



SLOVENSKI STANDARD

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Safety of machinery - Guidance and recommendations for the avoidance of hazards due to static electricity

Safety of machinery - Guidance and recommendations for the avoidance of hazards due to static electricity

iTeh STANDARD PREVIEW

Sécurité des machines - Guide et recommandations pour éviter les risques dus à l'électricité statique

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REPORT

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English version

Safety of machinery
Guidance and recommendations for the avoidance
of hazards due to static electricity

This CENELEC Report has been prepared by the Technical Committee CENELEC TC 44X, Safety of machinery: electrotechnical aspects. It was approved by the Technical Committee on 1997-11-07 and endorsed by the CENELEC Technical Board on 1999-01-01.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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Foreword

This CENELEC Report has been prepared by the Technical Committee CENELEC TC 44X, Safety of machinery: electrotechnical aspects.

The text of the draft was approved by CLC/TC 44X on 1997-11-07. Publication was authorized by the CENELEC Technical Board on 1999-01-01. CENELEC BT decided that the maintenance of this CENELEC Report will be undertaken by the Technical Committee CENELEC TC 31, Electrical apparatus for explosive atmospheres - General requirements.

This CENELEC Report is based on a number of documents including two national Codes of Practice: from the UK, BS 5958: Parts 1 & 2:1991, *Control of undesirable static electricity*; and from Germany, ZH 1/200: October 1989, *Code of Practice for preventing risks of ignition due to electrostatic charges: Guidelines in static electricity*, and a document published by Shell International Petroleum: *Static electricity - Technical and safety aspects*. It recommends good, accepted practice as followed by competent practitioners and brings together the results of practical experience and scientific investigation for ease of access and use of information.

This CENELEC Report takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading. It may be used after a risk assessment in the preparation of product family or dedicated product standards for machines (i.e. type C standards in CEN, as defined in EN 414: 1992, 3.1). The guidance can also be used by suppliers of equipment (e.g. machines) for which no product family or dedicated product standard exists. Where a product family or dedicated product standard exists its requirements take precedence.

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1 Scope

This document gives guidance and recommendations for avoiding ignition and electric shock hazards arising from static electricity.

It deals with the problems of static electricity that can give rise to ignition of flammable substances and to electric shock. Basic information about the generation of undesirable static electricity in solids, liquids and gases, and also on persons, together with descriptions of how the charges generated cause ignitions or electric shocks, is given in the annexes.

The processes that most commonly give rise to problems of static electricity are described in detail. The processes include the handling of different types of liquids, powders, gases and sprays. In each case, the source and nature of the electrostatic hazard are identified and specific recommendations are given for dealing with them.

This report is not applicable to the hazards of static electricity relating to lightning, to damage to electronic components, to medical hazards nor to the handling and care of detonators and explosives.

2 Definitions

Regulations relating to safety and electrostatics make use of many adjectives in order to quantify the conducting ability of materials. Different regulations and different industries use different adjectives; even when the same adjectives are used their definitions can vary. In order to avoid confusion, and to assist with translation, the adjectives normally used to quantify the resistance of a material in this document are conductive, dissipative and non-conductive (see 2.6, 2.8 and 2.9). However, in parts of the document liquids are also described according to their conductivities (see 5.1) and powders according to their resistivities (see 7.2.1).

NOTES

1 - The values given in the following definitions are the generally accepted ones. However, in parts of the document the values quoted in the text differ from those in the definitions. This is because the process, the method of handling or the material being handled is sufficiently unusual that a different (higher or lower value) is required.

2 - Several types of electrical discharge are frequently mentioned in this document; they have not been defined but they are described in detail in annex A.

For the purpose of this report the following definitions apply:

- 2.1 **volume resistivity:** The resistance of a body of unit length and unit cross-sectional area.
- 2.2 **surface resistivity:** The resistance across opposite sides of a surface of unit length and unit width commonly expressed in ohms/square.
- 2.3 **surface resistance:** The resistance between two parallel electrodes, each 100 mm long and 10 mm apart, in contact with the surface to be measured.
- 2.4 **leakage resistance:** The resistance between an electrode (usually circular and 20 cm² in area) in contact with the surface to be measured and earth.
- NOTE - The resistance depends upon the volume or surface resistivity of the materials and the distance between the chosen point of measurement and earth.
- 2.5 **conductivity:** The reciprocal of volume resistivity.
- 2.6 **conductive:** An adjective describing a material incapable of retaining a significant electrostatic charge when in contact with earth and having a volume resistivity equal to or lower than 10⁴ Ωm. (for certain items there are special definitions e.g. conductive hose).
- 2.7 **conductor:** A conductive object.

