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ELECTROSTATICS - CODE OF PRACTICE FOR THE AVOIDANCE OF HAZARDS DUE TO STATIC ELECTRICITY

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Electrostatics - Code of practice for the avoidance of hazards due to static electricity

This Technical Report was approved by CENELEC on 2003-04-19.

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

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
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Foreword

This CENELEC code of practice gives information about the product and process properties necessary to avoid electrostatic hazards as well as operational requirements to be written in the users manual to ensure safe use of the product or process. It can be used in a risk assessment of electrostatic hazards or for 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).

This CENELEC document 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 gives the best available accepted state of the art guidance for the avoidance of hazards due to static electricity.

This document is mainly written for designers of processes, manufacturers and test houses. Appropriate information about the procedures necessary to avoid electrostatic hazards shall be written in the users manual or on the product to ensure safety. This document can also be used by suppliers of equipment (e.g. machines) when no product family or dedicated product standard exists or where the existing standard does not deal with electrostatic hazards.

This CENELEC document was originally prepared by the Technical Committee CENELEC TC 44X, Safety of machinery: electrotechnical aspects. The text of the first edition approved by CLC/TC 44X on 1997-11-07 and its publication was authorised by the CENELEC Technical Board on 1999-01-01.

Following a decision by CENELEC BT, the maintenance of the document was undertaken by the Technical Committee CENELEC TC 31, Electrical apparatus for explosive atmospheres - General requirements, which has delegated the revision to its Working Group 20 dealing with electrostatic hazards.

The text of the draft was submittted to the National Committees for approval by correspondence and was approved by CENELEC as CLC/TR 50404 on 2003-04-19.

This Technical Report supersedes R044-001:1999.

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Contents

1 Scope

This document is a code of practice for avoiding ignition and electric shock hazards arising from static electricity. The processes that most commonly give rise to problems of static electricity are described in detail. They include the handling of solids, liquids, powders, gases, sprays and explosives. In each case, the source and nature of the electrostatic hazard is identified and specific recommendations are given for dealing with them.

Basic information about the generation of undesirable static electricity in solids, liquids, gases, explosives, and also on persons, together with descriptions of how the charges generated cause ignitions or electric shocks, is given in the annexes.

This document is not applicable to the hazards of static electricity relating to lightning, to damage to electronic components, nor to medical hazards.

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).

NOTE 1 More details about electrostatic properties, concepts and terms are given in the annexes
NOTE 2 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.

For the purpose of this document 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 (or ohms/square)

2.3
surface resistance
the resistance expressed in ohms between two electrodes in contact with the surface to be measured (usually parallel electrodes, each 100 mm long and 10 mm apart)

2.4
leakage resistance
the resistance expressed in ohms between an electrode in contact with the surface to be measured and earth (usually a circular electrode, 20 cm^2 in area)

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 10^4 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 Ωm but equal to or lower than 10^9 Ωm, or a surface resistivity less than 10^{10} Ω (or surface resistance less than 10^9 Ω) measured at ambient temperature and 50 % relative humidity

2.9
non-conductive
an adjective describing a material that is neither conductive nor dissipative and on which electrostatic charges can accumulate and not readily dissipate even when in contact with earth (e.g. most common plastics)

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

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 Ω but less than 10^8 Ω

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 of less than $5 \times 10^{10}\ \Omega$ (see EN 1149-1) or with good charge decay characteristics (see prEN 1149-3)

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

3.1 Standard approaches

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 document 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, this document attempts to describe the problems associated with each process and to give a code of practice on how to avoid them. This information should enable the plant operator to take whatever precautions could be necessary to avoid ignitions of potentially flammable atmospheres and electric shocks.

For convenience this document 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;
- the storage and handling of explosives
- electrostatic problems caused by persons;
- avoidance of electric shock;
- earthing and bonding of plant and machinery.

This document 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.

3.2 Alternative approaches

If the requirements of this document cannot be fulfilled, alternative approaches can be applied under the condition that at least the same level of safety is achieved. This may be established by a special risk assessment carried out by persons having appropriate experience.

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 $10^{12}\ \Omega$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 if charging mechanisms capable of generating hazardous potentials are unlikely to occur during normal operation (including maintenance and cleaning).

- in the dust zones 20, 21 and 22 consideration should be given to spark, brush, cone, and propagating brush discharges (see Annex B). However, practical experience and the absence of incidents indicate that brush discharges are of low incendivity with regard to powder clouds.

  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.

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