously classified as both Type B and Type D, or as both Type B and Type C, or as Type CD.

4.1.2 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.

4.1.3 Type B

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

Conductive materials, as used in the manufacture of Type C FIBC for example, shall not be used in the manufacture of Type B FIBC.

NOTE Type B FIBC are not normally connected to earth. Conductive material that is not connected to earth creates a risk of incendiary sparks.

4.1.4 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 before the commencement of filling and emptying operations and remain connected to earth during these operations.

4.1.5 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 Components of inner liners

Materials used for inner liners can be single layer, or multi-layered materials. In the latter case, the layers are typically permanently bonded together. Examples of FIBC with a single layer inner liner and with a multi-layer inner liner are shown in Figure 1.

For the purposes of this document, and for both single layer inner liners and multi-layer inner liners, the outside surface of the inner liner is the surface that physically contacts the FIBC, and the inside surface of the inner liner is the surface that physically contacts the product with which the FIBC is filled.

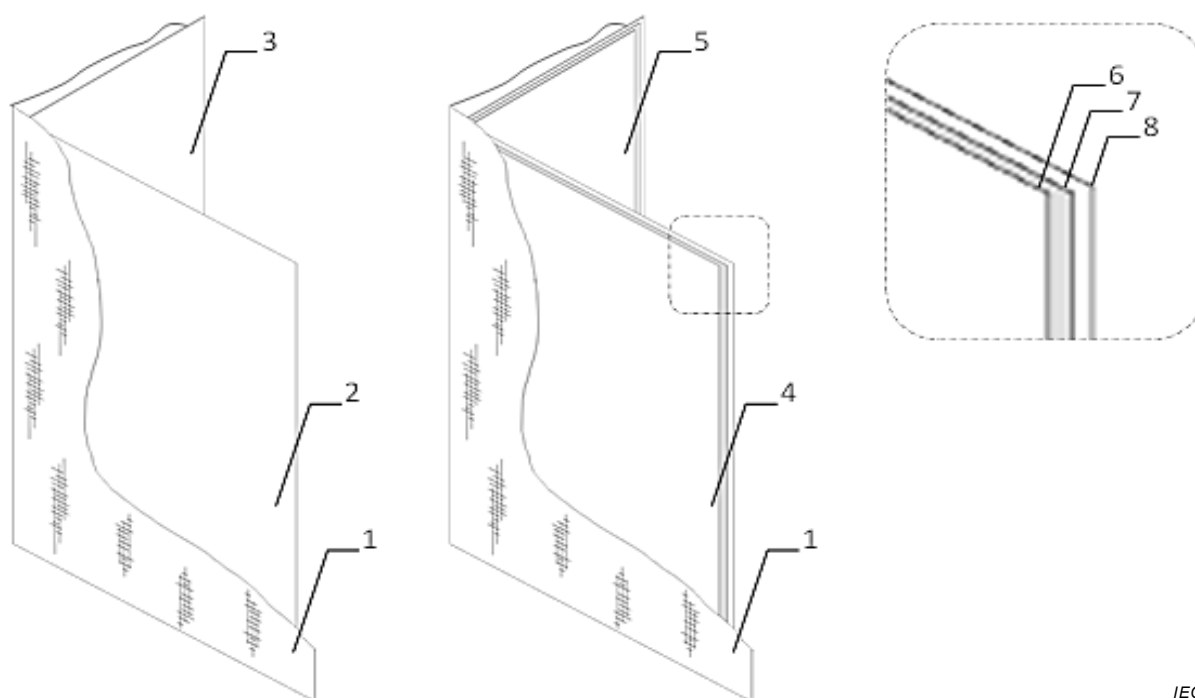
In Figure 1, the multi-layer inner liner is shown as comprising of three layers. In practice, more than three layers can be used. For the purposes of this document, an inner liner is

any layer of a multi-layer liner that does not physically contact either the FIBC or the product with which the FIBC is filled.

The electrical properties of the outside surface of a single layer or multi-layer inner liner can be the same as the inside surface, or they can be different. For example, one of the surfaces can be treated with a topical finish to reduce surface resistivity.

With multi-layer inner liners, there are many possible combinations of layers with similar or different electrical properties.

Notwithstanding the many possible combinations of materials for inner liners, for the purposes of this document it is the electrical properties of the outside surface and inside surface of inner liners that are of interest, together with the presence of any conductive internal layers.



IEC

Key

- | | |
|---|---|
| 1 FIBC | 5 inside surface of multi-layer inner liner |
| 2 outside surface of single layer inner liner | 6 external layer of multi-layer inner liner |
| 3 inside surface of single layer inner liner | 7 internal layer of multi-layer inner liner |
| 4 outside surface of multi-layer inner liner | 8 external layer of multi-layer inner liner |

NOTE For illustrative purposes, the layers of the multi-layer inner liner are shown separated. In practice, they are typically permanently bonded together.

Figure 1 – Examples of inner liners in FIBC

4.2.2 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.