- 2.8 **dissipative (electrostatic dissipative):** An adjective describing a material incapable of retaining a significant amount of electrostatic charge when in contact with earth. These materials have a volume resistivity higher than $10^4 \Omega\text{m}$ but equal to or lower than $10^9 \Omega\text{m}$, or a surface resistivity less than $10^{10} \Omega$ (or surface resistance less than $10^9 \Omega$) measured at ambient temperature and 50 % relative humidity.
- 2.9 **non-conductive:** An adjective describing a material having a volume resistivity higher than $10^9 \Omega\text{m}$ measured at ambient temperature and 50 % relative humidity (many materials, e.g. polymers, have volume resistivities much higher than this value).
- 2.10 **non conductor:** A non-conductive object.
- 2.11 **antistatic (deprecated):** An adjective commonly used as a synonym for conductive or dissipative describing a material that is incapable of retaining a significant electrostatic charge when in contact with earth. In this context the word is commonly used to describe a type of footwear and antistatic additives (ASAs) for use with liquids.
- 2.12 **electric shock:** Pathophysiological effect resulting from an electric current passing through human or animal body. [IEV 826-03-04]
- 2.13 **relaxation time:** The time during which the electrostatic charge on a solid surface, in the bulk of a liquid or powder, or in a cloud of mist or powder, decays exponentially to $1/e$ (i.e. about 37 %) of its original value.
- 2.14 **hazardous area:** An area in which flammable or explosive gas/vapour-air or dust-air mixtures are, or can be, present in such quantities as to require special precautions against ignition.
- 2.15 **two-phase liquid:** A mixture of two immiscible liquids which, when settled, forms two separate phases with a distinct interfacial boundary.
- 2.16 **dissipative footwear:** Footwear that ensures that a person standing on a conductive or dissipative floor has a resistance to earth of more than $10^5 \Omega$ but less than $10^8 \Omega$.
- 2.17 **conductive footwear:** Footwear ensuring a resistance to earth typically of less than $10^5 \Omega$.
- 2.18 **dissipative clothing:** Clothing made from a material with a surface resistivity typically less than $5 \times 10^{10} \Omega$ per square (see EN 1149-1).
- 2.19 **minimum ignition energy (MIE):** The minimum energy that can ignite a mixture of a specified flammable material with air or oxygen, measured by a standard procedure.

3 General

Static electricity occurs commonly in industry and in daily life. Many of the effects are harmless and either pass completely unnoticed or are simply a nuisance, but static electricity can also give rise to a hazardous situation. Hazards caused by electrostatic charge include:

- ignition and/or explosion;
- electric shock in combination with another hazard (e.g. fall, trip) - see EN 292-1, 4.3 and 4.10;
- electric shock giving rise to injury or death, see EN 292-1, 4.3.

In addition, static electricity introduces operational problems during manufacturing and handling processes, e.g. by causing articles to adhere to each other, or by attracting dust.

It is generated by:

- the contact and separation of solids e.g. the movement of conveyor belts, plastics film, etc. over rollers, the movement of a person;
- the flow of liquids or powders, and the production of sprays;
- an induction phenomenon, i.e. objects becoming charged due to being in an electric field.

The accumulation of electrostatic charge can give rise to hazards and problems in a wide range of industries, and to ignition and explosion hazards particularly in chemicals, pharmaceuticals, petroleum and food processing industries.

The purpose of this guidance is to provide recommendations for the control of static electricity. In some cases static electricity plays an integral part of a process, e.g. paint spraying, but more often it is an unwelcome side effect and it is with the latter that this guidance is concerned.

Because of the large number of industrial processes which could be involved it is not possible to give detailed information relevant to all of them. Instead, the guidance attempts to describe the problems associated with each process and to give recommendations on how to avoid them. This information should enable the plant operator to take whatever precautions could be necessary to avoid ignitions of potentially explosive atmospheres and electric shocks.

For convenience the guidance is divided into a number of clauses. These deal with problems associated with the following:

- the handling of solids;
- the storage and handling of liquids;
- the handling of gases and vapours;
- the storage and handling of powders;
- electrostatic problems caused by persons;
- avoidance of electric shock;
- earthing and bonding of plant and machinery.

