9.4.4 Dust separators

In separators for flammable dusts insulating filter fabrics should not interrupt the earthing connections of parts made of conductive or dissipative materials, e.g. supporting cages of filter sleeves or metal clamps to keep the filter socks in place. Particularly when the MIE of the bulk material is lower than 3 mJ ensuring earthing of all metal parts such as clamps, etc. having a capacitance greater than 10 pF is of great importance. This limit is due to the practical experience that it is nearly impossible to make sure that even the smallest metal parts (single screws, clamps etc.) are always earthed by cable connections. The earthing and bonding should be guaranteed by the construction itself and/or by the properties of the materials used.

For this purpose the use of filter fabrics made of fibre containing conductive threads, or the use of normal filter socks with copper straps sewed around the end of the filter socks which automatically bond the supporting cages and metal clamps have proven to be very useful.

Filter fabrics made from conductive and earthed material should always be used where flammable vapours are present or where non-metallic conductive powders with a MIE less than 30 mJ are handled. Such fabrics should also be used for combustible metallic dusts having MIE less than 30 mJ provided that dry media type dust collectors are not expressly prohibited by prevailing regulation. The resistance to earth should be below 100 MΩ. The use of fibres containing conductive threads also helps to reduce charge on the powder and filter by corona discharge.

NOTE Al, Mg, Ti and Zr dusts usually have MIE of less than 30 mJ whereas Fe, Co, Ni, Cu and Mn dusts usually exceed this limit. More details can be found in NFPA 484, *Standard for combustible metal*.

9.4.5 Silos and Containers

9.4.5.1 General

Bulk materials should be handled and processed in such a way that a hazardous charge build up is avoided. A hazardous charge can be accumulated on the bulk material as well as on the wall of the silo or container.

NOTE This applies to large silos and containers as well as also to small mobile containers, bins, drums, bags, FIBC or other packages. The specific requirements for FIBC are given in 9.6.

Figures 1 to 3 detail how to analyse whether the bulk material itself can be charged to a hazardous amount during the filling of a silo or container. If required, measures against the occurrence of cone, lightning like or spark discharges have to be taken. The flow diagram to be chosen depends on the resistivity of the bulk material:

Figure 1: Assessment of low resistivity bulk material ($\rho \leq 1$ MΩ m)

Figure 2: Assessment of medium resistivity bulk material (1 MΩ m $< \rho \leq$ 10 GΩ m)

Figure 3: Assessment of high resistivity bulk material ($\rho >$ 10 GΩ m)

NOTE In Figures 2 and 3 $W_{cone\ discharge}$ means the maximum expected energy of the cone discharge (see A.3.7).

As an alternative to the measurement of the strength of the electrical field above the powder heap, this field strength may be estimated by modelling the electrical field within the silo taking into account charge relaxation during the filling procedure. Such model calculations should be based on the charge to mass ratio, bulk density and filling rate of the powder, the relative permittivity and resistivity of the bulked powder as well as on the silo geometry. If the radially directed electrical field stays below 3 MV/m, the criterion for the field of the bulked powder is fulfilled. The difference between the 500 kV/m average electrical field over the gap of the discharge and 3 MV/m limit value is based on the field distribution within silos, where the maximum field is always directed radially against the wall of the silo measured at the silo wall and not axially directed measured above the powder heap.