4.2.3 Breakdown voltage measurements for inner liners

Breakdown voltage shall be measured according to 9.2 under the conditions specified in 8.2. The measured breakdown voltage is highly dependent on the thickness of the insulating material and its electrical resistivity. As even minor changes can affect the breakdown voltage,

the result only applies to the configuration of liner tested (including the thickness of the individual layers for co-extruded liners, in addition to the overall thickness).

When measuring breakdown voltage between an insulating layer and an internal conductive layer, a means of making electrical contact with the conductive layer is required. If an electrical connection is present, for example the earth bonding point on a finished liner, this can be used. When measuring films without earth bonding points, electrical contact with the conductive layer can be made using a staple inserted through the film, or by partially removing the insulating layer from an area at least 100 mm from the edge of the area where the electrode will be applied to the insulating layer. In the latter cases, either at least two staples shall be inserted, or at least two areas of insulating film shall be removed so that electrical connection to the conductive layer can be checked by measuring the resistance between staples or exposed conductive areas.

4.2.4 Type L1

Type L1 inner liners are made from materials with surface resistivity on at least one surface less than or equal to $1,0 \times 10^8 \Omega$ (see Annex F), measured under the conditions specified in 8.2. Type L1 shall not include internal conductive layers; such inner liners are classified as Type L1C (see 4.2.5). Type L1 inner liners may be used in Type C FIBC.

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 9.2 under the conditions specified in 8.2.

Fortuitous contact between the inner liner and the inside of the FIBC cannot be relied upon to ensure proper earthing of the inner liner. Therefore, the surface with resistivity less than $1,0 \times 10^8 \Omega$ shall be securely connected to the earth bonding system of the FIBC via specific connections. The connections to the earth bonding system of the FIBC shall be sufficiently strong to withstand the stresses present during filling, transport and emptying operations and maintain electrical continuity.

The total thickness of any layer(s) 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 (without conductive internal layers)

Configuration	Parameters			
	Resistivity of inside surface ρ_I	Resistivity of outside surface ρ_O	Breakdown voltage V_B	Thickness d
1	$\rho_I \leq 1,0 \times 10^8 \Omega$	$\rho_O \leq 1,0 \times 10^8 \Omega$	No measurement required	No limit
2A	$\rho_I \leq 1,0 \times 10^8 \Omega$	$\rho_O \leq 1,0 \times 10^{12} \Omega$	No measurement required	No limit
2B	$\rho_I \leq 1,0 \times 10^{12} \Omega$	$\rho_O \leq 1,0 \times 10^8 \Omega$	No measurement required	No limit
3	$\rho_I \leq 1,0 \times 10^8 \Omega$	$\rho_O > 1,0 \times 10^{12} \Omega$	$V_B < 4 \text{ kV}$	No limit
4	$\rho_I > 1,0 \times 10^{12} \Omega$	$\rho_O \leq 1,0 \times 10^8 \Omega$	$V_B < 4 \text{ kV}$	$d < 700 \mu\text{m}$
All layers with surface resistivity less than $1,0 \times 10^8 \Omega$ shall be securely bonded to earth when installed in FIBC.				

4.2.5 Type L1C

Type L1C inner liners are made from multi-layered materials with an internal layer of surface resistivity less than or equal to $1,0 \times 10^8 \Omega$ (see Annex F). Type L1C inner liners may be used in Type C FIBC.

The breakdown voltage between any surface with resistivity greater than $1,0 \times 10^{12} \Omega$ and the conductive internal layer shall be less than 4 kV, measured according to 9.2 under the conditions specified in 8.2.

The total thickness of any layer(s) 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 .

All layers with surface resistivity less than $1,0 \times 10^8 \Omega$ shall be securely connected to the earth bonding system of the FIBC via specific connections. The connections to the earth bonding system of the FIBC shall be sufficiently strong to withstand the stresses present during filling, transport and emptying operations and maintain electrical continuity.

Even if the surface of the inner liner in contact with the inside of the FIBC has a surface resistivity less than $1,0 \times 10^8 \Omega$, fortuitous contact between the inner liner and the inside of the FIBC cannot be relied upon to ensure proper earthing of the inner liner, and specific earth bonding connections are still required.

Permissible configurations and requirements for Type L1C inner liners are summarized in Table 2.

Table 2 – Permissible configurations and requirements for Type L1C inner liners (with conductive internal layers^a)

Configuration	Parameters			
	Resistivity of inside surface ρ_I	Resistivity of outside surface ρ_O	Breakdown voltage V_B	Thickness d
1	$\rho_I \leq 1,0 \times 10^{12} \Omega$	$\rho_O \leq 1,0 \times 10^{12} \Omega$	No measurement required	No limit
2	$\rho_I \leq 1,0 \times 10^{12} \Omega$	$\rho_O > 1,0 \times 10^{12} \Omega$	$V_B < 4 \text{ kV}^b$	No limit
3	$\rho_I > 1,0 \times 10^{12} \Omega$	$\rho_O \leq 1,0 \times 10^{12} \Omega$	$V_B < 4 \text{ kV}^b$	$d < 700 \mu\text{m}$
4	$\rho_I > 1,0 \times 10^{12} \Omega$	$\rho_O > 1,0 \times 10^{12} \Omega$	$V_B < 4 \text{ kV}^b$	$d < 700 \mu\text{m}$
^a All layers with surface resistivity less than $1,0 \times 10^8 \Omega$ shall be securely bonded to earth when installed in FIBC. ^b Breakdown voltage is measured between the surface with resistivity $> 1,0 \times 10^{12} \Omega$ and the conductive internal layer.				

