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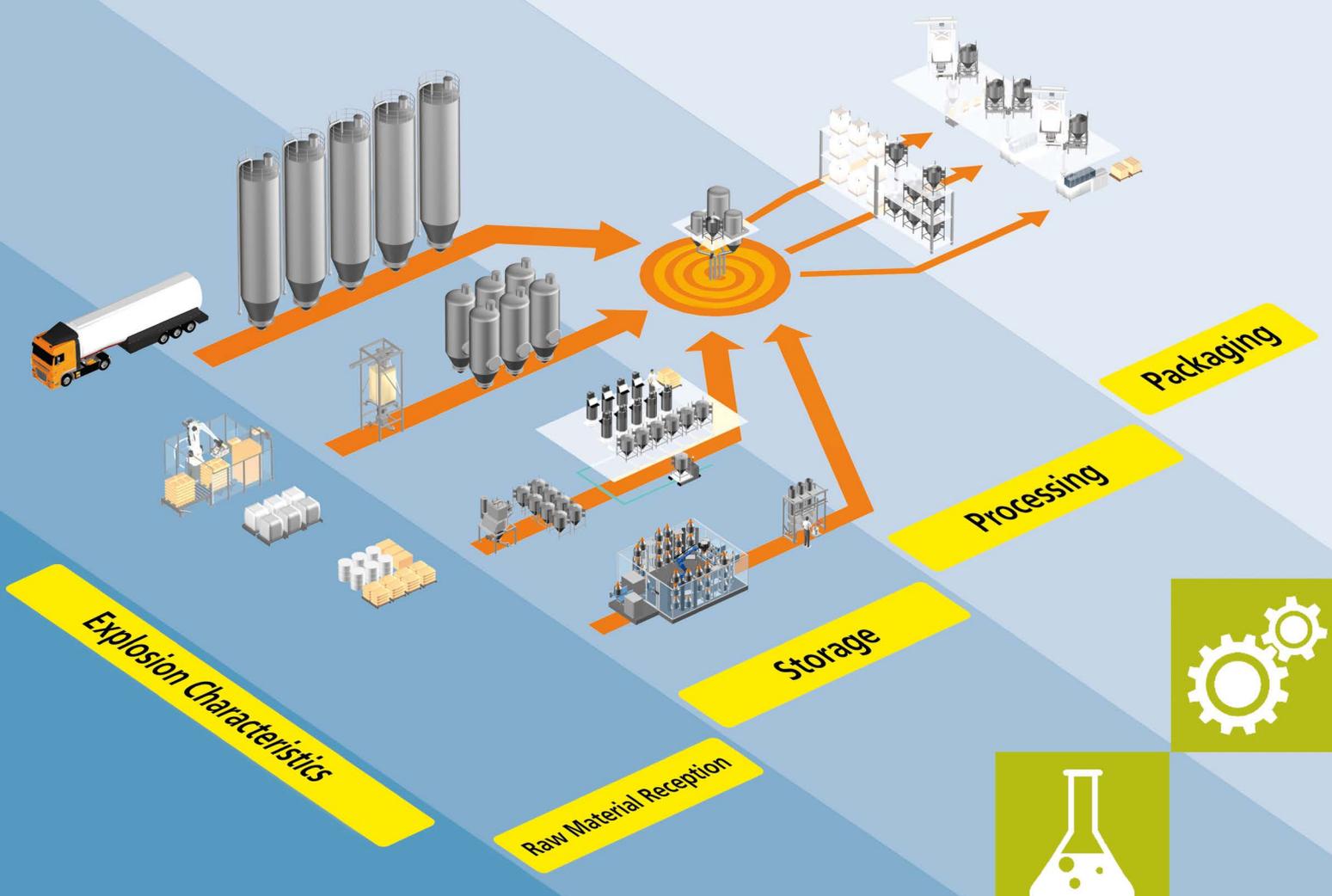
Section on Prevention in the Chemical Industry
Section on Machine and System Safety

Explosion safety of bulk material plants

Module: Packaging

2/2026

Process Steps



Explosion Characteristics

Raw Material Reception

Storage

Processing

Packaging



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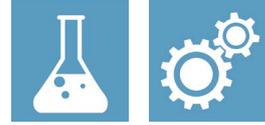
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Explosion Safety of Bulk Material Plants

Module: Packaging

Legal regulations refer to both the employer and the entrepreneur. The two terms are not completely identical because entrepreneurs do not necessarily have employees. In the context of the present topic, this does not result in any relevant differences, so that these terms are used synonymously.

To facilitate readability, the forms chosen for personal designations (e.g. employer, entrepreneur) apply to both genders in this brochure.

Content

	Foreword	7
1	Introduction.....	8
2	Assessment of electrostatics as an ignition hazard of an explosive atmosphere when handling packaging materials.....	10
	2.1 Explosive atmosphere	10
	2.2 Ignition source electrostatics.....	11
	2.2.1 Discharge types	11
	2.2.1.1 Spark discharge	11
	2.2.1.2 Corona and brush discharge	12
	2.2.1.3 Propagating brush discharge (GSB)	12
	2.2.1.4 Cone discharge (SKE)	14
	2.2.1.5 Lightning-like discharge	15
	2.2.2 Ignition probabilities of the different types of discharge	15
	2.2.3 Definitions and limit values for the conductivity of media and materials.....	16
	2.2.3.1 Conductive	16
	2.2.3.2 Dissipative	16
	2.2.3.3 Insulating.....	16
	2.2.4 Limit value for conductivity of bulk materials	16
	2.2.5 Earthing.....	16
	2.2.6 Electrostatic ignition hazards emanating from the various packaging materials and bulk materials	17
	2.2.7 Electrostatic ignition hazards emanating from employees.....	25
	2.2.7.1 Footwear	25
	2.2.7.2 Clothing.....	25



3	Packaging for bulk materials, taking into account their suitability for avoiding electrostatic ignition hazards during filling and emptying	26
3.1	Packaging for solvent-free bulk materials without flammable gases, vapors or hybrid mixtures from the environment	28
3.2	Packaging for solvent-free bulk materials but flammable gases or vapors from the environment possible (zone 1 or 2)	40
3.3	Packaging for solvent-moist bulk solids (flammable solvent) with or without flammable gases or vapors from the environment (zone 1 or 2)	50
3.4	Bulk packaging with volumes > 0.25 m ³ (flexible bulk containers, big bags, containers, octabins, etc.)	60
4	Bibliography	63
	The ISSA	64
	Legal notice	66

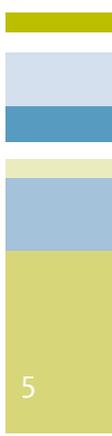




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Foreword

In this module, packaging for bulk material is evaluated with regard to the ignition source “discharges of static electricity”. A distinction is made between the possible discharge types that can originate from the bulk material and those that can originate from the packaging.

The suitability of a variety of packaging is assessed depending on their type (e.g. insulating plastic bags, dissipative plastic bags, paper bags, drums), their volume and the specific resistance of the bulk material, and the necessary measures for safe use are identified.

Furthermore, a distinction is made between solvent-moist and solvent-free bulk material and the possibility of the presence of flammable gases, vapors and hybrid mixtures is also taken into account.

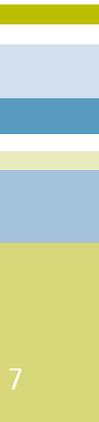
The resulting multitude of possible combinations is presented in tabular form and the respective suitability is illustrated in the form of color coding.