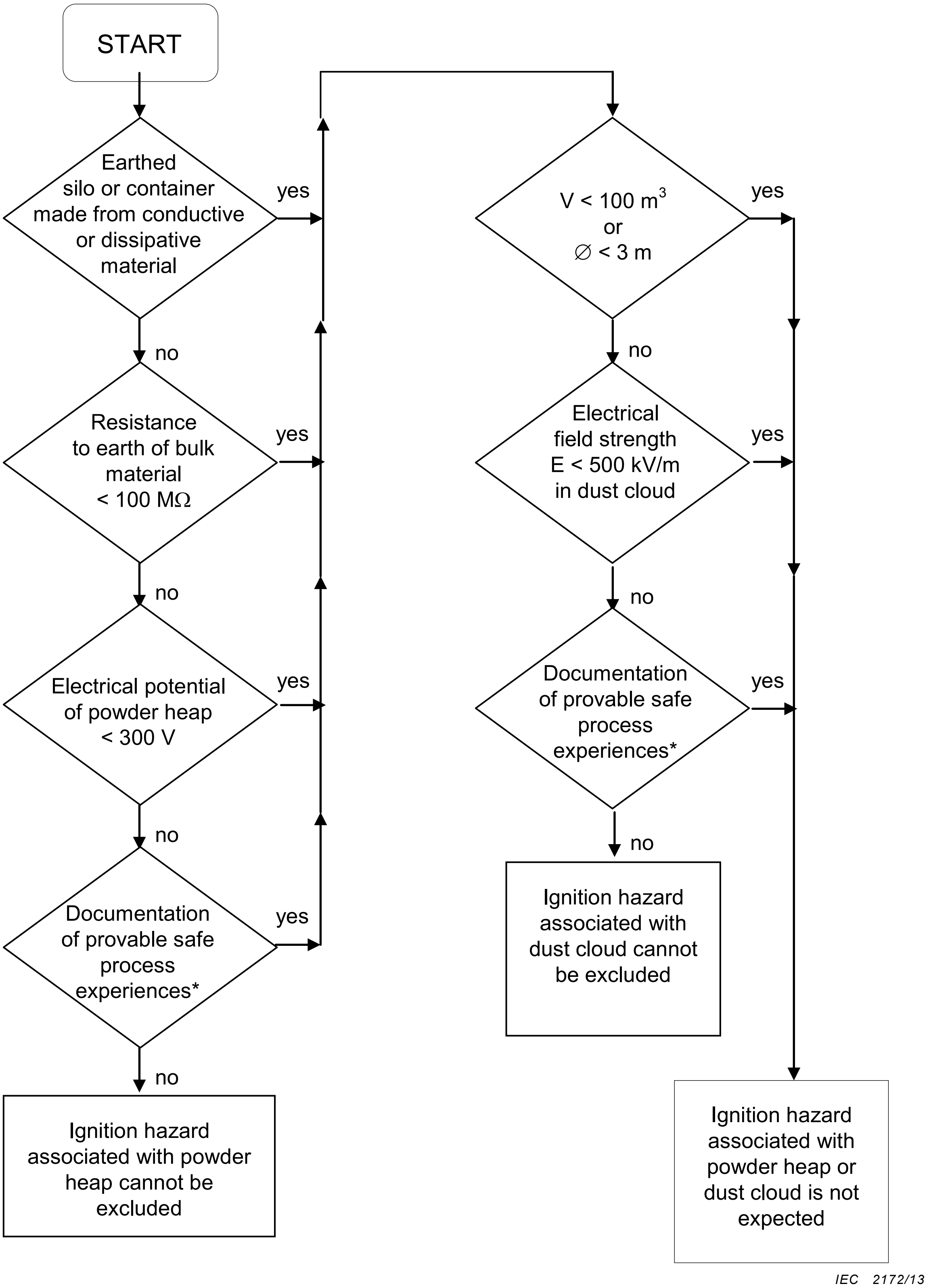
To assess the charge build up on the wall of the silos and containers 9.3 as well as 9.4 should be considered in addition.

During discharging of silos and containers in the absence of flammable gases and vapours no hazardous charge build up on the bulk material has generally to be expected. In addition all discharge and transfer devices require a separate analysis.

NOTE See also 9.3.