4.2.6 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.

Materials with surface resistivity less than $1,0 \times 10^8 \Omega$ shall not be used in any layer within Type L2 inner liners.

If Type L2 inner liners are used in Type C FIBC, fortuitous contact between the inner liner and the inside of the FIBC cannot be relied upon to ensure proper earthing of the inner liner. Therefore, the surface with resistivity between $1,0 \times 10^9 \Omega$ and $1,0 \times 10^{12} \Omega$ shall be securely connected to the earth bonding system of the FIBC via specific connections. The connections to the earth bonding system of the FIBC shall be sufficiently strong to withstand the stresses present during filling, transport and emptying operations and maintain electrical continuity.

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 3.

Table 3 – 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	$1,0 \times 10^9 \Omega \leq \rho_I \leq 1,0 \times 10^{12} \Omega$	$\rho_O > 1,0 \times 10^{12} \Omega$	$V_B < 4 \text{ kV}^a$	No limit
3	$\rho_I > 1,0 \times 10^{12} \Omega$	$1,0 \times 10^9 \Omega \leq \rho_O \leq 1,0 \times 10^{12} \Omega$	$V_B < 4 \text{ kV}^a$	$d < 700 \mu\text{m}$
^a Breakdown voltage less than 4 kV cannot always be achieved if the thickness of the layer with resistivity greater than $1,0 \times 10^{12} \Omega$ exceeds 20 μm .				

4.2.7 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.

Materials with surface resistivity less than $1,0 \times 10^8 \Omega$ shall not be used in any layer within Type L3 inner liners.

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 4.

Table 4 – 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

When inner liners are used in FIBC, the inner liners and FIBC shall comply separately with their respective requirements, i.e. 4.2 for inner liners and Clause 7 for FIBC, and shall comply with all requirements specified for the combination, including the earthing requirements for Type C FIBC/Type L1/L1C/L2 inner liner combinations and ignition testing requirements for Type D FIBC/Type L2 inner liner combinations. 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 shall 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 document do not necessarily ensure that hazardous electrostatic discharges, for example cone discharges or spark discharges from charged conductive products, 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 5.

Table 5 – Use of different types of FIBC

Bulk product in FIBC	Surroundings		
MIE of dust ^a	Non-flammable atmosphere	Dust zones 21-22 ^b (1 000 mJ $\geq$ MIE > 3 mJ) ^a	Gas zones 1-2 ^b (explosion groups IIA/IIB) ^b or dust zones 21-22 ^b (MIE $\leq$ 3 mJ) ^a
MIE > 1 000 mJ	A,B,C,D	B,C,D	C,D ^c
1 000 mJ $\geq$ MIE > 3 mJ	B,C,D	B,C,D	C,D ^c
MIE $\leq$ 3 mJ ^d	C,D	C,D	C,D ^c

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 Non-flammable atmosphere includes dusts having MIE > 1 000 mJ.

^a Measured in accordance with ISO/IEC 80079-20-2, 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 6. 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 6.

Table 6 – Inner liners and FIBC: combinations that are permissible and not permissible in hazardous explosive atmospheres

FIBC	Inner liner			
	Type L1	Type L1C	Type L2	Type L3
Type B	Not permissible	Not permissible	Permissible	Permissible
Type C	Permissible ^a	Permissible ^b	Permissible ^c	Not permissible
Type D	Not permissible	Not permissible	Permissible ^d	Not permissible

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.

^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 $1,0 \times 10^8 \Omega$, measured according to 9.4 under the conditions specified in 8.2.

^b To ensure the inner liner is properly earthed, the resistance from any conductive layer of the inner liner to the groundable points on the FIBC shall be less than $1,0 \times 10^8 \Omega$, measured according to 9.4 under the conditions specified in 8.2.

^c To ensure the inner liner is properly earthed, the resistance from any dissipative layer of the inner liner to the groundable points on the FIBC shall be less than $1,0 \times 10^{12} \Omega$, measured according to 9.4 under the conditions specified in 8.2.

^d Combination of FIBC and liner shall meet the requirements of 7.3.2 tested under the conditions specified in 8.4.

Isolated conductive objects (e.g. tools, bolts, clips) shall 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 which case the conductive object will remain isolated from earth.

In accordance with general safety guidance (see IEC TS 60079-32-1 [1]), all conductive objects, including personnel, Type C FIBC and any conductive contents of FIBC, within a hazardous explosive atmosphere, shall be properly earthed. Type D FIBC are not considered to be conductive objects and are not required to be earthed.