The guidance also contains some fundamental information relating to electrostatic charging and its problems. This is contained in the annexes and it should enable the reader to better understand the advice given and also to extend the advice to processes that have not been dealt with in the guidance.

It is very seldom that an electrostatic hazard can be treated in isolation. Precautions against electrostatic hazards should be in addition to other precautions, e.g. explosion protection. They should also be consistent with precautions taken to avoid other hazards that may be present, such as ignitions due to other causes, and toxicity. It is important that all sources of risk in a system of work are considered and that a balanced approach to safety covering all risks be considered. In particular, care should be exercised in the provision of earthing systems where they can interfere with other protective systems, e.g. cathodic protection or intrinsically safe electrical equipment.

4 Static electricity in non-conductive solid materials

4.1 *General considerations*

Non-conductive solid materials are being used increasingly in equipment and structures in many forms including pipes, containers, sheets, coatings and liners. Many of these materials have volume resistivities greater than $10^{12} \Omega\text{m}$ and their use in hazardous areas can give rise to the following electrostatic hazards:

- the material could insulate conductive objects from earth which could become charged and give rise to sparks;
- charges on the surface of the material could lead to brush discharges;
- a combination of conductive and non-conductive materials in the presence of prolific charge generators (e.g. pneumatic transfers of powders, spraying of charges) could lead to very energetic propagating brush discharges.

The use of non-conductive materials needs to be restricted in some hazardous areas. The restrictions depend on the zone classification of the hazardous area (see annex D):

- in Zone 0, non-conductive solid materials should only be used if charging mechanisms capable of generating hazardous potentials will not occur either during normal operation (including maintenance and cleaning) or even in the case of rare malfunctions;
- in Zone 1, non-conductive solid materials should only be used if charging mechanisms capable of generating hazardous potentials will not occur either during normal operation (including maintenance and cleaning) or in the case of likely malfunctions;
- in Zone 2, non-conductive solid materials may be used unless their use results in the occurrence of frequent incendive discharges during normal operation;
- in the dust Zones 20, 21 and 22 there are, in general, no restrictions on the use of non-conductive materials unless there is a possibility of incendive discharges (see annex C).

NOTE - Many powders and dusts are non-conductive materials and recommendations for the avoidance of electrostatic hazards associated with powders are given in clause 7.

4.2 *Dissipative solid materials*

A solid material is defined as dissipative if its surface resistance does not exceed $10^{11} \Omega$. However, since surface resistance normally increases considerably with decreasing humidity the upper limit will depend on relative humidity. When testing materials, this value is acceptable only if it is measured at a relative humidity of less than 30 %. For measurements at 50 % relative humidity the upper limit is $10^9 \Omega$.

Providing that materials which meet these values of surface resistance are connected to earth no further protective measures need to be taken. In processes involving high speed separation (e.g. conveyor and transmission belts, see 4.5.3 to 4.5.5) other values can be required.

4.3 *The use of conductive or dissipative materials in place of non-conductive ones*

It is good practice to minimize the use of non-conductive materials in hazardous areas and there are many materials which used to be entirely non-conductive, e.g. rubbers or plastics, that are now available in grades which are dissipative, i.e. they comply with the requirements of 4.2. However these grades normally contain additives such as carbon black and the high proportion of carbon black required can degrade the physical properties of the material.

In some cases conductive or dissipative coatings are used to make the non-conductive material non-chargeable. However, the durability of these applications and their suitability for use in hazardous areas of Zone 0 and Zone 1 has yet to be proven. In any case, it is important that the conductive coating is properly earthed.

Fabrics, e.g. filter cloth, can be made dissipative by incorporating stainless steel or other conductive or dissipative fibres in the fabric. Care has to be taken to ensure that, as a result of washing or mechanical stress, the overall conductivity of the fabric is maintained and isolated patches of conductive fibres are not formed.

4.4 *Precautions required when using non-conductive solid materials*

4.4.1 General

To prevent incendive discharges the precautions given in 4.4.2 to 4.4.8 should be taken in all zones where the use of non-conductive solid materials is unavoidable.

The precautions given in 4.4.2 relate to avoidance of spark discharges, those given in 4.4.3 to 4.4.7 to incendive brush discharges, and those given in 4.4.8 to propagating brush discharges.

4.4.2 Unearthed metal and other conductive materials

With the exception of very small items, all metal and other conductive material should be bonded to earth (see table 6, clause 10).