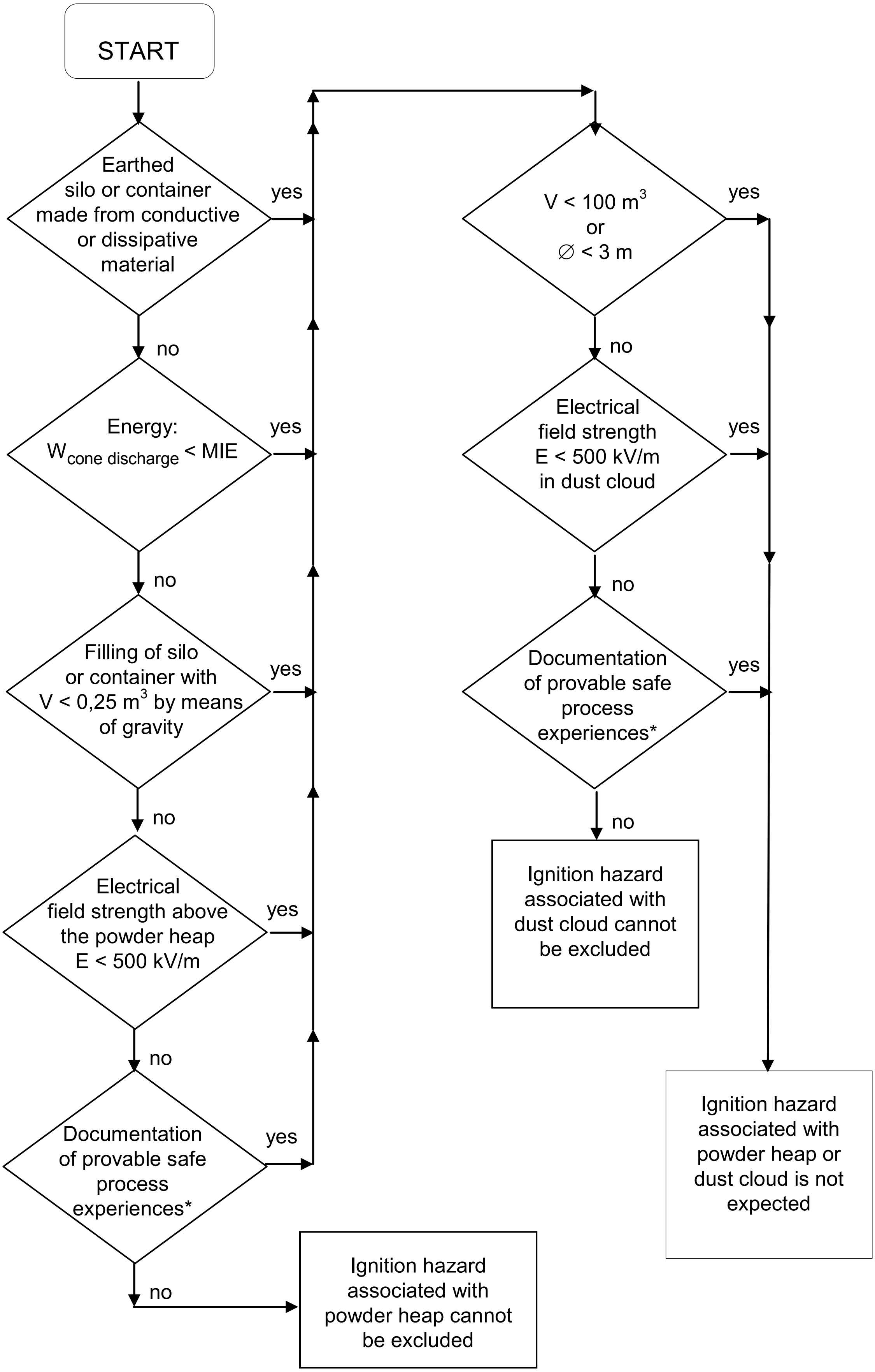
It should however be kept in mind that most discharging operations represent a filling operation for the successive silo or container.

Conductive silos and containers should be earthed and dissipative silos and containers should be in contact with earth during filling and emptying.