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

6 Labelling

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

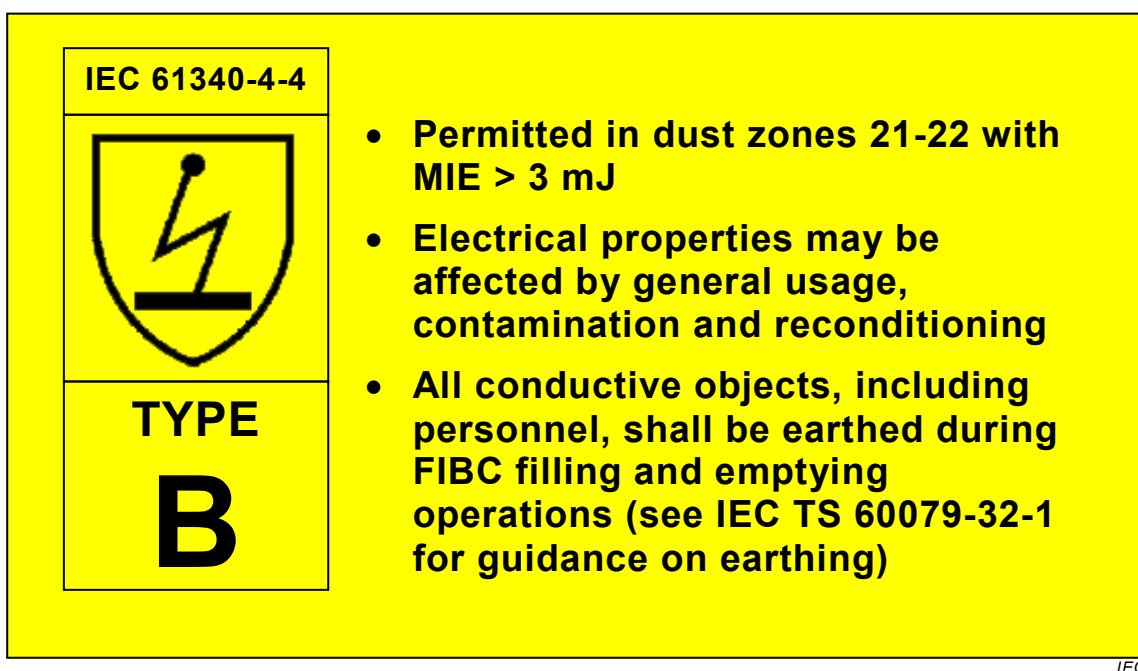
- a) the number of this document, i.e. IEC 61340-4-4;
- b) the type of FIBC, i.e. Type B, Type C or Type D (the type designation shall be emphasized so that it is easily readable at a glance);
- c) the symbol ISO 7000-2415:2004-01 on Type B, Type C and Type D to indicate protection from static electricity;
- d) for Type B, the phrase "permitted in dust zones 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, Type C and Type D the phrase "all conductive objects, including personnel shall be earthed during FIBC filling and emptying operations (see IEC TS 60079-32-1 for guidance on earthing)";
- k) certifying authority and certificate number (only for FIBC certified by independent certifying authorities).

Type A FIBC are not required to be labelled.

Yellow is preferred for the background colour for labels or marking, but other colours may be used. Conductive black material may be used for labels for Type C FIBC, but shall not be used for labels for Type B or Type D FIBC.

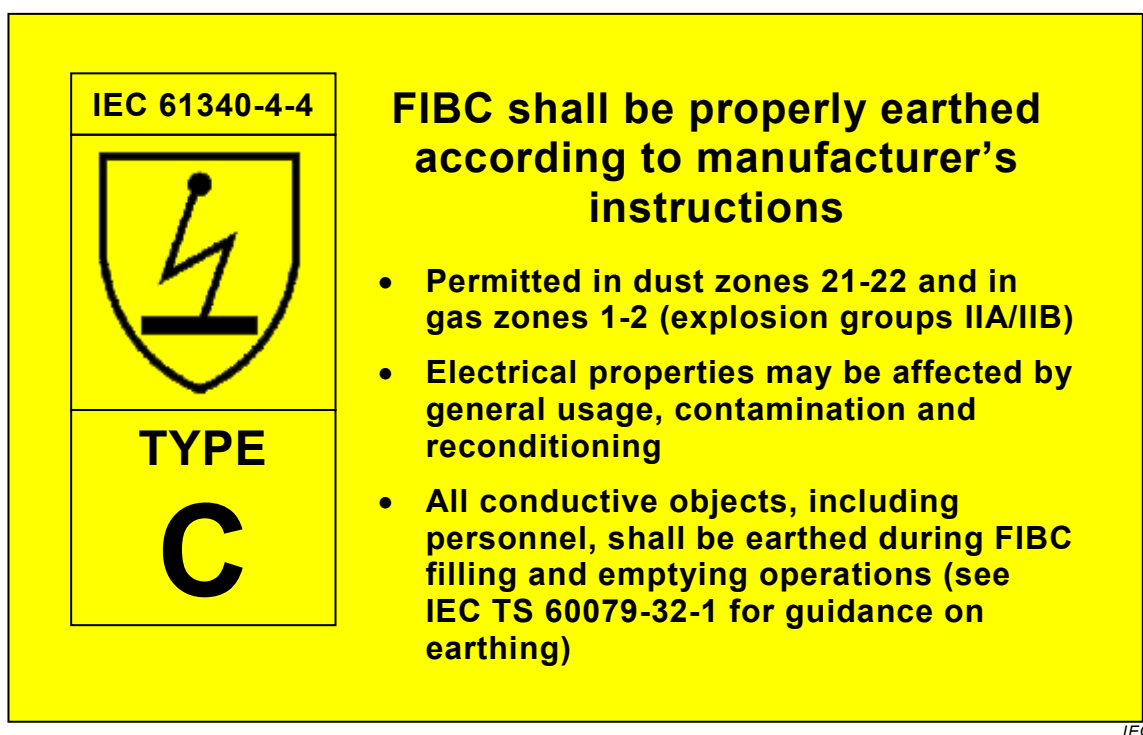
The designated earth bonding points on Type C FIBC shall be labelled or marked with the earth symbol (IEC 60417-5019:2006-08), as shown for example in Figure 5. The background colour for labels or marking shall be yellow and the lettering shall be black, or the background colour shall be black and the lettering shall be yellow. 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 2 to 4.



