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BSI Standards Publication

Selection, use, care and maintenance of personal protective equipment for preventing electrostatic risks in hazardous areas (explosion risks)

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee GEL/101, Electrostatics.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Selection, use, care and maintenance of personal protective equipment for preventing electrostatic risks in hazardous areas (explosion risks)

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CEN-CENELEC Management Centre:
Avenue Marnix 17, B-1000 Brussels

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Contents

Page

Foreword

This document (CEN/TR 16832:2015) has been prepared by Technical Committee CEN/CLC/JWG 7 "PPE against electrostatic risks", the secretariat of which is held by NEN.

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Introduction

European Standards for personal protective equipment (PPE) are developed to ensure compliance with the European Directive 89/686/EEC. Since the primary aim of this directive is to guarantee a free market in the European Union, these standards are made to meet the needs for a common set of safety requirements and test methods.

The actual use of PPE is not covered by this directive, nor by related standards.

This Technical Report has been developed to meet the needs for a document on selection, use, care and maintenance. Regulations on health and safety are based on Directive 89/686/EEC, giving minimum requirements on the selection and use of PPE in the workplace. EU Member States may impose more stringent requirements and may define exposure limits.

The information in this Technical Report has been produced to assist employers in making the necessary decisions regarding the selection, use, care and maintenance of PPE. The guidance given may also be useful for other parties such as suppliers of PPE or services, inspection agencies, insurance companies, etc.

The purpose of this Technical Report is to highlight the main areas that an employer needs to consider.

This Technical Report may serve as guidance and as a checklist when a company is preparing its own management system or programme for PPE.

1 Scope

This Technical Report sets out guidance for the selection, use, care and maintenance of clothing and related items of personal protective equipment designed to prevent hazards caused by static electricity in hazardous areas.

Static electricity should not be confused with mains supply electricity, or other forms of electric current; the requirements for protection against static electricity are different to the requirements for protection against hazards associated with electric current. Protection against electrostatic risks should not be confused with protection against electric arc; the former is concerned with electrical properties and the latter is concerned with heat, flame and projectile protection.

Directive 89/686/EEC requires that PPE intended for use in explosive atmospheres must be so designed and manufactured that it cannot be the source of an electric, electrostatic or impact-induced arc or spark likely to cause an explosive mixture to ignite. Whereas this Technical Report addresses electrostatic ignition risks, it does not address other possible sources of ignition. Nevertheless, other possible sources of ignition are required to be considered when certifying PPE to the requirements of Directive 89/686/EEC.

NOTE EN 13463–1 gives guidance on assessing possible ignition sources in non-electrical equipment that may be used for some items of PPE.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1081, *Resilient floor coverings — Determination of the electrical resistance*

EN 1149-1, *Protective clothing — Electrostatic properties — Part 1: Test method for measurement of surface resistivity*

EN 1149-2, *Protective clothing — Electrostatic properties — Part 2: Test method for measurement of the electrical resistance through a material (vertical resistance)*

EN 1149-3, *Protective clothing — Electrostatic properties — Part 3: Test methods for measurement of charge decay*

EN 1149-5, *Protective clothing — Electrostatic properties — Part 5: Material performance and design requirements*

CEN/TR 15321:2006, *Guidelines on the selection, use, care and maintenance of protective clothing*

EN 16350, *Protective gloves — Electrostatic properties*

EN 60079-10-1, *Explosive atmospheres — Part 10-1: Classification of areas — Explosive gas atmospheres (IEC 60079-10-1)*

EN 60079-10-2, *Explosive atmospheres — Classification of areas — Combustible dust atmospheres (IEC 60079-10-2)*

CLC/TR 60079-32-1:2015, *Explosive atmospheres — Part 32-1: Electrostatic hazards, Guidance (IEC/TS 60079-32-1:2013)*

EN 60079-32-2:2015, *Explosive atmospheres — Part 32-2: Electrostatics hazards — Tests (under consideration) (IEC 60079-32-2:2015)*