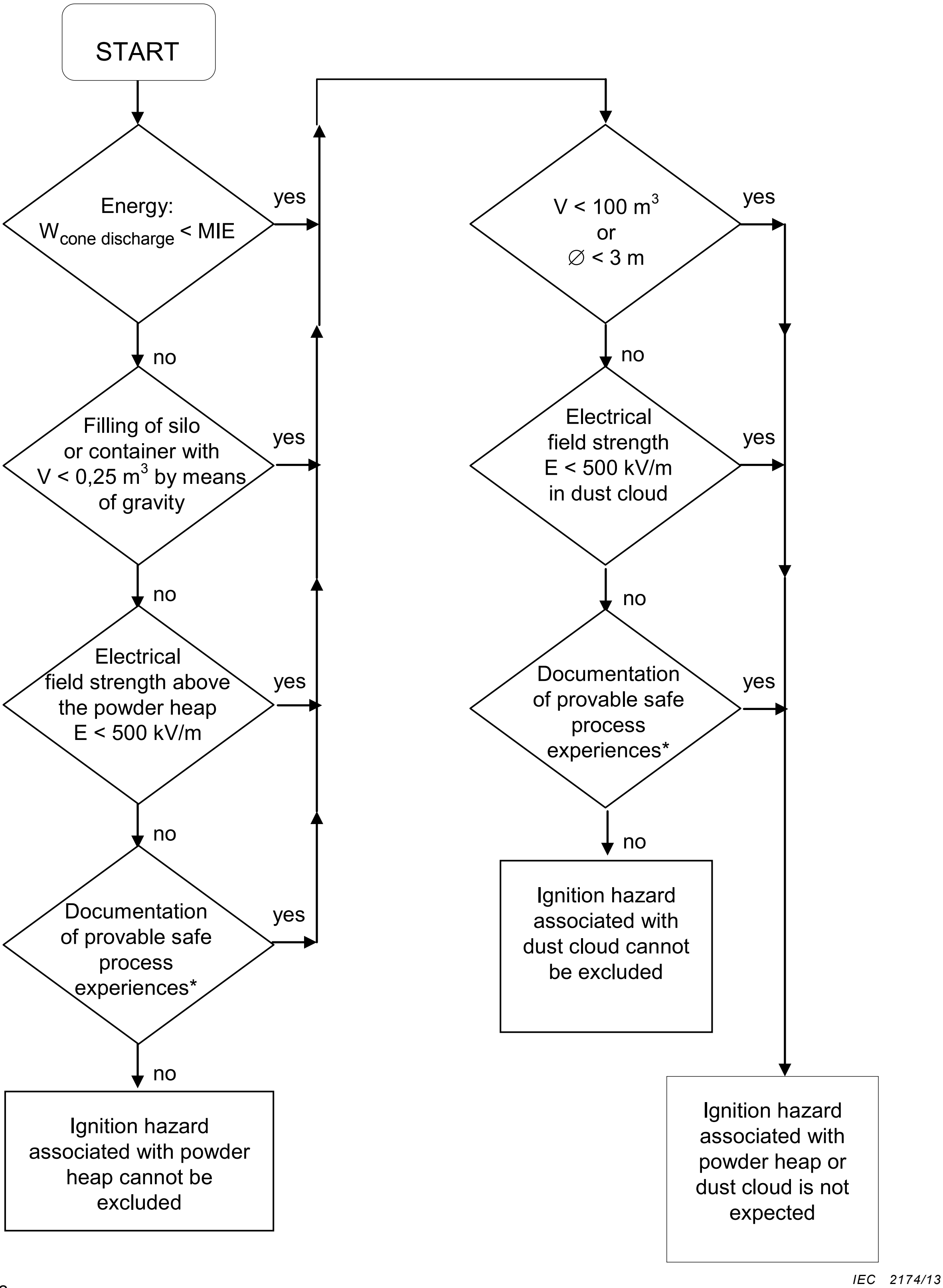
* see 9.4.5.2

Figure 1 – Flow diagram: Assessment of bulk material with ρ ≤ 1 MΩ m



* see 9.4.5.2

Figure 2 – Flow diagram: Assessment of bulk material with 1 MΩ m < ρ ≤ 10 GΩ m



* see 9.4.5.2

Figure 3 – Flow diagram: Assessment of bulk material with ρ > 10 GΩ m

9.4.5.2 Documentation of provable safe process experiences

If according to one of the flow diagrams in Figures 1 to 3 the ignition hazard is excluded based on the decision step "Documentation of proven safe process experiences", the explosion hazards should have been analysed in detail and subjected to an assessment. In this context it has to be kept in mind that minor changes in the process, product, equipment, packages, etc. may have a significant effect on the occurrence and incendivity of discharges as well as on the occurrence and concentration of an explosive atmosphere. The relevant justification explaining even the most marginal changes and their possible consequences should be explained in an explosion protection document. In any case, protective measures should to be taken (e.g. explosion venting, inerting, design for containment) where credible ignition sources cannot be excluded and flammable atmosphere is present.