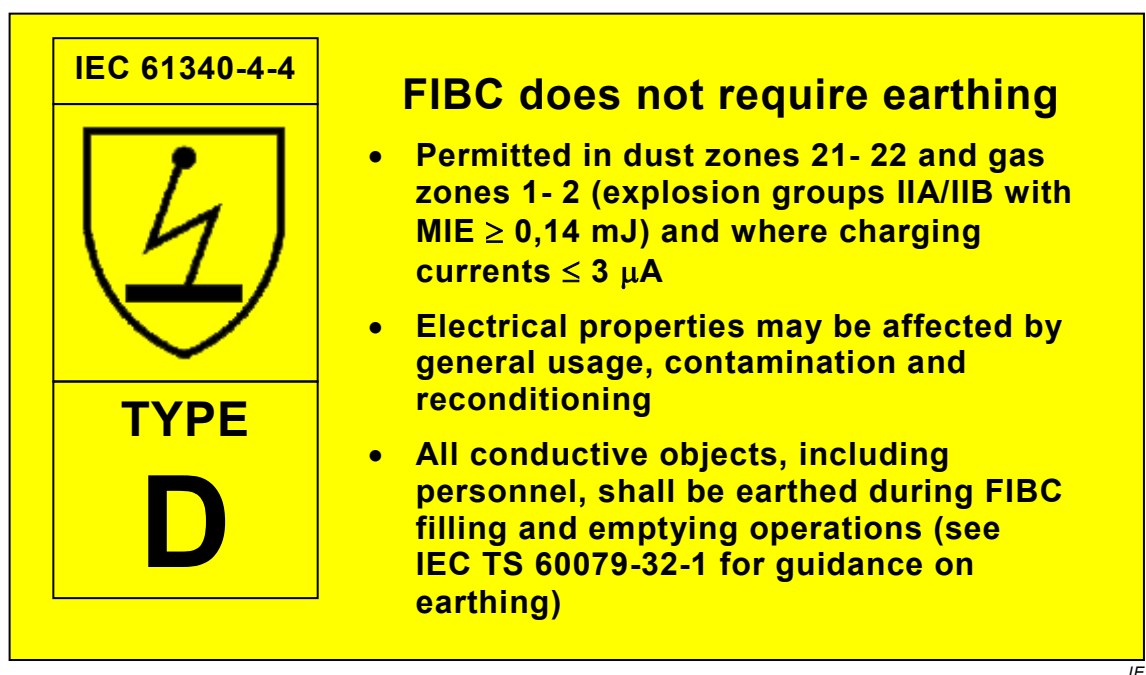
IEC

Figure 2 – Example of a label for Type B FIBC



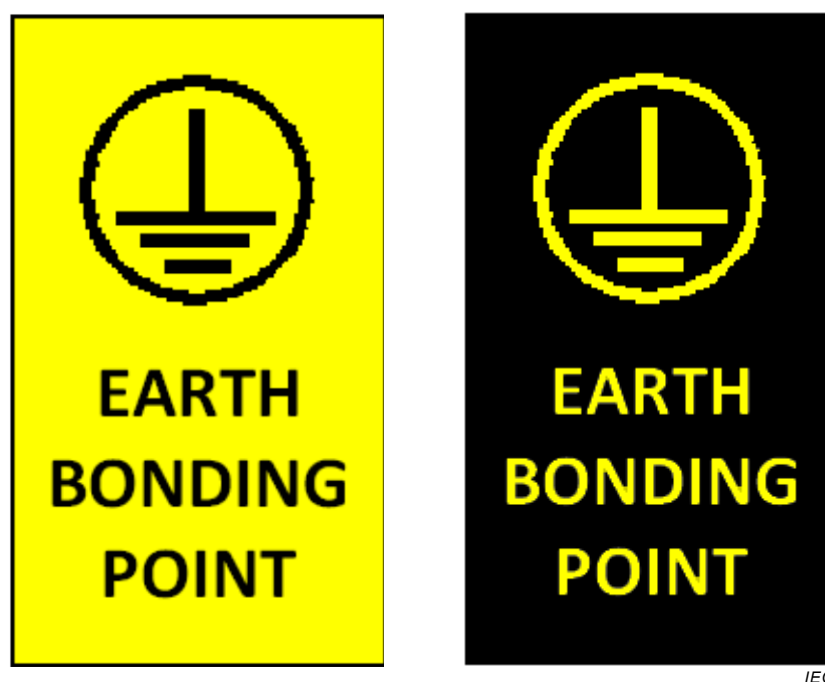
IEC

Figure 3 – Example of a label for Type C FIBC



IEC

Figure 4 – Example of a label for Type D FIBC



IEC

Figure 5 – Example of labels 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 document, 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 8.3 b).

Type C FIBC labels made from materials with surface resistivity less than $1,0 \times 10^8 \Omega$, 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 9.4 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 C FIBC labels 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, shall not be greater than 100 cm^2 in area, or greater than or equal to $700 \mu\text{m}$ in thickness.

Type D FIBC labels greater than 100 cm^2 shall be subjected to ignition testing according to 9.2 and shall meet the requirements specified in 7.3.2.

Printing ink can modify the surface electrical properties of labels. Therefore, measurements made to verify compliance with the requirements of Clause 6 shall be made on printed labels. Printed and unprinted surfaces of labels shall comply with the surface resistivity requirements of Clause 6.

7 Requirements for FIBC

7.1 General remarks

An 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.

For FIBC manufactured from multiple layers of materials that are not permanently and intimately bonded together over the entire surface area, the material requirements listed in 7.2 and 7.3 shall be applied separately to each layer of material.

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

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.

NOTE It is possible that compliance with the requirements of this document does not extend to FIBC that have been contaminated or degraded through use, or are used contrary to manufacturers' recommendations.

Type qualification certificates based on this document 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 an 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 an 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 9.2. The materials used to construct inner baffles, other than mesh or net baffles, shall also meet these requirements.

Although conductive materials can be used to achieve an electrical breakdown voltage of less than 6 kV, such materials shall not be used in the manufacture of Type B FIBC because there is a risk of incendiary sparks if such materials are not connected to earth.