Thomas Köhler
President of the Section on
Prevention in the Chemical Industry



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President of the Section on
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1 Introduction

Fires and explosions occur time and again in the chemical, pharmaceutical, food, animal feed and general process industries when filling and emptying packaging with flammable bulk materials. This is due to a wide variety of reasons:

- The filling and emptying of packaging is usually carried out openly, i.e. under atmospheric conditions. If the bulk material is flammable and fine-grained or if the transfer operation is carried out in the presence of flammable gases or vapors, such as when solids are introduced into a solvent, the formation of an explosive atmosphere can hardly be avoided. Depending on the operating situation, this may be a dust-air or solvent vapor-air atmosphere or a hybrid mixture. Even in the event of coarse-grained bulk material, fine-grained product can form due to abrasion during transportation, for example.
- If an explosive atmosphere cannot be avoided, the avoidance of all effective ignition sources is the only protective measure to prevent an explosion. Ignition sources that are not directly associated with the transfer process, such as open flames, welding, smoking, electrical installations, must be excluded by organizational measures and suitable equipment selection and installations. The same applies to hot surfaces and mechanically generated sparks. Static electricity is a particularly insidious source of ignition. This is particularly true because it is directly associated with filling or emptying operations and is difficult to avoid, depending on the packaging material and bulk goods.
- Electrostatic charging of packaging materials and filling goods is in many cases directly linked to operational processes and operations. It represents an ignition source that can become effective under normal conditions, i.e. without any malfunction occurring, but also in the event of deviations.
- As stated in the points described above, fuel and oxygen (formation of an explosive atmosphere) as well as the electrostatic ignition source are brought together in terms of location and time during open filling, emptying and transfer operations, thus closing the hazard triangle. It is therefore not surprising that fires and explosions repeatedly occur during these operations if no additional protective measures are taken.
- Measures to prevent electrostatic charges are often of an organizational nature, such as grounding mobile packaging materials and feeding or discharge aids. The reliability of these measures is therefore strongly influenced by possible human error.
- The phenomena of electrostatics, such as induction, are not always easy to understand and therefore not easy to predict. Both a basic knowledge of physics and experience from the process industry are required to assess the dangers resulting from electrostatic charges.
- The last two issues mentioned require a high level of training for personnel, from those working on the reaction vessel to the planning engineers and chemists. This level of training is often difficult to guarantee, especially in times of rapid personnel and structural change.
- Measures to prevent ignition hazards due to electrostatic charges often conflict with other requirements and protective measures, such as the weight of the packaging material, compatibility with the filling product, water vapor permeability, working under GMP (Good Manufacturing Practice), accident prevention, productivity, cost-effectiveness, etc.



- Changes and innovations in process engineering or equipment technology are often introduced without considering the consequences with regard to electrostatic charges and without taking into account the ignition hazards caused by electrostatics. For example, the bulk material supplier switches to a new packaging material without informing the customer sufficiently, or the production plant changes the raw material supplier and receives the product in a different packaging.
- In addition to other sources of ignition such as open flames, hot gases, mechanically generated sparks, electrical equipment, etc., particular attention must be paid to hot surfaces when handling packaging, especially when using equipment for sealing film bags.

2 Assessment of electrostatics as an ignition hazard of an explosive atmosphere when handling packaging materials

2.1 Explosive atmosphere

During filling or emptying operations of packaging, an explosive atmosphere may be created by the filling material or by flammable substances in the environment. Examples of this are:

- Dust cloud emanating from the fine fraction of the bulk material that is whirled up during transfer
- Solvent vapors emanating from solvent-moist filling material
- Solvent vapors or gases from the environment
- Hybrid mixture of fine dust and flammable gases or vapors

In the presence of an explosive dust cloud, the formation of a hybrid mixture must be assumed if flammable gases or vapors with a concentration of more than approx. 20 % LEL (lower explosion limit) are present [1]. As a rule of thumb, hybridization can be assumed for flammable liquids if the working temperature is less than approx. 40 K below the flash point of the liquid. In the case of dusts with a high minimum ignition energy, this "hybridization effect" can already occur at fuel gas concentrations below 20 % LEL. However, with regard to the rather low-energy ignition source electrostatics to be assessed here, the limit value of 20 % LEL (lower explosion limit) applies to the formation of a hybrid mixture.

After a drying process from solvent at an elevated temperature in a vacuum, it can be assumed that, with a residual moisture content of less than 0.5 % by weight, the formation of a hybrid mixture is no longer to be expected, provided that no further crushing processes are carried out (breaking up of pores and renewed release of solvent vapors).

From the point of view of electrostatics as an ignition source, the question of whether a pure dust-air mixture or a hybrid mixture can be present is of great importance, since brush discharges (see section 2.2.1) cannot ignite pure dust-air mixtures, but can ignite hybrid mixtures.

To assess the probability of an explosive atmosphere occurring and to evaluate its ignition sensitivity, the following parameters must be known:

- Particle size distribution in the bulk material or at least median value and fines content below 63 μm
- Solvent content in the bulk material as well as flash point of the solvent in question and working temperature
- Flash point of possible solvents in the environment and working temperature
- Ex zone in which the filling and emptying process takes place
- Minimum ignition energy of the bulk material
- Minimum ignition energy of the flammable gas or solvent vapor or at least the relevant explosion group

The choice and reliability of different packaging materials depends largely on the above-mentioned properties of a potentially explosive atmosphere.



2.2 Ignition source electrostatics

Whether static electricity can become an effective ignition source or not depends largely on which materials are charged, how these materials are arranged and how ignition-sensitive the explosive atmosphere is. In the relevant literature, this situation is taken into account by differentiating between various so-called discharge types, see references [2–5]. Depending on the charged material and geometric arrangement, different types of discharge can occur (spark, brush, propagating brush, corona, cone discharge), which in turn can be assigned different ignition capabilities. These types of discharge are briefly described below.

Finally, Table 1 provides an overview of the different types of discharge and their ignition capabilities.

2.2.1 Discharge types

2.2.1.1 Spark discharge

Spark discharges occur between two conductive objects at different potentials, typically between an earthed object and an electrostatically charged object. The charging of such insulated conductors in practice can occur either by separation processes between insulating materials and the insulated conductive system part or between conductive materials and non-conductive system part or via induction. The difference in potential between the charged object and the earthed, conductive object generates an electric field in the space between them. Depending on the difference in potential and distance, the electric field in the gap can reach the breakdown field strength (approx. 3 MV/m under normal conditions) and trigger a spark discharge. The energy W of such a spark discharge can be calculated using the equation

$$W = \frac{1}{2} \cdot CU^2 \quad 1$$

C is the capacitance of the insulated, conductive object and U is its potential. To assess the ignition hazard, the energy obtained according to equation (1) must be compared with the minimum ignition energy of the explosive atmosphere in question. The value of the minimum ignition energy obtained without additional inductance in the discharge circuit is to be used here. In principle, flammable gases, vapors and dusts can be ignited by spark discharges. Spark discharges must therefore be avoided by earthing all conductive system parts and materials wherever explosive atmospheres are to be expected.

2.2.1.2 Corona and brush discharge

If charges of one sign are distributed on the surface of an insulator, so-called corona discharges (also known as point discharges) or brush discharges can occur as soon as an earthed electrode is brought close to the surface. Whether a corona or brush discharge occurs depends on many factors such as the radius of curvature of the electrode, the approach speed of the electrode and the polarity of the surface charges. In practice, it can generally be assumed that only corona discharges occur if the radius of curvature of the electrode is less than approx. 0.5 mm. If the radius of curvature is greater than approx. 5 mm, brush discharges primarily occur. In the intermediate range between a radius of curvature of 0.5 to 5 mm, both types of discharge are possible.

With regard to a risk assessment in practice, it should always be assumed that the higher-energy brush discharges occur in the sense of considering the worst-case scenario. However, corona or brush discharges do not only occur in connection with highly charged insulating plastic surfaces. Whenever an earthed conductive electrode is placed in an electric field of high field strength, the occurrence of corona or brush discharges must be expected. The electric field can be generated by a highly charged insulating solid surface, liquid, suspension, droplet mist, bulk of insulating bulk material or a dust cloud.

According to current knowledge, dust ignition cannot occur by brush discharges, even with a minimum ignition energy below 3 mJ, unless flammable gases or vapors are also present [2–3].

2.2.1.3 Propagating brush discharge

If the charge is not arranged in the form of a charge layer of one charge sign on an insulating surface, but in the form of a charge double layer with charges of opposite sign on the opposite surfaces of an insulating film, propagating brush discharges can occur. The maximum surface charge density of a charge layer of one sign on an insulating surface in air is approx. $2.7 \cdot 10^{-5} \text{ C/m}^2$. At this surface charge density, the electric field in the air above the charge layer reaches the value of the breakdown field strength and any additional charge would trigger a gas discharge into the air space. If, on the other hand, a charge double layer with charges of opposite sign is arranged on the surfaces of a thin insulating film, the surface charge density can become much higher. This can be explained by the fact that the electric field in the air space above one charge layer is compensated to a certain extent by the electric field of the other charge layer with the opposite sign. The electric field between the two charge layers, on the other hand, is very high, but it runs in the dielectric, in which the breakdown field strength is generally much higher than that in air.

Propagating brush discharges are triggered by an electrical short circuit between the two oppositely charged surfaces of an insulating film. This short circuit can be caused either by the approach of two electrically connected electrodes to the two surfaces of the film or by electrical or mechanical perforation of the film. The discharge image always looks the same: many discharge channels spread out in a star shape from the location of the short circuit.



Through these discharge channels, which all end in a bright central discharge channel between the electrodes and the film surface or – in the case of the film perforation – between the two film surfaces, the charges are discharged from the film surfaces over a large area.