EN 61340-4-1, *Electrostatics — Part 4-1: Standard test methods for specific applications — Electrical resistance of floor coverings and installed floors (IEC 61340-4-1)*

EN 61340-4-3, *Electrostatics — Part 4-3: Standard test methods for specific applications — Footwear (IEC 61340-4-3)*

EN 61340-4-5, *Electrostatics — Part 4-5: Standard test methods for specific applications — Methods for characterizing the electrostatic protection of footwear and flooring in combination with a person (IEC 61340-4-5)*

EN ISO 11611, *Protective clothing for use in welding and allied processes (ISO 11611)*

EN ISO 13688, *Protective clothing — General requirements (ISO 13688)*

CEN ISO/TR 18690, *Guidance for the selection, use and maintenance of safety and occupational footwear and other personal protective equipment offering foot and leg protection (ISO/TR 18690)*

EN ISO 20344, *Personal protective equipment — Test methods for footwear (ISO 20344)*

EN ISO 20345, *Personal protective equipment — Safety footwear (ISO 20345)*

EN ISO 20346, *Personal protective equipment — Protective footwear (ISO 20346)*

EN ISO 20347, *Personal protective equipment — Occupational footwear (ISO 20347)*

ISO 7000, *Graphical symbols for use on equipment — Registered symbols*

ISO 10965, *Textile floor coverings — Determination of electrical resistance*

3 Term and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
hazard
situation which can be the cause of harm or damage to the health of the human body

[SOURCE: CEN/TR 15321:2006, 2.1]

Note 1 to entry: The effects of static electricity can be a nuisance. Electrostatic attraction of dirt and electrostatic shocks to personnel, for example, are not directly harmful, but they are nonetheless undesirable. Nuisance effects may cause hazards indirectly. For example, a person working on a ladder may fall off the ladder because of an involuntary reflex after receiving an electrostatic shock. If nuisance shocks are felt, it is an indication that there is an electrostatic ignition risk, if the person concerned is in a hazardous area.

3.2
risk
combination of the frequency, or probability, of occurrence and the consequence of a specified hazardous event

[SOURCE: CEN/TR 15321:2006, 2.2]

3.3
selection
process of determining the type of protective equipment (garments) that is necessary for the required protection

[SOURCE: CEN/TR 15321:2006, 2.3]

3.4
use
application of protective clothing including its limitations

[SOURCE: CEN/TR 15321:2006, 2.4]

3.5
care
to keep in good working order, including procedures for cleaning, decontamination and storage

[SOURCE: CEN/TR 15321:2006, 2.5]

3.6
maintenance
to preserve from loss or deterioration, to include procedures for inspection, repair and ultimate removal from service

[SOURCE: CEN/TR 15321:2006, 2.6]

3.7
explosive atmosphere
mixture with air, under atmospheric conditions, of flammable substances in the form of gas, vapour, dust, fibres, or flyings which, after ignition, permits self-sustaining propagation

[SOURCE: IEV 426-01-06]

3.8
hazardous area
area in which an explosive material, pyrotechnic article or explosive atmosphere is present, or may be expected to be present, in quantities such as to require special precautions for construction and use of personal protective equipment

[SOURCE: IEV 426-03-01, modified — The definition has been modified and the original Notes to the definition are not reproduced here.]

3.9
hazardous zone
hazardous area classified based on the frequency of the occurrence and duration of an explosive atmosphere

Note 1 to entry: See Annex B.

3.10
electricity
set of the phenomena associated with electric charges and electric currents

[SOURCE: IEV 121-11-76]

3.11
electric current
electric charges that continuously move through a conductor under the influence of a potential gradient

3.12
electric field
electrostatic field
vector field that surrounds electric charge

3.13
electric induction
electrostatic induction
phenomenon in which the electric charge distribution in a body is modified by an electric field

[SOURCE: IEV 121-11-68]

3.14
static electricity
accumulation of electric charge on an object or surface

3.15
electrostatic
associated with static electricity

3.16
electrostatic discharge
ESD
transfer of electric charge between bodies of different electrostatic potential in proximity or through direct contact

[SOURCE: IEV 161-01-22, modified — "Electric" is here replaced with "electrostatic" and the original Note to the definition is not reproduced here.]