4.4.3 Restrictions on the size of chargeable surfaces

The restriction on the size of chargeable surfaces depends on the ignitability of the gases and vapours (expressed by the representative groups IIA, IIB and IIC, see EN 50014) and the classification of the hazardous area:

- (a) for sheet materials the area is defined by the exposed (chargeable) area;
- (b) for curved objects the area is the projection of the object giving the maximum area;
- (c) for long narrow materials, such as cable sheaths or pipes, the maximum size is defined by the transverse dimension (i.e. the diameter for a cable sheath or pipe); when it is coiled it should be treated as for a sheet (see item a).

It is essential that non-conductive solid materials used in hazardous areas do not exceed the maximum area or width values given in Tables 1(a) and 1(b) for the zone within which it is used.

Table 1: Restriction on area or width values of non-conductive solid materials in hazardous areas containing potentially explosive atmospheres of groups IIA, IIB and IIC

(a) Restrictions on areas

Zone	Maximum area, cm ²		
	Group IIA	Group IIB	Group IIC
0	50	25	4
1	100	100	20
2	No limit (see 4.1)	No limit (see 4.1)	No limit (see 4.1)

(b) Restrictions on widths of narrow materials (e.g pipes, cable sheaths)

Zone	Maximum width, cm		
	Group IIA	Group IIB	Group IIC
0	0,3	0,3	0,1
1	3,0	3,0	2,0
2	No limit (see 4.1)	No limit (see 4.1)	No limit (see 4.1)

NOTE - Even smaller diameters can be required for narrow pipes (or tubes) containing flowing liquids or powders.

4.4.4 Brush discharges from thin non-conductive layers or coatings on conductors

Layers or coatings of non-conductive solids on earthed conducting surfaces (in particular metal surfaces) will not give rise to incendive brush discharges if the thickness of the layer does not exceed a value of 2 mm in the case of gases and vapours of groups IIA and IIB and a value of 0,2 mm in the case of gases and vapours of group IIC. In those cases no special protective measures are necessary within hazardous areas. It should, however, be noted that in the presence of very efficient charge generating mechanisms propagating brush discharges could occur (see 4.4.8).

4.4.5 Use of earthed metal meshes

If the restriction on size given in 4.4.3 cannot be met, incendive brush discharges can be avoided by incorporating an earthed mesh (or metal frame) into the non-conductive solid or by wrapping such a mesh around its surface. This method of protection is acceptable in hazardous areas providing that:

- the mesh size (i.e. the area contained by the wires) is restricted to a factor of four times the values given in table 1(a);
- the layer thickness above the mesh is restricted to the values given in 4.4.4; and
- high charging mechanisms do not occur.

However, an internal mesh does not guarantee protection against propagating brush discharges (see 4.4.8).

4.4.6 Humidification

The surface resistivity of some non-conductive solid materials can be reduced to dissipative levels if the relative humidity is maintained above about 65 %. Even though damp air is not conductive, a film of moisture forms on the surface on many materials depending on the hygroscopic nature of the material. Whereas some materials such as glass or natural fibres form a sufficiently conducting film of moisture, other materials such as polytetrafluoroethylene (PTFE) or polyethylene do not. Increasing the relative humidity, therefore, is not effective in all cases and, in general, it should not be used as the sole protective measure, especially not in Zone 0.

4.4.7 Ionizing the air

4.4.7.1 General

Ionization of the air is a method of making the air locally conductive so that charges on non-conductive solid materials are dissipated. It is particularly useful for discharging plastic sheets or films. Methods that may be employed include those given in 4.4.7.2 to 4.4.7.4. Correct installation and regular maintenance is essential for those devices.

4.4.7.2 Passive ionizers

Pointed electrodes such as earthed sharp needles, fine wires or conductive tinsel produce corona discharges when placed in the electric field from a charged body. These provide ions which neutralize the charge on the body. This method, however, is limited in its effectiveness and should not be used in Zone 0.

4.4.7.3 Active ionizers

A more efficient method of producing ions is to apply a high voltage to a number of corona points. Commercial systems commonly use alternating voltages in the range 5 kV to 10 kV supplied to a row of points. The currents from the corona points are limited either by high resistance or capacitive coupling. For use in potentially explosive atmosphere of Zone 1 the ionizer has to be type tested and approved as electrical apparatus. Active ionizers should not be used in Zone 0.

4.4.7.4 Radioactive sources

Radioactive sources ionise the surrounding air and can be used to dissipate the charges from a charged body. Radioactive ionisation itself does not present an ignition hazard; however, it is limited in its effectiveness and should not be used in Zone 0.