Based on practical experience and the results of experimental investigations, it can be assumed that the high surface charge densities required to trigger brush discharges cannot be triggered by manual separation processes such as wiping an insulating surface or emptying powder from a plastic bag. Charging processes in conjunction with rapid separation processes or with large quantities of product in contact with small system surfaces are required to build up such high surface charge densities. These are referred to in the relevant literature as “strongly charge-generating processes” [2, 3]. Typically, when pneumatically transporting bulk material through insulating pipelines or conductive pipelines with an insulating inner coating of high dielectric strength, propagating brush discharges must be expected.

According to practical experience and experimental investigations in the laboratory, it cannot be assumed that porous product deposits of insulating product (e.g. in metallic conveyor pipes) or paint coatings cause brush discharges, as their dielectric strength is very low. A breakdown voltage of at least 4 kV for films and 6 kV for textile fabrics, e.g. FIBC, is required for the formation of brush discharges. However, if the product is melted or sintered onto the tube wall due to its properties (e.g. low melting point or tendency to form hard, non-porous deposits), thus creating an insulating inner layer with high dielectric strength, brush discharges can no longer be ruled out a priori.

The energy of propagating brush discharges is generally sufficient to ignite explosive gas, solvent vapor and dust-air mixtures. People can suffer a shock if they trigger a propagating brush discharge by touching a highly charged surface, for example. Discharges of this kind must be avoided in areas in which explosive gas, vapor or dust atmospheres can form.

2.2.1.4 Cone discharge

When filling silos and large containers with insulating bulk materials, so-called cone discharges can occur. The bulk material enters the silo or container more or less charged via pipes, discharge chutes and the like. The charge is accumulated in the bulk material and, depending on the resistivity of the bulk material and its entry rate, only flows slowly to earth via the conductive earthed silo or container wall. The electric field in the silo or container emanating from the charged bulk material can therefore become so high that the breakdown field strength in air (approx. 3 MV/m) is reached on the inner surface of the silo or container wall. If this is the case, the occurrence of cone discharges must be expected. They are formed in the form of discharge channels that run radially outwards or, in special cases, through the fill.

Whether the breakdown field strength is achieved can be calculated using computer models based on the silo geometry, the feed rate, the bulk density, the resistivity of the bulk material, the specific product charge and the relative permittivity of the product. Experience has shown that when using conductive earthed silos or containers with a specific bulk density of up to approx. $10^{10} \Omega\text{m}$, the occurrence of bulk cone discharges need not be expected, as in this case the charge is dissipated sufficiently fast. For higher bulk material resistivity, dangerously high charge accumulation in the silo can no longer be ruled out a priori, depending on the silo geometry, type and speed of entry, etc.

Cone discharges can ignite explosive gas, vapor and dust atmospheres. Their ignitability (equivalent ignition energy W) increases with increasing silo diameter and with increasing particle size of the bulk material generating the cone discharge according to the numerical equation (2) [2–3].

$$W = 5.22 \cdot D^{3.36} \cdot d^{1.462} \quad 2$$

Where: D = silo diameter and d = median value of the particle size distribution. The equivalent energy calculated according to equation (2) is based on extensive practical tests and represents an enveloping curve around the individually determined equivalent energies. No additional safety margins are required when using the equivalent energies determined in this way.

Cone discharges are caused by highly charged bulk materials and can occur in receiving containers with a volume of more than 0.25 m^3 regardless of the choice of packaging material to be emptied.



2.2.1.5 Lightning-like discharge

In principle, lightning-like discharges can occur in large dust clouds. Discharges of this kind have been observed in ash clouds during volcanic eruptions; however, they have never been detected in industrial processes. In experimental investigations, discharges of this kind could not be detected in silos and containers with a volume $V < 100 \text{ m}^3$ or in containers of any height with a diameter $d < 3 \text{ m}$. Theoretical considerations suggest that lightning-like discharges can occur in larger silos or containers at field strengths above 500 kV/m [2–3].

Lightning-like discharges originate from highly charged dust clouds and can occur in receiving containers with a volume of more than 100 m^3 regardless of the choice of package material to be emptied.

2.2.2 Ignition capability of the different discharge types

Table 1 summarizes the ignition capability of the different discharge types for the various explosive mixtures.

Discharge type	Ignition capability			
	Gases, vapors		Hybrid mixtures	Dusts
	Minimum ignition energy < 0.025 mJ	Minimum ignition energy > 0.025 mJ		
Spark discharge	+	+	+	+
Corona discharge ¹⁾	(+) ¹⁾	–	–	–
Brush discharge	+	+	+	–
Propagating brush discharge	+	+	+	+
Cone discharge	+	+	+	+
Lightning-like discharge	+	+	+	+

¹⁾ Exact results are not known

Table 1: Discharge types and their ignition capabilities.

2.2.3 Definitions and limit values for the conductivity of media and materials

In the Technical Rules for Hazardous Substances applicable in Germany and thus also in TRGS 727 [2], gases, liquids, bulk materials or solids that are handled during operation are referred to as "media". Furthermore, "material" is used as a term for materials from which objects, equipment or packaging are made. In the following definitions of conductive, dissipative and insulating, the terms "medium" therefore refer to the bulk material and the term "material" to the packaging material.

2.2.3.1 Conductive

A medium or material with a resistivity $\rho \leq 10^4 \Omega\text{m}$ or with a surface resistance $R_0 \leq 10^4 \Omega$, measured with a 10 mm x 100 mm strip electrode, is conductive.

2.2.3.2 Dissipative

A medium or material with a resistivity $\rho > 10^4 \Omega\text{m}$ and $\leq 10^9 \Omega\text{m}$ is "dissipative." An object, device or packaging material with a surface resistance between $10^4 \Omega$ and $10^9 \Omega$, measured with a 10 mm x 100 mm strip electrode at 23 °C and 50 % relative humidity, or with a surface resistance between $10^4 \Omega$ and $10^{11} \Omega$, measured with a 10 mm x 100 mm strip electrode at 23 °C and 30 % relative humidity, is also dissipative.

2.2.3.3 Insulating

Media or materials that are neither conductive nor dissipative are insulating.

2.2.4 Limit value for conductivity of bulk materials

For the purposes of this brochure and in accordance with the Technical Rules for Hazardous Substances TRGS 727 [2], bulk materials (pure or solvent-moist) are described as conductive if their resistivity is $\rho \leq 10^8 \Omega\text{m}$. Bulk materials are described as insulating if their resistivity is $\rho > 10^8 \Omega\text{m}$.

2.2.5 Earthing

Conductive objects, equipment and packaging materials must be earthed. The maximum earth leakage resistance must not exceed $10^6 \Omega$.

Dissipative objects, equipment and packaging materials must be in contact with earth. In practice, this means that a fixed screw connection or the clamping of an earthing clamp with earthing cable is not necessarily required. For example, contact with an earthed surface, environment or person is sufficient (dissipative packaging material is held, for example, by a person earthed via shoes and floor without gloves or with conductive gloves). The leakage or contact resistance to earth must not exceed $10^8 \Omega$.



2.2.6 Electrostatic ignition hazards emanating from the various packaging materials and bulk materials

No.	Packaging	Volume	Resistivity of bulk material ρ	Ignition hazards from						
				Packaging			Bulk material			
				Spark	Brush	Propagating brush	Spark	Brush	Cone discharge	
1	Bags									
1.1	Conductive plastic bag (e.g. conductive plastic bag equipped with graphite or carbon black)	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	+				+		
1.2	Conductive plastic bag (e.g. conductive plastic bag equipped with graphite or carbon black)	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	+			+			
1.3	Dissipative plastic bag (e.g. plastic bag equipped with antistatic additive)	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	+				+		
1.4	Dissipative plastic bag (e.g. plastic bag equipped with antistatic additive)	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	+			+			
1.5	Paper bag (single- or multi-layer)	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	+				+		
1.6	Paper bag (single- or multi-layer)	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	+			+			
1.7	Paper bag with plastic lamination	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	+				+		
1.8	Paper bag with plastic lamination	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	+			+			
1.9	Paper bag with loose plastic bag inside	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	+	+			+		
1.10	Paper bag with loose plastic bag inside	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	+	+		+			

Table 2: Electrostatic ignition hazards emanating from the various packaging materials and bulk materials.