NOTE In Europe, the explosion protection document is written according to Directive 99/92/EC.

9.4.5.3 Conductive and dissipative containers with conductive or dissipative liners

In addition to the measures listed in 9.3, only conductive and dissipative liners should be used in hazardous areas if they are safely earthed and if they remain earthed when taken out of or put into the container. This can be established e.g. by a reliable contact to earth via the container and a reliable contact to earth via the person when the liners are taken out or put into the container. Otherwise conductive and dissipative liners should not be taken out of or put into the container in a hazardous area.

9.4.5.4 Conductive and dissipative containers with insulating liners

Insulating liners should in general be avoided due to the risk of propagating brush discharges. They may only be used if, in addition to the measures listed in 9.3, at least one of the following conditions is met:

a) Volume $< 0,25$ m^3,

b) Breakdown voltage < 4 kV (6 kV in the case of woven materials),

c) Liner thickness > 10 mm

d) Documented evidence that no propagating brush discharges will occur.

NOTE Propagating brush discharges may occur depending on the thickness, the resistivity and the breakdown voltage of the liner as well as on the electrical properties of the bulk material. They are not expected for thin paint and polymeric coatings < 50 µm typically found inside containers due to the low breakdown voltage of such coatings.

If the bulk material has a resistivity of less than 100 MΩ m it should be earthed.

Earthing can be achieved e.g. by introducing one or several metal rods or metal pipes into the container leading down to the bottom of the container. These should be introduced prior to the addition of the conductive bulk material.

9.4.5.5 Insulating containers

Insulating containers should in general be avoided due to the risk of propagating brush discharges. They may only be used, if in addition to the measures listed in 9.3 at least one of the conditions a) – d) in 9.4.5.4 is met. If the bulk material has a resistivity of less than 100 MΩ m it should be earthed. Cone discharges should be avoided.

NOTE Propagating brush discharges may occur depending on the thickness, the resistivity and the breakdown voltage of the container as well as on the electrical properties of the bulk material.

9.4.5.6 Insulating containers with liners

Conductive liners should not generally be used in insulating containers due to the risk of them being isolated from earth. If conductive liners are indispensable they should reliably be earthed.

Insulating liners in insulating containers should be assessed as insulating containers according to 9.4.5.5.

9.5 Additional requirements for bulk material in the presence of flammable gases and vapours

9.5.1 General

In the presence of flammable gases or vapours a combination of the gas or vapour concentration and the suspended bulk material concentration (see 3.14) determines whether a flammable gas or vapour/air mixture or a so called hybrid mixture (mixture of flammable gases or vapours and flammable dusts in air) is formed. The minimum ignition energy (MIE) of the mixture is mainly determined by the amount of gas or vapour and commonly lies below the MIE of the pure dust. The flammable gas/vapour may arise from another source (e.g. if a powder is added to a flammable liquid), or from the powder itself (e.g. if it contains significant solvent or may evolve flammable gas).

Special care should be taken when handling solvent wet powders, because when handling large amounts of medium or insulating powders, brush discharges incendive for the evolved gas / vapour or hybrid atmosphere cannot be avoided.

Rather than differentiating between low, average or high resistivities of bulk materials as is the case when no flammable gases or vapours are present, the important limit of the bulk material resistivity in the presence of flammable gases or vapours is only 100 MΩ m.

The following requirements do apply only to gases and vapours of the explosion groups IIA and IIB. In hazardous zones of explosion group IIC inerting is necessary.

9.5.2 Measures for resistivity greater equal 100 MΩ m

The open handling of solvent wet bulk materials with a resistivity greater equal 100 MΩ m should generally be avoided. Where handling of such materials cannot be avoided, additional measures of explosion prevention or protection are normally required, particularly when handling large quantities. Such measures are

a) inerting,
b) processing of the solvent wet material under vacuum,
c) processing at a temperature significantly below the flash point,
d) processing within explosion proof equipment,
e) exclusion of the hybrid mixture, or
f) special constructional measures.

NOTE As handling of bulk material with a resistivity greater equal 100 MΩ m commonly generates a high level of electrostatic charges, brush discharges cannot be avoided and ignition is therefore possible.