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 $1,0 \times 10^8 \Omega$ (see Annex F) when tested according to 9.4. 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 $1,0 \times 10^8 \Omega$ when tested according to 9.4. If the inside layer does not have a resistance to groundable point of less than $1,0 \times 10^8 \Omega$, 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.

One or more groundable points shall be permanently attached to Type C FIBC. Earth bonding cables shall be attached to the groundable points during all filling and emptying operations.

Any lift loops attached to Type C FIBC shall be made from conductive material or shall at least contain conductive threads or tapes with a maximum spacing of 20 mm.

Lift loops may be designated as groundable points, but fortuitous earthing via lifting hooks cannot be relied upon as these may be painted/coated, or covered with powder etc., and so cannot guarantee an adequate earth path. Therefore, earth bonding cables shall be attached to lift loops if they are designated as groundable points.

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 9.3.

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 9.3 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.

When inner liners are used with Type D FIBC, the combination of FIBC and inner liner shall not cause any ignition when tested according to 9.3.

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 9.3, pellets shall be circulated at intervals during this period to ensure adequate conditioning.

8.2 Electrical breakdown voltage, surface resistivity 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 Surface resistivity 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 $(60 \pm 5) \%$ relative humidity.

8.4 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 Sampling

For qualification purposes, test samples shall be representative of production FIBC and FIBC/inner liner combinations as supplied. The following elements, and any others not listed here, shall be identical between test samples and supplied products:

- labels;
- document pockets, placards;
- inner liners (type, shape and size);
- inner liner attachment;
- design of FIBC (type, shape, size, attachments).

9.2 Electrical breakdown voltage

Breakdown voltage shall be determined in accordance with IEC 60243-1 and IEC 60243-2. The method used is specified in 10.1 of IEC 60243-1:2013, 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 can 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.

9.3 Ignition testing

9.3.1 Apparatus

9.3.1.1 General

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.

9.3.1.2 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 6). 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.