Electrostatic ignition hazards emanating from the various packaging materials and bulk materials

No.	Packaging	Volume	Resistivity of bulk material ρ	Ignition hazards from					
				Packaging			Bulk material		
				Spark	Brush	Propagating brush	Spark	Brush	Cone discharge
1 Bags									
1.11	Insulating plastic bag	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$		+			+	
1.12	Insulating plastic bag	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$		+		+		
1.13	Aluminum bag with insulating plastic coating inside and outside	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	+				+	
1.14	Aluminum bag with insulating plastic coating inside and outside	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	+			+		
2 Drums									
2.1	Conductive drum (e.g. metal drum or conductive plastic drum) without liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	+				+	
2.2	Conductive drum (e.g. metal drum or conductive plastic drum) without liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	+			+		
2.3	Conductive drum (e.g. metal drum or conductive plastic drum) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	+				+	
2.4	Conductive drum (e.g. metal drum or conductive plastic drum) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	+			+		
2.5	Conductive drum (e.g. metal drum or conductive plastic drum) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	+				+	

Table 2: Electrostatic ignition hazards emanating from the various packaging materials and bulk materials.



Electrostatic ignition hazards emanating from the various packaging materials and bulk materials

No.	Packaging	Volume	Resistivity of bulk material ρ	Ignition hazards from							
				Packaging			Bulk material				
				Spark	Brush	Propagating brush	Spark	Brush	Cone discharge		
2	Drums										
2.6	Conductive drum (e.g. metal drum or conductive plastic drum) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	+			+				
2.7	Conductive drum (e.g. metal drum or conductive plastic drum) with insulating inner coating	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	+	+			+			
2.8	Conductive drum (e.g. metal drum or conductive plastic drum) with insulating inner coating	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	+	+		+				
2.9	Conductive drum (e.g. metal drum or conductive plastic drum) with insulating inner coating	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	+				+			
2.10	Conductive drum (e.g. metal drum or conductive plastic drum) with insulating inner coating	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	+			+				
2.11	Conductive drum (e.g. metal drum) with insulating plastic bubble (Valethen drum)	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	+	+				+		
2.12	Conductive drum (e.g. metal drum) with insulating plastic bubble (Valethen drum)	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	+	+		+				

Table 2: Electrostatic ignition hazards emanating from the various packaging materials and bulk materials.

Electrostatic ignition hazards emanating from the various packaging materials and bulk materials

No.	Packaging	Volume	Resistivity of bulk material ρ	Ignition hazards from					
				Packaging			Bulk material		
				Spark	Brush	Propagating brush	Spark	Brush	Cone discharge
2 Drums									
2.13	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	+				+	
2.14	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	+			+		
2.15	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	+				+	
2.16	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	+			+		

Table 2: Electrostatic ignition hazards emanating from the various packaging materials and bulk materials.



Electrostatic ignition hazards emanating from the various packaging materials and bulk materials

No.	Packaging	Volume	Resistivity of bulk material ρ	Ignition hazards from					
				Packaging			Bulk material		
				Spark	Brush	Propagating brush	Spark	Brush	Cone discharge
2	Drums								
2.17	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	+				+	
2.18	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	+			+		
2.19	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	+	+			+	
2.20	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	+	+		+		

Table 2: Electrostatic ignition hazards emanating from the various packaging materials and bulk materials.

Electrostatic ignition hazards emanating from the various packaging materials and bulk materials

No.	Packaging	Volume	Resistivity of bulk material ρ	Ignition hazards from					
				Packaging			Bulk material		
				Spark	Brush	Propagating brush	Spark	Brush	Cone discharge
2 Drums									
2.21	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \text{ } \Omega\text{m}$	+				+	
2.22	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \text{ } \Omega\text{m}$	+			+		
2.23	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \text{ } \Omega\text{m}$	+				+	
2.24	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \text{ } \Omega\text{m}$	+			+		

Table 2: Electrostatic ignition hazards emanating from the various packaging materials and bulk materials.



Electrostatic ignition hazards emanating from the various packaging materials and bulk materials

No.	Packaging	Volume	Resistivity of bulk material ρ	Ignition hazards from					
				Packaging			Bulk material		
				Spark	Brush	Propagating brush	Spark	Brush	Cone discharge
2	Drums								
2.25	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	+				+	
2.26	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	+			+		
2.27	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	+	+			+	
2.28	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	+	+		+		

Table 2: Electrostatic ignition hazards emanating from the various packaging materials and bulk materials.

Electrostatic ignition hazards emanating from the various packaging materials and bulk materials

No.	Packaging	Volume	Resistivity of bulk material ρ	Ignition hazards from					
				Packaging			Bulk material		
				Spark	Brush	Propagating brush	Spark	Brush	Cone discharge
2 Drums									
2.29	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$		+			+	
2.30	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$		+		+		
2.31	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$		+			+	
2.32	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$		+		+		
2.33	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	+	+			+	
2.34	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	+	+		+		

Table 2: Electrostatic ignition hazards emanating from the various packaging materials and bulk materials.



Electrostatic ignition hazards emanating from the various packaging materials and bulk materials

No.	Packaging	Volume	Resistivity of bulk material ρ	Ignition hazards from					
				Packaging			Bulk material		
				Spark	Brush	Propagating brush	Spark	Brush	Cone discharge
2 Drums									
2.35	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	+	+			+	
2.36	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	+	+		+		

Table 2: Electrostatic ignition hazards emanating from the various packaging materials and bulk materials.

2.2.7 Electrostatic ignition hazards emanating from employees

2.2.7.1 Footwear

When handling and in particular when filling and emptying packaging materials, employees are often in a zone 21 or zone 1 and can become dangerously charged when walking or via induction as a result of charged packaging materials or bulk materials and generate ignitable sparks. In potentially explosive atmospheres in zones 0, 1 and 20, dissipative footwear with a leakage resistance of the person to earth of no more than $10^8 \Omega$ must be worn. The same requirement applies in zone 21 for dusts with a minimum ignition energy $< 10 \text{ mJ}$ (see also [1, 3]).

2.2.7.2 Clothing

Work clothing or protective clothing may not be changed, taken off or put on in potentially explosive atmospheres in zones 0 and 1. Commercially available clothing and protective clothing can be charged. It does not generally present an ignition hazard when worn, provided the person is earthed, e.g. by wearing suitable footwear and suitable flooring. Nevertheless, in individual cases, e.g. with PU-coated weatherproof clothing or other clothing that does not fit closely to the body, dangerous charges may occur. In zone 1, such clothing should have a dissipative finish.

In zone 0 areas and in areas where oxygen enrichment or the presence of hazardous substances of explosion group IIC is to be expected, only dissipative clothing may be worn (see also [1, 3]).

3 Packaging for bulk materials taking into account their suitability for avoiding electrostatic ignition hazards during filling and emptying

The following Tables 3, 4 and 5 list packaging for bulk materials, taking into account their suitability for avoiding electrostatic ignition hazards during filling and emptying. The measures required to avoid these ignition hazards are also listed. Tables 3, 4 and 5 differ as follows:

- **Table 3: The bulk material is solvent-free. No flammable gases, vapors or hybrid mixtures are present.**
- **Table 4: The bulk material is solvent-free. However, the packaging material is handled in a zone 1 or 2.**
- **Table 5: The bulk material is solvent-moist and contains a flammable solvent with a flash point that is no more than 5 K for pure liquids or 15 K for solvent mixtures above the working and storage temperature.** It must therefore be assumed that the packaging material is in zone 0 and the environment is either solvent-free or assigned to zone 1 or 2. In this case, the occurrence of hybrid mixtures is not expected, as dust clouds do not usually occur when handling solvent-moist bulk materials.

According to the relevant standards (in Germany, see TRGS 727 [2]), the absence of flammable gases and vapors is also assumed if

- the concentration of flammable gases and vapors in non-combustible bulk materials is safely below the lower explosion limit (LEL),
- for flammable bulk materials, the concentration of flammable gases and vapors is safely below 20 % of the LEL of the gas/vapor (for further details see section 2.1). This condition is fulfilled if, for example, immediately after a drying process at an elevated temperature and under vacuum, the remaining proportion of a combustible solvent is less than 0.5 % by weight of the bulk material and no further crushing processes are carried out which could lead to the renewed release of solvent by breaking open pores (see also section 2.1).



In the tables, the individual packaging materials are rated in the last column using the colors green, yellow, orange, red or purple.

 Good packaging solutions are marked in **green**.

 Possible packaging solutions are marked in **yellow**, but these are associated with special measures that are rather unusual and/or impractical in practice. In practice, for example, it is rather unusual to insert a conductive earthed rod into the packaging material before filling.