9.5.3 Measures for resistivity less than 100 MΩ m

If the resistivity of the bulk material is less than 100 MΩ m, e.g. in case of bulk material containing a polar solvent, the bulk material should be handled in conductive earthed equipment or any other type of equipment that provides a sufficiently large earth point for the bulk material.

NOTE 1 In case of large amounts of bulk material a representative sample is required for an assessment of the resistivity. Instead of the resistivity also the nature and the amount of the solvent content can be used for an assessment.

NOTE 2 The bulk material as well as the flammable liquid might become charged to a hazardous level when filled into a container or added to a liquid.

9.5.4 Filling of bulk material into a container

Filling bulk material into a container containing flammable gases or vapours may lead to the generation of hazardous charging levels at the container to be emptied, at a liner, at the chute pipe or funnel, at the product falling into the collecting receiver, at the collecting receiver, at the product in the collecting receiver or at the operators. Filling of bulk material is, therefore, preferably performed with a closed and / or automated system, typically under inert gas atmosphere.

NOTE 1 Charge build up during the filling of bulk material from metal or plastic drums or from plastic bags has caused many fires and explosions in the past.

NOTE 2 Charge build up occurs when bulk material is discharged from a container or bag or if it flows through a chute, pipe or funnel.

Manual addition to an open vessel should be avoided whenever possible. If the open addition of powder to a container containing an explosive atmosphere cannot be avoided, special measures should be provided to reduce the charge build up:

a) Containers or packages to be emptied should be made from conductive or dissipative material.

b) During emptying, conductive containers or packages should be earthed and dissipative containers or packages should be in contact with earth.

   NOTE 1 Examples of dissipative materials used to make containers include paper, dissipative composite material and some plastic laminated papers. For packages made from dissipative material, e.g. paper bags, an earth contact via the hands of an operator is sufficient. In this case the floor, the shoes, and the gloves should also be dissipative and the resistance to earth should not be increased by contaminants.

   NOTE 2 During storage the dissipative property of the packages may be lost by aging, adsorption or if the relative humidity is low. Steps to increase relative humidity in storage areas may be necessary, especially at wintertime.

   NOTE 3 Dissipative plastic bags are normally not earthed via an earthing clamp but by contact to earth, e.g. by the operator only.

   NOTE 4 It is advantageous to handle sacks and bags etc. on a conductive support shelf or table with a clean surface connected to earth.

c) Insulating liners should not be used if they may come into contact with flammable gases / vapours.

d) Conductive liners should only be used in conductive or dissipative containers. It should be ensured that they are in good contact with the earthed container and remain earthed when they are taken out or put into the container. Otherwise they should not be taken out or put into the container in a hazardous area. During handling the liner should not become detached from the container.

e) Dissipative liners may be used in conductive or dissipative containers. It should be ensured that they are in good contact with the earthed container and remain in contact with earth when they are taken out or put into the container. Otherwise they should not be taken out or put into the container in a hazardous area. During handling the liner should not become detached from the container.

f) Multiple layer packages or packages with insulating coatings should be avoided whenever possible. If they have to be used for other reasons, the following conditions have to be met:

   – The insulating coating should not be thicker than 2 mm, and

   – All conductive or dissipative layers of the package should always be earthed or in contact with earth.

g) Auxiliary devices for the addition of the bulk material should be conductive and earthed. Any chute or funnel should have a maximum length of 3 m.

   NOTE Examples of such auxiliary devices are shovels, funnels, chutes, etc.

h) Earthing of all involved operators should be ensured.

i) The rate of adding the bulk material should be limited to 1 kg/s.

However, due to the high level of risk inherent with such operations, it may still be necessary to use additional control measures to achieve the required level of safety.

If by the addition of the bulk material a suspension or emulsion is formed in the receiving vessel – even only for a short period of time – it should be considered that agitation of such a multiple phase system may generate a hazardous charge build up independent of the charging procedure. In these cases 7.9.4 has to be taken into account.

NOTE 3 A typical example is the addition of pigments when manufacturing dyes, lacquers and paints.