4.4.7.5 Ionized air blowers

Ionized air blowers using either high voltages or radioactive sources are used mainly for dissipating charges from awkwardly shaped objects. However, the ion concentration can rapidly decrease downstream due to recombination or adsorption of the ions by the walls. As a result, it is difficult to convey the ionized air over large distances. Unless it is approved for use in a hazardous area, the parts containing the high voltages should be placed outside. This method of protection should not be used in Zone 0.

4.4.8 Propagating brush discharges from non-conductive layers and coatings on metal surfaces

Non-conductive layers or coatings can lead to propagating brush discharges (see B.3.9.) but this can be prevented by the following measures:

- (a) Avoid having thin non-conductive coatings on metals or other conductive materials. Propagating brush discharges tend to occur with thin coatings; they can normally be prevented by having thicknesses greater than about 10 mm;

(b) Increase the surface or volume conductivity of the coating. It is not known exactly what value of surface resistance will prevent the occurrence of propagating brush discharges but the values of surface and leakage resistances quoted in 4.2 and a leakage resistance less than $10^{11} \Omega$ are sufficiently low;

(c) Use a coating with a low dielectric strength (breakdown voltage <4 kV, see A.3.5) instead of one with a high dielectric strength. Coatings with a low dielectric strength tend to electrically break down before a propagating brush discharge can develop. Due to their slight porosity, layers of paint usually show a low breakdown voltage so that propagating brush discharges are difficult to obtain from such layers.

NOTE - Polymer films which are wound on to a reel or are lifted from a conductive or non-conductive surface can acquire bipolar charges i.e. equal and opposite charges on the two surface of the film. This can lead to brush discharges and occasionally even to propagating brush discharges.

4.5 *Conveyor belts and transmission belts*

4.5.1 General

Due to the continuous separation of the contacting surfaces, e.g. a driving shaft and a belt, the moving surface can acquire a considerable amount of charge and become an ignition hazard. The amount of charge acquired depends on the material of the conveyor belt as well as the materials of the driving shaft and the rollers. It will increase with the velocity and tension of the belt and the width of the area of contact.

4.5.2 Conveyor belts

Conveyor belts are endless belts which run over rollers and transport materials. Usually the conveyor belt is made of non-conductive material whereas the driving shaft and the rollers are made of metal.

The charge acquired by the belt can only be safely dissipated to earth via the earthed dissipative rollers if the conveyor belt is sufficiently dissipative (see 4.5.3).

4.5.3 Conductivity criteria for conveyor belts

A belt is considered to be dissipative if the surface resistances on both sides of the belt are below $3 \times 10^8 \Omega$. In cases where the belt consists of layers of different materials it is considered to be dissipative if the resistance through it does not exceed $10^9 \Omega$ (resistance measured at 23°C and 50 % relative humidity). Care should be taken to ensure that repairs do not increase the values given.

4.5.4 Conditions of use for conveyor belts

In Zone 0 and Zone 1 containing potentially explosive atmosphere of group IIC, conveyor belts which meet the criteria of 4.5.3 may be used providing the belt velocity is restricted to 0,5 m/s and belt connectors are not used.

In Zone 1 containing potentially explosive atmosphere of groups IIA and IIB, conveyor belts may be used if the belt velocity is restricted to 5 m/s; belt connectors are permitted. If the belt velocity exceeds 5 m/s the criteria for transmission belts apply (see 4.5.6).

In Zone 2 protective measures are not necessary unless experience shows that frequent discharges occur.

4.5.5 Transmission belts

Transmission belts are V-belts and flat belts which drive rotating parts or machines. Sometimes the belt materials are non-conductive whereas the pulleys are normally of metal. The amount of charge acquired by the belt due to the continuous separation of the contacting surfaces depends on the material of the belt and pulleys and increases with the velocity and tension of the belt and the width of the contact area.

4.5.6 Conductivity criteria for transmission belts

The belt material is sufficiently dissipative if:

$$R.B \leq 10^5 \Omega\text{m}$$

where R is the resistance measured at the inner side of the mounted transmission belt between an electrode halfway between the two pulleys and earth and B is the width of the flat belt or double the width of the side face of the V-belt.

In cases where the belt consists of layers of different materials the belt is considered to be dissipative if the resistance across it does not exceed $10^9 \Omega$ (resistance measured at 23°C and 50 % relative humidity). Care should be taken to ensure that repairs do not increase the value given.