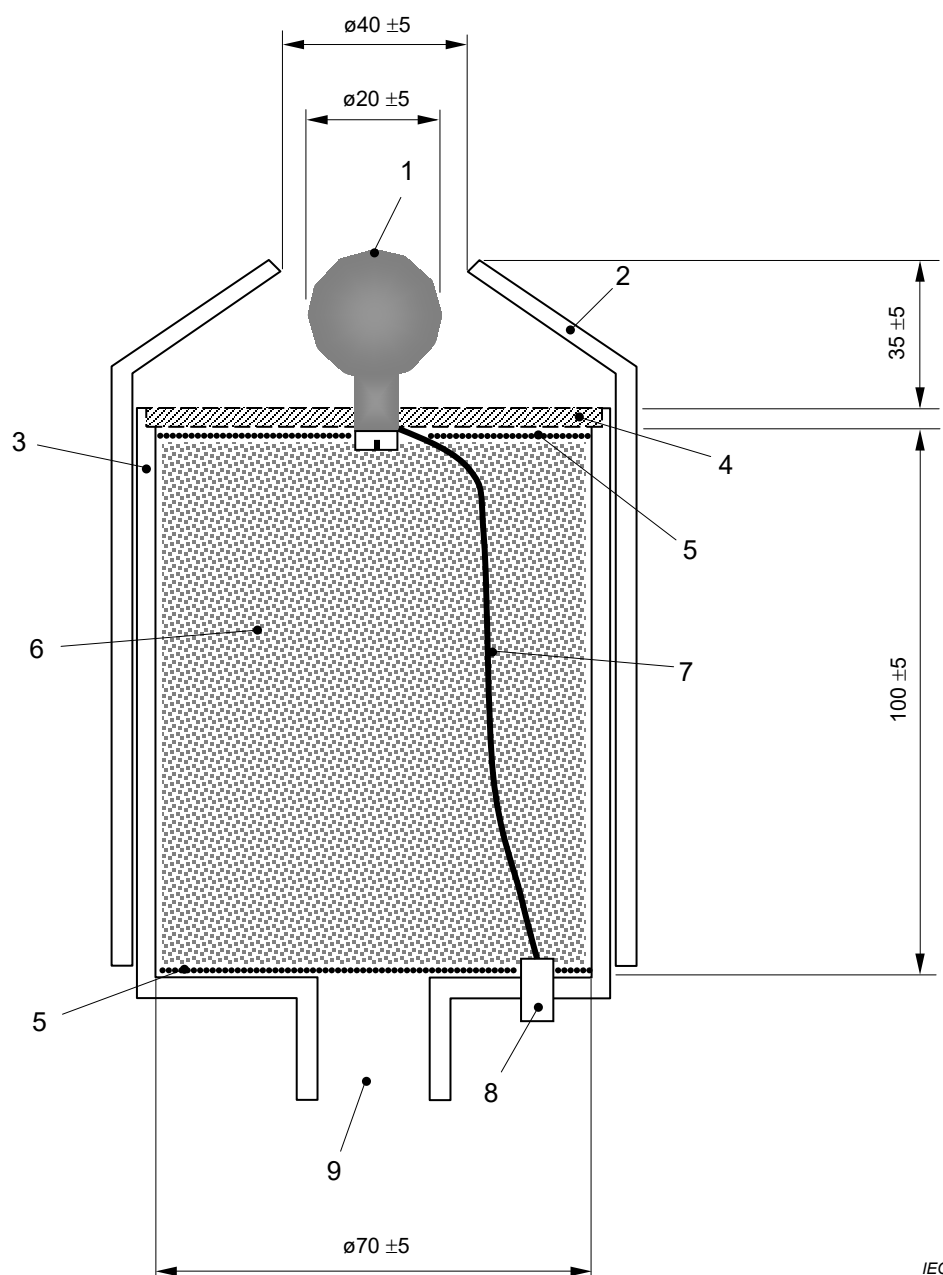
A metal plate is fitted to the other end of the cylinder to form a fixing base for the discharge electrode (see Figure 7). The metal plate is drilled with holes, (5 ± 1) mm in diameter, to allow the uniform flow of gas through it and around the discharge electrode.