9.6 Flexible intermediate bulk containers (FIBC)

9.6.1 General

Flexible intermediate bulk containers (FIBC) are used in industry for storage and transport of powders and granules. They are commonly constructed from polypropylene fabric or similar strong and heavy duty insulating material.

Electrostatic charge can be generated during filling and emptying and it can accumulate on the product as well as on the fabric from which a FIBC is constructed or on any parts of it. An ignition could occur if the accumulated charge is released in the form of an incendiary discharge in the presence of a flammable atmosphere. Spark, brush, cone and propagating brush discharges are all possible when FIBC are used.

The requirements and specifications which FIBC should meet depend on the nature and sensitivity of the flammable atmosphere present during filling and emptying. The final goal for the construction of FIBC is to exclude incendive discharges from the FIBC fabric during their intended use. Since discharges of different incendivity (i.e. different types of discharges, such as spark, brush or propagating brush discharges) may be generated, the necessity of their exclusion and thus the requirements for construction of the FIBC depends on the intended use of the FIBC. For this reason different types of FIBC have been developed, which are defined as Type A, B, C or D (see IEC 61340-4-4):

– Type A FIBC are made from fabric or plastic sheet without any measures against the build up of static electricity.
– Type B FIBC are made from fabric or plastic sheet designed to prevent the occurrence of sparks and propagating brush discharges.
– 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.
– 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.

Depending on the mechanism applied to exclude incendive discharges, the requirements which the different types of FIBC should meet, refer either to purely physical parameters such as breakdown voltage and conductivity (Type B and C) or to more general procedures in which it should be demonstrated that no incendive discharges occur (Type D). These requirements are given in IEC 61340-4-4.

The four different types of FIBC should be used as shown in Table 19. Other types of FIBC or FIBC of unknown type should only be used in the presence of flammable atmospheres after detailed evaluation by an expert.

Document pockets and pouches made from insulating material should fulfil the requirements of IEC 61340-4-4 which are similar to 6.3. In the case of document pockets for Type C it should be considered that they are usually backed with an earthed conductive fabric which helps to prevent a high surface charge.

Table 19 – Use of the different types of FIBC

Bulk Product in FIBC	Surroundings		
MIE of dust[a]	Non flammable atmosphere	Dust zones 21-22[b]	Gas zones 1-2[b] (Explosion Groups IIA/IIB)[c]
MIE > 1 000 mJ	A,B,C,D	B,C,D	C,D[d]
3 mJ < MIE ≤ 1 000 mJ	B,C,D	B,C,D	C,D[d]
MIE ≤ 3 mJ	C,D	C,D	C,D[d]

[a] Measured in accordance with IEC 61241-2-3, ASTM E2019 and EN 13821 with a capacitive discharge circuit (no added inductance).

[b] See D.2 for the definition of zones.

[c] See D.3 for an explanation of Explosion Groups.

[d] Use of Type D should be limited to Explosion Groups IIA/IIB with MIE ≥ 0,14 mJ.

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.

NOTE 3 The MIE limit of 3 mJ is based on the incendivity of cone discharges. Cone discharges might have a much higher energy in a Type B FIBC than in a Type C or D FIBC because the wall of a Type C or D FIBC will be at close to zero potential. Based on this fact the internal field distribution will be such that in Type C or D FIBC cone discharges will at most only jump across half the diameter of the FIBC. A calculation with the formula given in A.3.7 for the largest FIBC commonly used (diameter of 1,5 m) yields 3 mJ for powder with a median size of only 0,055 mm in a Type B FIBC, whereas in a Type C or D FIBC the 3 mJ limit is only reached with a coarse powder having a median size of 0,27 mm or higher. However, such coarse powders usually have a MIE higher than 3 mJ.

In order for a propagating brush to occur from a FIBC in practice, it is generally necessary to handle a high resistivity powder in a way that leads to high levels of electrostatic charge generation (e.g. pneumatic transfer). If these conditions are not met, particularly with medium or high MIE powders, then a detailed expert assessment may conclude that the risk of an incendive propagating brush discharge is acceptably low.

The ability to use FIBC safely 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 atmospheres are shown in Table 20. In addition there are some precautions that certain combinations of FIBC and inner liner should meet. These precautions are also shown in Table 20.