4.5.7 Conditions of use for transmission belts

Transmission belts should not be used in Zone 0 and in Zone 1 containing potentially explosive atmosphere of group IIC.

In Zone 1 containing potentially explosive atmosphere of groups IIA and IIB, transmission belts may be used if the following criteria are met:

- (a) The belt velocity does not exceed 30 m/s (no information is available for higher velocities);
- (b) The belt material meets the conductivity criteria defined in 4.5.6;
- (c) The belt is earthed via the metal pulleys.

A layer of wax or dirt on the belt could increase the adhesiveness of the belt and also its resistance and this could increase the charging hazard. It is essential that layers of non-conductive adhesives used to connect the belt do not interrupt the conductive path. Belt connectors should not be used.

For low speed transmission belts, the criteria given in 4.5.4 for conveyor belts can be used.

5 Static electricity in liquids

5.1 General considerations

Liquids can become electrostatically charged when there is relative movement between the liquid and adjacent solids or there is a second immiscible phase. Spraying of liquids can also create a highly charged mist or spray. Further details of charge generation and charge accumulation in liquids are given in A.1.3 and A.2.2. The level of charge accumulation in a particular liquid (and therefore the electrostatic hazards that can be created) is strongly dependent upon the conductivity of the liquid. To describe the possible hazards and associated means of prevention the conductivities of liquids have been defined as follows:

high conductivities	> 1 000 pS/m;
medium conductivities	between 50 pS/m and 1 000 pS/m;
low conductivities	< 50 pS/m.

With the exception of processes that produce mists or sprays, a hazardous level of charging is encountered only with liquids of low electrical conductivity. The conductivities and relaxation times for a number of liquids are given in Table 2.

NOTE: - For further details on the mechanisms of charging in liquids see annex A.

Table 2: Conductivities and relaxation times of some liquids

Liquid	Conductivity ($\mu\text{S m}^{-1}$)	Relaxation time (seconds)
Low conductivity		
highly purified paraffins	10^{-2}	2 000
typical paraffins	$10^{-1} - 10$	2 - 200
purified aromatic compounds (toluene, xylene etc.)	$10^{-1} - 10$	2 - 200
typical aromatic compounds	5 - 50	0,4 - 4
gasoline	$10^{-1} - 10^2$	0,2 - 200
kerosene	$10^{-1} - 50$	0,4 - 200
gas oil	$1 - 10^2$	0,2 - 20
white oils	$10^{-1} - 10^2$	0,2 - 200
lubricating oils	$10^{-2} - 10^3$	0,02 - 2 000
ethers	$10^{-1} - 10^2$	0,2 - 200
proprietary aromatic solvent mixtures	$1 - 10^3$	0,02 - 20
natural gas condensate without corrosion inhibitor	$10 - 10^2$	0,2 - 2
Medium conductivity		
fuels and oils containing (dissipative additives)	$50 - 10^3$	0,02 - 0,04
heavy (black) fuel oils	$50 - 10^5$	$2 \times 10^{-4} - 0,4$
esters	$10^2 - 10^6$	$2 \times 10^{-5} - 0,2$
High conductivity		
crude oil	$\geq 10^3$	$\leq 0,02$
natural gas condensate with corrosion inhibitor	$\geq 10^3$	$\leq 0,02$
alcohols	$10^6 - 10^8$	$2 \times 10^{-7} - 2 \times 10^{-5}$
ketones	$10^5 - 10^8$	$2 \times 10^{-7} - 2 \times 10^{-4}$
water	$\geq 10^8$	$\leq 2 \times 10^{-7}$
NOTE - In practice, liquids do not take more than 100 s for the charge to decay to a safe level.		

5.2 Ignition hazard

5.2.1 Occurrence of flammable atmosphere

NOTE - General information about flammability and ignitability of gaseous atmospheres is given in annex C.

When handling liquids, any flammable atmosphere that occurs is usually associated with the liquid being handled. If the flash point of the liquid is below that of its surface temperature, a flammable atmosphere should always be assumed to be present above the liquid surface. In cases where tanks are exposed to strong sunlight it should be assumed that a flammable atmosphere is present when liquids with a flash point up to 55°C are being handled. In areas of high ambient temperature and strong sunlight flammable atmospheres may occur with liquids with flash points above 55°C. When handling liquids with flash points well below the ambient temperature it should not be assumed that the atmosphere above the liquid is always saturated and, therefore, over-rich (i.e. non-flammable) unless it can be shown that a flammable atmosphere cannot be formed.