 Possible but not recommended packaging solutions are marked in **orange**. For example, earthing an aluminum bag is not easy because the aluminum layer is usually coated on both sides with insulating plastic and therefore cannot be reliably earthed with earthing clamps without strong tips and without strong contact pressure.

 Packaging solutions marked in **red** are strongly discouraged.

 Packaging solutions that are not approved for open handling are marked in **purple**. Closed handling in combination with inertization and/or constructive measures is required.

3.1 Packaging for solvent-free bulk materials without flammable gases, vapors or hybrid mixtures from the environment

Solvent-free bulk material · Environment zone 21 or 22

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
1 Bags				
1.1	Conductive plastic bag (e.g. conductive plastic bag equipped with graphite or carbon black)	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	😊 - Earthing of the plastic bag during filling and emptying
1.2	Conductive plastic bag (e.g. conductive plastic bag equipped with graphite or carbon black)	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earthing of the plastic bag during filling and emptying
1.3	Dissipative plastic bag (e.g. plastic bag equipped with antistatic additive)	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	😊 - Earth contact of the plastic bag required during filling and emptying (e.g. via contact with conductive or dissipative earthed underlay or via earthed person wearing conductive or dissipative gloves)
1.4	Dissipative plastic bag (e.g. plastic bag equipped with antistatic additive)	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earth contact of the plastic bag required during filling and emptying (e.g. via contact with an earthed surface or via earthed person wearing conductive or dissipative gloves) - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
1.5	Paper bag (single- or multi-layer)	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	😊 - Earth contact of the bag required during filling and emptying (e.g. via contact with conductive or dissipative earthed underlay or via earthed person with conductive or dissipative gloves)

Table 3: Packaging for solvent-free bulk materials without flammable gases, vapors or hybrid mixtures from the environment.



Solvent-free bulk material · Environment zone 21 or 22

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
1 Bags				
1.6	Paper bag (single- or multi-layer)	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	 - Earth contact of the paper bag required during filling and emptying (e.g. via contact with earthed surface or via earthed person wearing conductive or dissipative gloves) - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
1.7	Paper bag with plastic lamination	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	 - Earth contact of the paper bag required during filling and emptying (e.g. via contact with conductive or dissipative earthed underlay or via earthed person with conductive or dissipative gloves)
1.8	Paper bag with plastic lamination	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	 - Earth contact of the paper bag required during filling and emptying (e.g. via contact with earthed surface or via earthed person wearing conductive or dissipative gloves) - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
1.9	Paper bag with loose plastic bag inside	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	 - Earth contact of the paper bag required during filling and emptying (e.g. via contact with conductive or dissipative earthed underlay or via earthed person with conductive or dissipative gloves)

Table 3: Packaging for solvent-free bulk materials without flammable gases, vapors or hybrid mixtures from the environment.

Solvent-free bulk material · Environment zone 21 or 22

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
1 Bags				
1.10	Paper bag with loose plastic bag inside	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	 - Earth contact of the paper bag required during filling and emptying (e.g. via contact with earthed surface or via earthed person wearing conductive or dissipative gloves) - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
1.11	Insulating plastic bag	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	 - No additional measures required
1.12	Insulating plastic bag	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	 - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
1.13	Aluminum bag with insulating plastic coating inside and outside	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	 - Earthing of the aluminum layer required by clamping an earthing clamp with sharp tips and high spring force
1.14	Aluminum bag with insulating plastic coating inside and outside	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	 - Earthing of the aluminum layer required by clamping an earthing clamp with sharp tips and high spring force - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)

Table 3: Packaging for solvent-free bulk materials without flammable gases, vapors or hybrid mixtures from the environment.



Solvent-free bulk material · Environment zone 21 or 22

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.1	Conductive drum (e.g. metal drum or conductive plastic drum) without liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	😊 - Earthing of the metal drum during filling and emptying
2.2	Conductive drum (e.g. metal drum or conductive plastic drum) without liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earthing of the metal drum during filling and emptying
2.3	Conductive drum (e.g. metal drum or conductive plastic drum) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	😊 - Earthing of the metal drum during filling and emptying - Earthing of the liner when removing and shaking out
2.4	Conductive drum (e.g. metal drum or conductive plastic drum) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earthing of the metal drum during filling and emptying - Earthing of the liner when removing and shaking out
2.5	Conductive drum (e.g. metal drum or conductive plastic drum) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	😊 - Earthing of the metal drum during filling and emptying - Earth contact of the liner required when removing and shaking out (e.g. via earthed person with conductive or dissipative gloves)
2.6	Conductive drum (e.g. metal drum or conductive plastic drum) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earthing of the metal drum during filling and emptying - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins) - Earth contact of the liner required when removing and shaking out (e.g. via earthed person with conductive or dissipative gloves)

Table 3: Packaging for solvent-free bulk materials without flammable gases, vapors or hybrid mixtures from the environment.

Solvent-free bulk material · Environment zone 21 or 22

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.7	Conductive drum (e.g. metal drum or conductive plastic drum) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	😊 - Earthing of the metal drum during filling and emptying
2.8	Conductive drum (e.g. metal drum or conductive plastic drum) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earthing of the metal drum during filling and emptying - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
2.9	Conductive drum (e.g. metal drum or conductive plastic drum) with insulating inner coating	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	😊 - Earthing of the metal drum during filling and emptying
2.10	Conductive drum (e.g. metal drum or conductive plastic drum) with insulating inner coating	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earthing of the metal drum during filling and emptying - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
2.11	Conductive drum (e.g. metal drum) with insulating plastic bubble (Valethen drum)	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	😊 - Earthing of the metal drum during filling and emptying
2.12	Conductive drum (e.g. metal drum) with insulating plastic bubble (Valethen drum)	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earthing of the metal drum during filling and emptying - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)

Table 3: Packaging for solvent-free bulk materials without flammable gases, vapors or hybrid mixtures from the environment.



Solvent-free bulk material · Environment zone 21 or 22

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.13	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	😊 - Earth contact of the drum required when filling and emptying (e.g. via contact with conductive or dissipative earthed underlay or via earthed person with conductive or dissipative gloves)
2.14	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earth contact of the drum required when filling and emptying (e.g. via contact with conductive or dissipative earthed underlay or via earthed person with conductive or dissipative gloves) - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
2.15	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	😞 - Earth contact of the drum required when filling and emptying (e.g. via contact with conductive or dissipative earthed surface or via earthed person wearing conductive or dissipative gloves) - Earthing of the liner during filling and emptying - Earthing of the liner when removing and shaking out

Table 3: Packaging for solvent-free bulk materials without flammable gases, vapors or hybrid mixtures from the environment.

Solvent-free bulk material · Environment zone 21 or 22
 Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.16	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	☹️ - Earth contact of the drum required when filling and emptying (e.g. via contact with conductive or dissipative earthed underlay or via earthed person with conductive or dissipative gloves) - Earthing of the liner during filling and emptying - Earthing of the liner when removing and shaking out
2.17	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	😊 - Earth contact of the drum required when filling and emptying (e.g. via contact with conductive or dissipative earthed underlay or via earthed person with conductive or dissipative gloves) - Bring the liner into contact with earth during filling by contact with dissipative drum - Earth contact of the liner required when removing and shaking out (e.g. via earthed person with conductive or dissipative gloves)

Table 3: Packaging for solvent-free bulk materials without flammable gases, vapors or hybrid mixtures from the environment.



Solvent-free bulk material · Environment zone 21 or 22

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.18	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	☹️ - Earth contact of the drum required when filling and emptying (e.g. via contact with conductive or dissipative earthed underlay or via earthed person with conductive or dissipative gloves) - Bring the liner into contact with earth during filling by contact with dissipative drum - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins) - Earth contact of the liner required when removing and shaking out (e.g. via earthed person with conductive or dissipative gloves)
2.19	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	😊 - Earth contact of the drum required when filling and emptying (e.g. via contact with conductive or dissipative earthed underlay or via earthed person with conductive or dissipative gloves)
2.20	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earth contact of the drum required when filling and emptying (e.g. via contact with conductive or dissipative earthed underlay or via earthed person with conductive or dissipative gloves) - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)

Table 3: Packaging for solvent-free bulk materials without flammable gases, vapors or hybrid mixtures from the environment.