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

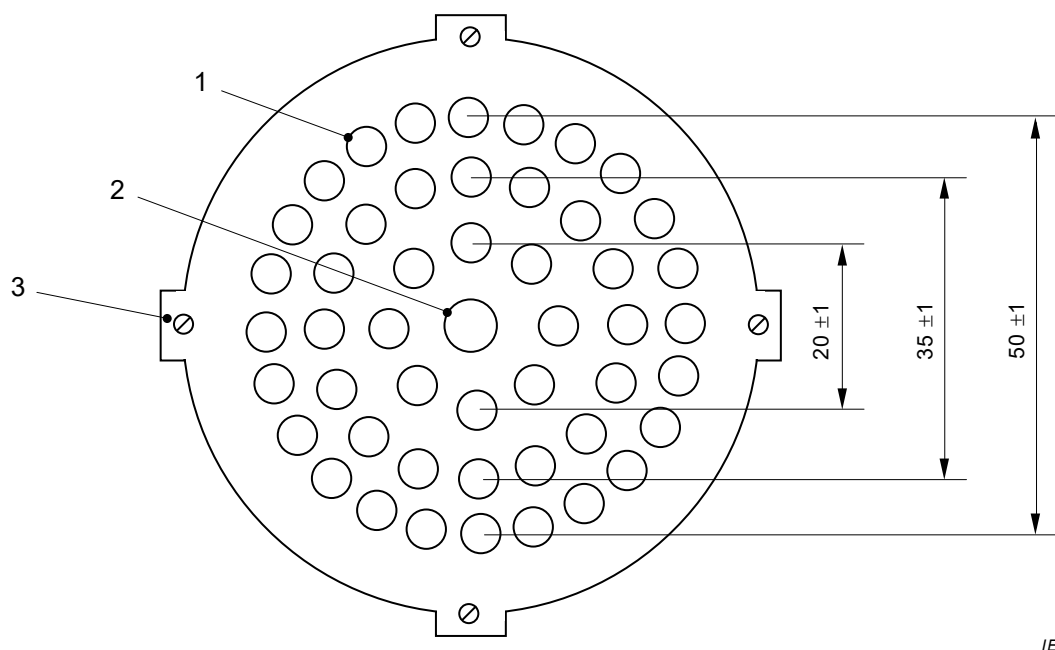


Key

- | | |
|---|--|
| 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 mm to 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 6 – Ignition probe

Dimensions in millimetres



IEC

Key

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

Figure 7 – Perforated metal plate for use in ignition probe**9.3.1.3 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 8).

The volume concentrations of gas used are shown in Table 7.

Table 7 – 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 7 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 can be different to that specified in Table 7.

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 ($79,0 \pm 0,5$) %

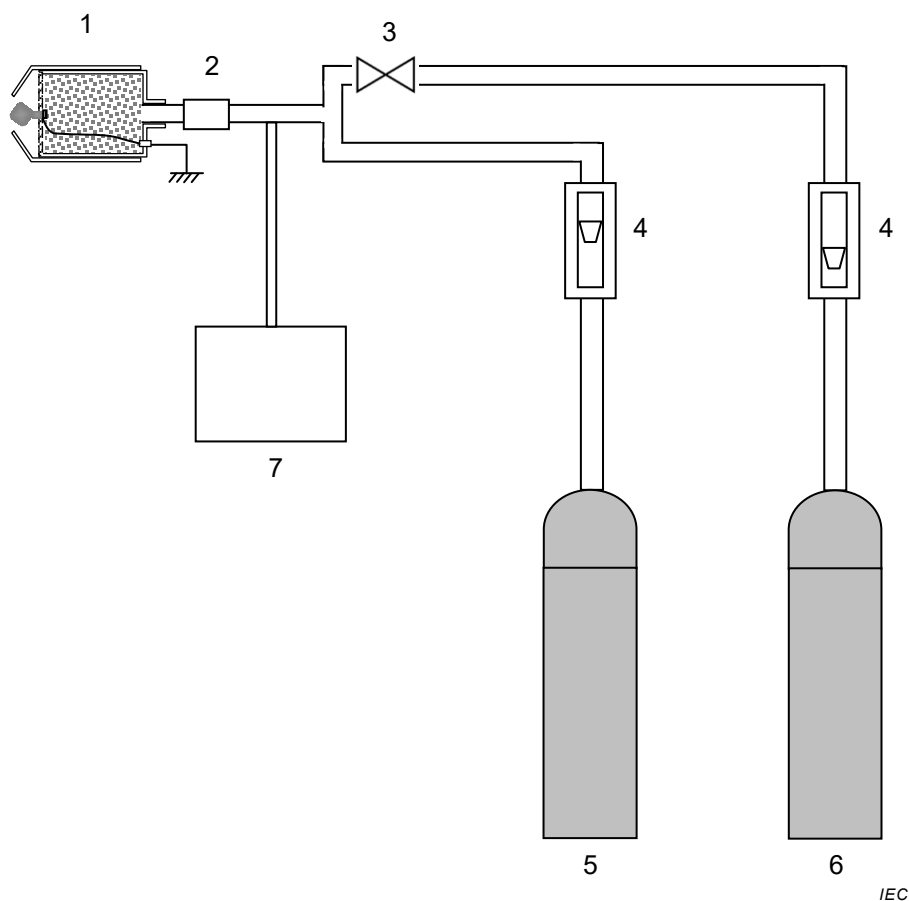
nitrogen may be used in place of air. If necessary, molecular sieve filters shall be used to ensure the gases have low moisture content. This is particularly important, for example, when using air directly from a compressor. Gases of at least 99,5 % purity shall be used.

"Breathing air", i.e. compressed air with low moisture and oil content, has a wider tolerance of oxygen concentration than is specified in Table 7 and shall not be used unless analysis shows that it meets the composition limits in Table 7.

NOTE 2 Some molecular sieves can 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 8 – Gas control and mixing apparatus (schematic)



9.3.1.4 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 9). 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 from 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 One way of checking the equivalence of different pellet materials is to carry out the procedures specified in 9.3.2 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 10). The size, number and geometry of corona points may vary, but shall be designed to ensure efficient charging of the pellets, which shall be verified using the procedure specified in 9.3.2. 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.

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.