3.17
brush discharge
type of electrostatic discharge that occurs when rounded (as opposed to sharp) earthed conductors are moved towards charged insulating objects or surfaces; characterized by branching discharge channels

3.18
spark discharge
spark
type of electrostatic discharge that occurs between two conductors; characterized by a well-defined luminous discharge channel carrying a high density current

3.19
corona discharge
corona
type of electrostatic discharge with slight luminosity produced in the neighbourhood of a pointed, or small radius conductor and limited to the region surrounding the conductor in which the electric field exceeds a certain value

Note 1 to entry: Other types of electrostatic discharge exist (e.g. propagating brush discharge, cone discharge, lightning, etc.), but they are not normally associated with PPE in the context of this document.

3.20
electrostatic shock
physiological effect resulting from an electrostatic discharge passing through a human body

3.21
tribocharging
triboelectric charging
triboelectrification
electrical charging process in which net charge is generated by the contact and separation of two surfaces which may be solid, liquid or particle-carrying gases

3.22
triboelectric series
list of materials ranked in order of how they charge when in contact with one another

Note 1 to entry: See Annex A.

3.23
antistatic
antielectrostatic
property of a material or object that reduces its tendency to acquire charge by contact or rubbing, or that reduces the time taken for charge to dissipate to an acceptable level

Note 1 to entry: Although "antistatic" is a commonly used term, it is deprecated in some standards documents because it has many different meanings, depending on the context in which it is used, and this can lead to confusion.

3.24
low charging
a-static
property of a material or object that reduces its tendency to acquire charge by contact or rubbing

3.25
conductive
describing materials or objects that allow charge to be dissipated rapidly by conduction to earth

3.26
insulating
describing materials or objects that retain charge for long periods of time even when connected to earth

Note 1 to entry: Conductive and insulating materials and objects are commonly defined quantitatively by their resistance or resistivity. The range of acceptable values of resistance or resistivity can vary significantly depending on the material or object and its application.

3.27
electrostatic dissipative (used in EN 1149 (all parts))
static dissipative
dissipative
describing materials or objects that dissipate charge to an acceptable level within an acceptable period of time

Note 1 to entry: Electrostatic dissipative materials and objects may be defined quantitatively by their resistance or resistivity, or by other parameters such as decay time, shielding factor, etc. If resistance or resistivity is used to define electrostatic dissipative materials or objects, the acceptable range of values is between that of conductive materials and objects and insulating materials and objects.

3.28
oxygen-enriched atmosphere
atmosphere in which the oxygen content exceeds 21,5 % volume fraction of air

Note 1 to entry: Minimum ignition energy values are commonly specified for mixtures with air containing normal levels of oxygen, i.e. (21,0 ± 0,5) % volume fraction.

Note 2 to entry: In normal industrial situations, it is unlikely that people will be working in an oxygen-enriched atmosphere. Nevertheless, an oxygen-enriched atmosphere can occur inadvertently, for example when gas welding is carried out. Oxygen-enriched atmospheres can also occur in medical applications.

3.29
earth (verb)
ground
to connect a conductor to the main body of the Earth to ensure that it is at earth potential

3.30
earth (noun)
ground
part of the Earth which is in electric contact with an earth electrode and the electric potential of which is not necessarily equal to zero

[SOURCE: IEV 195-01-03]

NOTE In some contexts, earth can have a different meaning to ground, but for the purposes of this document earth and ground are synonyms.

3.31
equipotential bonding
to electrically connect all conductors and static dissipative materials and objects within a system together to ensure that no hazardous potential differences exist within the system

Note 1 to entry: For the purposes of this document, and unless otherwise stated, equipotential bonding may be used in cases where earthing is impossible or impractical.