Solvent-free bulk material · Environment zone 21 or 22

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.21	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	😊 - Earthing of the dissipative drum at the upper or lower metal reinforcement (clamping ring, metal base, etc.) during filling and emptying
2.22	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earthing of the dissipative drum at the upper or lower metal reinforcement (clamping ring, metal base, etc.) during filling and emptying - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
2.23	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	😞 - Earthing of the dissipative drum at the upper or lower metal reinforcement (clamping ring, metal base, etc.) during filling and emptying - Earthing of the liner during filling and emptying - Earthing of the liner when removing and shaking out
2.24	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😞 - Earthing of the dissipative drum at the upper or lower metal reinforcement (clamping ring, metal base, etc.) during filling and emptying - Earthing of the liner during filling and emptying - Earthing of the liner when removing and shaking out

Table 3: Packaging for solvent-free bulk materials without flammable gases, vapors or hybrid mixtures from the environment.



Solvent-free bulk material · Environment zone 21 or 22

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.25	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	 - Earthing of the dissipative drum at the upper or lower metal reinforcement (clamping ring, metal base, etc.) during filling and emptying - Bring the liner into contact with earth by contact at the upper clamping ring during filling - Earth contact of the liner required when removing and shaking out (e.g. via earthed person with conductive or dissipative gloves)
2.26	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	 - Earthing of the dissipative drum at the upper or lower metal reinforcement (clamping ring, metal base, etc.) during filling and emptying - Bring the liner into contact with earth by contact at the upper clamping ring during filling - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins) - Earth contact of the liner required when removing and shaking out (e.g. via earthed person with conductive or dissipative gloves)
2.27	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	 - Earthing of the dissipative drum at the upper or lower metal reinforcement (clamping ring, metal base, etc.) during filling and emptying

Table 3: Packaging for solvent-free bulk materials without flammable gases, vapors or hybrid mixtures from the environment.

Solvent-free bulk material · Environment zone 21 or 22

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.28	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earthing of the dissipative drum at the upper or lower metal reinforcement (clamping ring, metal base, etc.) during filling and emptying - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
2.29	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	😊 - No additional measures required
2.30	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
2.31	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	😊 - No additional measures required
2.32	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)

Table 3: Packaging for solvent-free bulk materials without flammable gases, vapors or hybrid mixtures from the environment.



Solvent-free bulk material · Environment zone 21 or 22

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.33	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	😊 - Ensure earth contact of the liner during filling and emptying
2.34	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😞 - Ensure earth contact of the liner during filling and emptying - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
2.35	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	😞 - Earthing of the liner during filling and emptying - Earthing of the liner when removing and shaking out
2.36	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😞 - Earthing of the liner during filling and emptying - Earthing of the liner when removing and shaking out

Table 3: Packaging for solvent-free bulk materials without flammable gases, vapors or hybrid mixtures from the environment.

3.2 Packaging for solvent-free bulk materials but flammable gases or vapors from the environment possible (zone 1 or 2)

Solvent-free bulk material · Environment zone 1 or 2 Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
1 Bags				
1.1	Conductive plastic bag (e.g. conductive plastic bag equipped with graphite or carbon black)	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
1.2	Conductive plastic bag (e.g. conductive plastic bag equipped with graphite or carbon black)	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earthing of the plastic bag during filling and emptying
1.3	Dissipative plastic bag (e.g. plastic bag equipped with antistatic additive)	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
1.4	Dissipative plastic bag (e.g. plastic bag equipped with antistatic additive)	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earth contact of the plastic bag required during filling and emptying (e.g. via contact with a earthed surface or via earthed person wearing conductive or dissipative gloves) - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
1.5	Paper bag (single- or multi-layer)	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
1.6	Paper bag (single- or multi-layer)	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earth contact of the paper bag required during filling and emptying (e.g. via contact with earthed surface or via earthed person wearing conductive or dissipative gloves) - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)

Table 4: Packaging for solvent-free bulk materials but flammable gases or vapors from the environment possible (zone 1 or 2).



Solvent-free bulk material · Environment zone 1 or 2

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
1 Bags				
1.7	Paper bag with plastic lamination	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
1.8	Paper bag with plastic lamination	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earth contact of paper bag required during filling and emptying (e.g. via contact with earthed surface or via earthed person wearing conductive or dissipative gloves) - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
1.9	Paper bag with loose plastic bag inside	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
1.10	Paper bag with loose plastic bag inside	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	☹️ - Not permitted
1.11	Insulating plastic bag	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
1.12	Insulating plastic bag	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	☹️ - Not permitted
1.13	Aluminum bag with insulating plastic coating inside and outside	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
1.14	Aluminum bag with insulating plastic coating inside and outside	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😬 - Earthing of the aluminum layer required by clamping an earthing clamp with sharp tips and high spring force - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)

Table 4: Packaging for solvent-free bulk materials but flammable gases or vapors from the environment possible (zone 1 or 2).

Solvent-free bulk material · Environment zone 1 or 2

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.1	Conductive drum (e.g. metal drum or conductive plastic drum) without liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
2.2	Conductive drum (e.g. metal drum or conductive plastic drum) without liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earthing of the metal drum during filling and emptying
2.3	Conductive drum (e.g. metal drum or conductive plastic drum) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
2.4	Conductive drum (e.g. metal drum or conductive plastic drum) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earthing of the metal drum during filling and emptying - Earthing of the liner when removing and shaking out
2.5	Conductive drum (e.g. metal drum or conductive plastic drum) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
2.6	Conductive drum (e.g. metal drum or conductive plastic drum) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😬 - Earthing of the metal drum during filling and emptying - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins) - Earth contact of the liner required when removing and shaking out (e.g. via earthed person with conductive or dissipative gloves)
2.7	Conductive drum (e.g. metal drum or conductive plastic drum) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted

Table 4: Packaging for solvent-free bulk materials but flammable gases or vapors from the environment possible (zone 1 or 2).



Solvent-free bulk material · Environment zone 1 or 2

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.8	Conductive drum (e.g. metal drum or conductive plastic drum) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	☹️ - Not permitted
2.9	Conductive drum (e.g. metal drum or conductive plastic drum) with insulating inner coating	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
2.10	Conductive drum (e.g. metal drum or conductive plastic drum) with insulating inner coating	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😬 - Earthing of the metal drum during filling and emptying - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
2.11	Conductive drum (e.g. metal drum) with insulating plastic bubble (Valethen drum)	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
2.12	Conductive drum (e.g. metal drum) with insulating plastic bubble (Valethen drum)	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😬 - Earthing of the metal drum during filling and emptying - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
2.13	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted

Table 4: Packaging for solvent-free bulk materials but flammable gases or vapors from the environment possible (zone 1 or 2).

Solvent-free bulk material · Environment zone 1 or 2

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.14	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \text{ } \Omega\text{m}$	😊 - Earth contact of drum required during filling and emptying (e.g. via contact with earthed surface or via earthed person wearing conductive or dissipative gloves) - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
2.15	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \text{ } \Omega\text{m}$	😞 - Not permitted
2.16	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \text{ } \Omega\text{m}$	😊 - Earth contact of the drum required when filling and emptying (e.g. via contact with conductive or dissipative earthed underlay or via earthed person with conductive or dissipative gloves) - Earthing of the liner during filling and emptying - Earthing of the liner when removing and shaking out

Table 4: Packaging for solvent-free bulk materials but flammable gases or vapors from the environment possible (zone 1 or 2).



Solvent-free bulk material · Environment zone 1 or 2

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.17	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	- Not permitted
2.18	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	- Earth contact of the drum required when filling and emptying (e.g. via contact with conductive or dissipative earthed underlay or via earthed person with conductive or dissipative gloves) - Bring the liner into contact with earth during filling by contact with dissipative drum - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins) - Earth contact of the liner required when removing and shaking out (e.g. via earthed person with conductive or dissipative gloves)
2.19	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	- Not permitted

Table 4: Packaging for solvent-free bulk materials but flammable gases or vapors from the environment possible (zone 1 or 2).

Solvent-free bulk material · Environment zone 1 or 2
 Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.20	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	☹️ - Not permitted
2.21	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
2.22	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earthing of the dissipative drum at the upper or lower metal reinforcement (clamping ring, metal base, etc.) during filling and emptying - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
2.23	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted

Table 4: Packaging for solvent-free bulk materials but flammable gases or vapors from the environment possible (zone 1 or 2).



Solvent-free bulk material · Environment zone 1 or 2

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.24	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	 <ul style="list-style-type: none"> - Earthing of the dissipative drum at the upper or lower metal reinforcement (clamping ring, metal base, etc.) during filling and emptying - Earthing of the liner during filling and emptying - Earthing of the liner when removing and shaking out
2.25	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	 <ul style="list-style-type: none"> - Earthing of the dissipative drum at the upper or lower metal reinforcement (clamping ring, metal base, etc.) during filling and emptying - Bring the liner into contact with earth by contact at the upper clamping ring during filling - Earth contact of the liner required when removing and shaking out (e.g. via earthed person with conductive or dissipative gloves)
2.26	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	 <ul style="list-style-type: none"> - Earthing of the dissipative drum at the upper or lower metal reinforcement (clamping ring, metal base, etc.) during filling and emptying - Bring the liner into contact with earth by contact at the upper clamping ring during filling - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins) - Earth contact of the liner required when removing and shaking out (e.g. via earthed person with conductive or dissipative gloves)

Table 4: Packaging for solvent-free bulk materials but flammable gases or vapors from the environment possible (zone 1 or 2).

Solvent-free bulk material · Environment zone 1 or 2
 Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.27	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
2.28	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	☹️ - Not permitted
2.29	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
2.30	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	☹️ - Not permitted
2.31	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted

Table 4: Packaging for solvent-free bulk materials but flammable gases or vapors from the environment possible (zone 1 or 2).



Solvent-free bulk material · Environment zone 1 or 2

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.32	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	☹️ - Not permitted
2.33	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
2.34	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	☹️ - Not permitted
2.35	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
2.36	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	☹️ - Not permitted

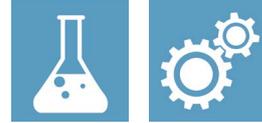
Table 4: Packaging for solvent-free bulk materials but flammable gases or vapors from the environment possible (zone 1 or 2).

3.3 Packaging for solvent-moist bulk material (flammable solvent) with or without flammable gases or vapors from the environment (zone 1 or 2)

Solvent-moist bulk material · Environment with or without zone 1 or 2 Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
1 Bags				
1.1	Conductive plastic bag (e.g. conductive plastic bag equipped with graphite or carbon black)	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \text{ } \Omega\text{m}$	☹️ - Not permitted
1.2	Conductive plastic bag (e.g. conductive plastic bag equipped with graphite or carbon black)	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \text{ } \Omega\text{m}$	😊 - Earthing of the plastic bag during filling and emptying
1.3	Dissipative plastic bag (e.g. plastic bag equipped with antistatic additive)	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \text{ } \Omega\text{m}$	☹️ - Not permitted
1.4	Dissipative plastic bag (e.g. plastic bag equipped with antistatic additive)	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \text{ } \Omega\text{m}$	😊 - Earth contact of the plastic bag required during filling and emptying (e.g. via contact with a earthed surface or via earthed person wearing conductive or dissipative gloves) - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
1.5	Paper bag (single- or multi-layer)	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \text{ } \Omega\text{m}$	☹️ - Not permitted
1.6	Paper bag (single- or multi-layer)	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \text{ } \Omega\text{m}$	😊 - Earth contact of the paper bag required during filling and emptying (e.g. via contact with earthed surface or via earthed person wearing conductive or dissipative gloves) - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)

Table 5: Packaging for solvent-moist bulk materials (flammable solvent) with or without flammable gases or vapors from the environment (zone 1 or 2).



Solvent-moist bulk material · Environment with or without zone 1 or 2

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
1 Bags				
1.7	Paper bag with plastic lamination	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
1.8	Paper bag with plastic lamination	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earth contact of paper bag required during filling and emptying (e.g. via contact with earthed surface or via earthed person wearing conductive or dissipative gloves) - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
1.9	Paper bag with loose plastic bag inside	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
1.10	Paper bag with loose plastic bag inside	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	☹️ - Not permitted
1.11	Insulating plastic bag	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
1.12	Insulating plastic bag	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	☹️ - Not permitted
1.13	Aluminum bag with insulating plastic coating inside and outside	$\leq 0.05 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
1.14	Aluminiumsack mit isolierender Kunststoffbeschichtung innen und außen	$\leq 0.05 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earthing of the aluminum layer required by clamping an earthing clamp with sharp tips and high spring force - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)

Table 5: Packaging for solvent-moist bulk materials (flammable solvent) with or without flammable gases or vapors from the environment (zone 1 or 2).

Solvent-moist bulk material · Environment with or without zone 1 or 2

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.1	Conductive drum (e.g. metal drum or conductive plastic drum) without liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
2.2	Conductive drum (e.g. metal drum or conductive plastic drum) without liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earthing of the metal drum during filling and emptying
2.3	Conductive drum (e.g. metal drum or conductive plastic drum) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
2.4	Conductive drum (e.g. metal drum or conductive plastic drum) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earthing of the metal drum during filling and emptying - Earthing of the liner when removing and shaking out
2.5	Conductive drum (e.g. metal drum or conductive plastic drum) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
2.6	Conductive drum (e.g. metal drum or conductive plastic drum) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earthing of the metal drum during filling and emptying - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins) - Earth contact of the liner required when removing and shaking out (e.g. via earthed person with conductive or dissipative gloves)

Table 5: Packaging for solvent-moist bulk materials (flammable solvent) with or without flammable gases or vapors from the environment (zone 1 or 2).



Solvent-moist bulk material · Environment with or without zone 1 or 2

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.7	Conductive drum (e.g. metal drum or conductive plastic drum) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
2.8	Conductive drum (e.g. metal drum or conductive plastic drum) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	☹️ - Not permitted
2.9	Conductive drum (e.g. metal drum or conductive plastic drum) with insulating inner coating	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
2.10	Conductive drum (e.g. metal drum or conductive plastic drum) with insulating inner coating	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earthing of the metal drum during filling and emptying - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
2.11	Conductive drum (e.g. Metallfass) with insulating plastic bubble (Valethen drum)	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
2.12	Conductive drum (e.g. metal drum) with insulating plastic bubble (Valethen drum)	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	☹️ - Not permitted
2.13	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted

Table 5: Packaging for solvent-moist bulk materials (flammable solvent) with or without flammable gases or vapors from the environment (zone 1 or 2).

Solvent-moist bulk material · Environment with or without zone 1 or 2

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.14	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earth contact of the drum required when filling and emptying (e.g. via contact with conductive or dissipative earthed underlay or via earthed person with conductive or dissipative gloves) - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
2.15	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	😞 - Not permitted
2.16	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😞 - Earth contact of the drum required when filling and emptying (e.g. via contact with conductive or dissipative earthed underlay or via earthed person with conductive or dissipative gloves) - Earthing of the liner during filling and emptying - Earthing of the liner when removing and shaking out

Table 5: Packaging for solvent-moist bulk materials (flammable solvent) with or without flammable gases or vapors from the environment (zone 1 or 2).



Solvent-moist bulk material · Environment with or without zone 1 or 2

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.17	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
2.18	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earth contact of the drum required when filling and emptying (e.g. via contact with conductive or dissipative earthed underlay or via earthed person with conductive or dissipative gloves) - Bring the liner into contact with earth during filling by contact with dissipative drum - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins) - Earth contact of the liner required when removing and shaking out (e.g. via earthed person with conductive or dissipative gloves)
2.19	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted

Table 5: Packaging for solvent-moist bulk materials (flammable solvent) with or without flammable gases or vapors from the environment (zone 1 or 2).

Solvent-moist bulk material · Environment with or without zone 1 or 2
 Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.20	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) without conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	☹️ - Not permitted
2.21	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
2.22	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	😊 - Earthing of the dissipative drum at the upper or lower metal reinforcement (clamping ring, metal base, etc.) during filling and emptying - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins)
2.23	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted

Table 5: Packaging for solvent-moist bulk materials (flammable solvent) with or without flammable gases or vapors from the environment (zone 1 or 2).



Solvent-moist bulk material · Environment with or without zone 1 or 2

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.24	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	 - Earthing of the dissipative drum at the upper or lower metal reinforcement (clamping ring, metal base, etc.) during filling and emptying - Earthing of the liner during filling and emptying - Earthing of the liner when removing and shaking out
2.25	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	 - Not permitted
2.26	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	 - Earthing of the dissipative drum at the upper or lower metal reinforcement (clamping ring, metal base, etc.) during filling and emptying - Bring the liner into contact with earth by contact at the upper clamping ring during filling - Earthing of the bulk material during filling (e.g. by inserting a conductive earthed rod before filling begins) - Earth contact of the liner required when removing and shaking out (e.g. via earthed person with conductive or dissipative gloves)

Table 5: Packaging for solvent-moist bulk materials (flammable solvent) with or without flammable gases or vapors from the environment (zone 1 or 2).

Solvent-moist bulk material · Environment with or without zone 1 or 2
Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.27	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹ - Not permitted
2.28	Dissipative drum (e.g. cardboard drum or plastic drum equipped with antistatic additive) with conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	☹ - Not permitted
2.29	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹ - Not permitted
2.30	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) without liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	☹ - Not permitted
2.31	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹ - Not permitted

Table 5: Packaging for solvent-moist bulk materials (flammable solvent) with or without flammable gases or vapors from the environment (zone 1 or 2).