3.32
resistance to earth
leakage resistance
total electrical resistance through a system between a person or item or component of PPE and earth

3.33
capacitance

relationship between charge on a conductor (Q) and its electrical potential (V) given by $C = \frac{Q}{V}$

Note 1 to entry: Capacitance is variable and is dependent on the proximity of the conductor relative to other large bodies or earth planes

3.34
minimum ignition energy
MIE (abbreviation)
minimum energy that can ignite a mixture of a specified flammable material with air or oxygen, measured by a standard procedure

Note 1 to entry: ASTM E582 defines standard procedures for determining MIE of gas and vapours; IEC 61241–2-3, EN 13821 and ASTM E2019 define standard procedures for determining MIE of dusts.

Note 2 to entry: Annex A of this Technical Report and CLC/TR 60079–32–1:2015, C.6 give additional information on minimum ignition energy.

3.35
probability of charging
probability of a charge mechanism occurring

Note 1 to entry: Probability of charging is only concerned with the occurrence of a charging mechanism, not the quantity of charge generated.

4 Selection

4.1 General

The primary defence against hazardous electrostatic discharges from personnel is to ensure that they are properly earthed (see 5.1). When people are earthed there is no possibility of electrostatic discharges occurring from their bodies. However, electrostatic discharges from their clothing and other items of PPE may still be possible and consideration should be given to the need for electrostatic dissipative protective clothing and equipment.

Depending of the sensitivity to ignition, and the probability of an explosive atmosphere being present, it may be possible to safely use PPE that has limited areas or limited widths of insulating materials. The size limitations for insulating materials that can be safely used in hazardous areas are given in CLC/TR 60079–32–1:2015, Table 3. For example, in Zone 1 with gases of explosion group IIA and IIB, it is permissible to have continuous areas of insulating material up to 10 000 mm^2 and up to 30 mm in width. Smaller items of PPE may fall within the permissible limits, but clothing and other large items of PPE will generally exceed the permissible size limits for insulating materials and it is for these items of PPE that there is normally a need for electrostatic dissipative materials to be used.

It is important to note that the use of electrostatic dissipative protective clothing and equipment cannot eliminate the risk of hazardous electrostatic discharges from isolated personnel. Some items of PPE, e.g. conductive or antistatic footwear is intended to provide an adequate connection between personnel and earth, but such items of PPE are only effective if the connection to earth is not compromised. For example, conductive or antistatic footwear is only effective if used in conjunction with conductive or dissipative flooring. Although electrostatic dissipative protective clothing and equipment may help to reduce the risk of hazardous electrostatic discharges, they cannot be used as a substitute for proper earthing.

Directive 1999/92/EC requires employers to eliminate all possible ignition sources from areas where it is identified that explosive atmospheres exist. If, for example, a person is working with a flammable gas – may be at a hydrogen filling station – there is a risk that a brush discharge from plain clothing could ignite the gas because the energy in a brush discharge may be greater than the minimum ignition energy (MIE) of the gas. In this case the employer has an obligation under Directive 1999/92/EC to provide electrostatic dissipative protective clothing if the hazard associated with explosive atmosphere cannot be eliminated by technical measures.

On the other hand, if a powder with MIE of a greater than 1 mJ is being handled, there is no risk of a brush discharge from plain clothing causing an ignition of the powder. In this case the employer can still comply with Directive 1999/92/EC by providing insulating clothing and ensuring that personnel are properly earthed.

The risk associated with electrostatic discharges from clothing depends on the presence and sensitivity to ignition of explosive atmospheres. To assist in identifying different levels of risk, EN 60079-10-1 and EN 60079-10-2 classify hazardous areas into zones depending on the nature of the flammable material (gas and vapour, or dust) and on the probability of an explosive atmosphere being present (see Annex B).