Solvent-moist bulk material · Environment with or without zone 1 or 2

Filling with gravity · Emptying with gravity or suction conveying

No.	Packaging	Volume	Resistivity of bulk material ρ	Measures and comments
2 Drums				
2.32	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with insulating liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	☹️ - Not permitted
2.33	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
2.34	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with dissipative liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	☹️ - Not permitted
2.35	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho > 10^8 \Omega\text{m}$	☹️ - Not permitted
2.36	Insulating drum (e.g. plastic drum) without conductive parts (metal reinforcements, clamping rings, etc.) with conductive liner	$\leq 0.25 \text{ m}^3$	$\rho \leq 10^8 \Omega\text{m}$	☹️ - Not permitted

Table 5: Packaging for solvent-moist bulk materials (flammable solvent) with or without flammable gases or vapors from the environment (zone 1 or 2).

3.4 Bulk packaging with volumes > 0.25 m³ (Flexible bulk containers, big bags, containers, octabins, etc.)

The requirements and approvals for flexible intermediate bulk containers and big bags are described in detail in the standard IEC 61340-4-4, Electrostatics – Part 4-4: Standard test methods for specific applications – Electrostatic Classification of flexible intermediate bulk containers (FIBC), Edition 3.0, 2018-01 [4].

The following tables 5, 6, 1, 2, 3 and 4 provide an overview. Details can be found in the standard IEC 61340-4-4, Edition 3.0, 2018-01 [4]. Requirements for other large containers such as containers, octabins, etc. are to be derived from the requirements for FIBCs.

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 > MIE > 3 mJ) ^a	Gas zones 1–2 (explosion groups IIA/IIB) or dust zones 21–22 (MIE ≤ 3 mJ) ^a
MIE > 1,000 mJ	A, B, C, D	B, C, D	C, D ^b
1,000 mJ > MIE > 3 mJ	B, C, D	B, C, D	C, D ^b
MIE ≤ 3 mJ	C, D	C, D	C, D ^b

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 atmospheres include dusts having MIE > 1,000 mJ.

^a Measured in accordance with ISO/IEC 80079-20-2, capacitive discharge circuit (no added inductance).

^b Use of Type D shall be limited explosion groups IIA/AB with MIE > 0.14 mJ.

Table 5 from the standard IEC 61340-4-4, Electrostatics – Part 4-4

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	Permissible	Permissible	Not permissible
Type D	Not permissible	Not permissible	Permissible	Not permissible

Table 6 from the standard IEC 61340-4-4, Electrostatics – Part 4-4



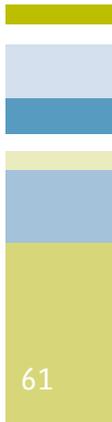
Permissible configurations and requirements for Type L1 inner liners (without conductive internal layers)				
Configuration	Parameters			
	Resistivity of inside surface ρ_i	Resistivity of outside surface ρ_o	Breakdown voltage V_B	Thickness d
1	$\rho_i \leq 1.0 \times 10^8 \Omega$	$\rho_o \leq 1.0 \times 10^8 \Omega$	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	$\rho_i \leq 1.0 \times 10^8 \Omega$	$\rho_o > 1.0 \times 10^{12} \Omega$	$V_B < 4kV$	No limit
4	$\rho_i > 1.0 \times 10^{12} \Omega$	$\rho_o \leq 1.0 \times 10^8 \Omega$	$V_B < 4kV$	$d < 700 \mu m$

Table 1 from the standard IEC 61340-4-4, Electrostatics – Part 4-4

Permissible configurations and requirements for Type L1C inner liner (with conductive inner layers ³)				
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	$\rho_i \leq 1.0 \times 10^{12} \Omega$	$\rho_o > 1.0 \times 10^{12} \Omega$	$V_B < 4kV^b$	No limit
3	$\rho_i > 1.0 \times 10^{12} \Omega$	$\rho_o \leq 1.0 \times 10^{12} \Omega$	$V_B < 4kV^b$	$d < 700 \mu m$
4	$\rho_i > 1.0 \times 10^{12} \Omega$	$\rho_o > 1.0 \times 10^{12} \Omega$	$V_B < 4kV^b$	$d < 700 \mu m$

^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 greater than $1.0 \times 10^{12} \Omega$ and the conductive internal layer.

Table 2 from the standard IEC 61340-4-4, Electrostatics – Part 4-4



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 .

Table 3 from the standard IEC 61340-4-4, Electrostatics – Part 4-4

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

Table 4 from the standard IEC 61340-4-4, Electrostatics – Part 4-4



4 Bibliography

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The ISSA

Creating social security

ISSA, the International Social Security Association is the world's leading umbrella organization for institutions, government agencies and authorities concerned with social security.

In a narrower sense, social security means protection against the consequences of "social risks". In addition to reduction in earning capacity due to occupational accident, occupational disease and occupational disability, this also includes illness, unemployment, assumption of family burdens, ageing and death of employed persons. In a broader sense, social security also includes an active labor market policy, a public education system and a balancing tax policy.

The ISSA was founded in 1927 by 17 European non-governmental organizations as the "International Conference of National Unions of Mutual Benefit Societies and Sickness Insurance Funds". Today, the ISSA has around 350 institutions, government agencies and authorities in more than 150 countries on all continents and is based at the United Nations International Labour Organization (ILO) in Geneva. The substantive work is carried out in 13 specialist committees, including those focusing on occupational accidents and diseases, health benefits and health insurance, employment policy and unemployment insurance, and family benefits and survivors' insurance.

Preventing occupational risks

The "Special Commission on Prevention" plays an important role within the ISSA". It consists of 14 international sections and deals with work-related risks in various sectors such as the chemical industry, mining, electricity and transport industry, but also with cross-cutting issues such as machine and system safety, information and prevention culture. The Special Commission coordinates the joint activities of the International Sections on Risk Prevention and other ISSA prevention activities.

As one of the first sections of the Special Commission, the International Section on Prevention in the Chemical Industry was founded in Frankfurt am Main in June 1970. It is committed to the prevention of occupational accidents and diseases in the chemical and allied industries, particularly in plastics and rubber, paints and coatings, pharmaceuticals and cosmetics, and specialty chemicals and petroleum refining. The chair and secretariat are held by the Berufsgenossenschaft Rohstoffe und chemische Industrie in Heidelberg.

In 1975, the International Section on Machine and System Safety was founded. Its objective is to increase safety and health protection at work worldwide in the field of machine and system safety. The chair and secretariat are held by the Berufsgenossenschaft Nahrungsmittel und Gastgewerbe in Mannheim.



Chemical Industry



Machine and System Safety



Transportation



Construction Industry



Information



Mining Industry



Agriculture

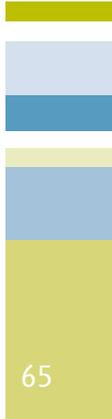


Communicating expertise

A particular thematic focus in many branches of industry, e.g. the chemical and food industries, is dealing with explosion risks. Therefore, in 1978, the working groups 'Hazardous Substances' and 'Explosion Protection' were established within the Section on Prevention in the Chemical Industry. In order to exploit synergy effects and increase efficiency, the 'Explosion Protection' working group merged with the corresponding working group of the Section on Machine and System Safety in 2008.

Intensive informal discussions are held in the working groups, brochures and instruction media are developed and workshops are organised to promote the international exchange of experience among experts and to develop targeted-oriented solutions for selected problems.

In this way, the Section on Prevention in the Chemical Industry and the Section on Machine and System Safety aim to contribute to a high level of technology that is comparable among industrialised countries and to pass on their knowledge to industrially less developed countries.



Occupational
Risks in Health
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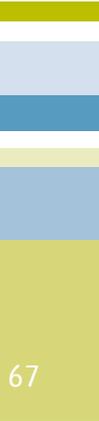
Information



Mining



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INTERNATIONAL SOCIAL SECURITY ASSOCIATION

Section on Prevention in the Chemical Industry
Section on Machine and System Safety

Explosion Safety of Bulk Material Plants

Module: Packaging

This ISSA brochure “Packaging” is a module of the series “Explosion safety of bulk materials handling equipment”. To assess the explosion risk of a plant, it is divided into smaller units, known as “modules”. In addition to a clear layout, this enables a targeted and process-oriented approach. This allows individual assessments from the ISSA sample collections as well as the processes and modules presented in the individual brochures to be used and ultimately linked for the risk assessment.

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