Another factor in determining risk is the probability of a charging mechanism occurring. The most common way in which clothing becomes charged is by contact and rubbing, a process known as tribocharging. A jacket, for example, may be tribocharged when a person sits in and then rises from a seat, the jacket having rubbed against the surface of the seat. A jacket, therefore, may be considered to have a high probability of being exposed to a charging mechanism. Conversely, a hat may not come in contact with other objects and may, therefore, be considered to have a low probability of being exposed to a charging mechanism. Clothing and other items of PPE can also become charged by exposure to equipment that generates ions, charged sprays or aerosols.

Another charging mechanism, only applicable to isolated conductors, is induction, which is the separation of charge in the presence of an electric field. Standards and codes of practice require that conductors, which in this context includes people, are properly and securely earthed in hazardous areas, so in most cases the risk of induction charging is not significant. However, care should be exercised in selecting PPE that may include small conductors that cannot be earthed for practical reasons.

Table 1 gives some examples of different situations with high and low probability of charging. The situations described in Table 1 are illustrative examples only and should not be considered as definitive statements of actual charging behaviour. Charging is dependent on a number of factors and should be evaluated on a case by case basis. Expert advice should be obtained if the probability of charging is not understood, particularly when evaluating new situations.

Although the nature of materials largely determines their propensity for charging, environmental factors, i.e. temperature and humidity, also have an influence. In general, as relative humidity, decreases, the propensity of materials to acquire and retain charge increases. Risk assessment should take account of the full range of environmental conditions workers are likely to be exposed to, including seasonal variations, outdoor or indoor working (or both), and the presence of heating and air conditioning in the workplace. A typical conditioning environment specified in test standards (e.g. EN 1149-1 and EN 1149-3) is (23 ± 1) °C and (25 ± 5) %RH. This conditioning environment is a compromise between the worst case conditions likely to occur in practice, and the practical limitations of testing. However, if risk assessment shows that workers are likely to be exposed for prolonged periods to drier conditions than this, testing of PPE should be done under correspondingly lower humidity conditions.

Table 1 — Some examples of high and low probability charging situations

Situation	Probability of Charging	Comments
PPE rubbed when rising from a seat	High	
PPE rubbed against other items of PPE being worn by the same person, e.g.: • Sleeve rubbing against body of jacket; • One trouser leg rubbing against another; • Clothing rubbing against a fall arrest harness	High	Charging does occur between layers of clothing (e.g. outer jacket rubbing against a shirt). However, the charge on one layer is balanced by opposite charge on the other layer. The electrostatic risk is low provided the layers are not separated, i.e. provided the jacket is not removed, not opened and not excessively loose.
Exposure to charged mists or aerosols, e.g. paint spraying	High	
Exposure to fire extinguishers emitting charged sprays or particles	High	
Helmets not normally subjected to rubbing	Low	
Removal of helmets – harness rubs against hair	High	PPE should not be removed while in hazardous areas.
Wiping of visors	High	
Opening hook-and-loop fasteners	High	PPE should not be opened while in hazardous areas.
PPE with no isolated conductive parts exposed to high electric or electrostatic fields	Low	Insulating materials are not easily charged by induction when exposed to high fields.
PPE with isolated conductive parts exposed to electric or electrostatic fields	High	Hazardous voltages can be induced on isolated conductive parts. Such components should be earthed to prevent charging, or should be of such low capacitance that incendiary discharges cannot occur.

PPE is specifically excluded from the scope of Directive 2014/34/EU (and previously Directive 94/9/EC). Some PPE can be fitted with electrical or electronic components. Such components are required to comply with Directive 2014/34/EU if they shall be used in hazardous areas, whereas the PPE is required to comply separately with Directive 89/686/EEC. The fitting of electrical or electronic components within PPE that has been certified to comply with Directive 89/686/EEC does not mitigate the requirement for certifying the electrical or electronic components in accordance with Directive 2014/34/EU.

At the time of writing this Technical Report, ATEX Guidelines suggested that following the Essential Health and Safety Requirements in Directive 94/9/EC is one way of demonstrating compliance with the Basic Health and Safety Requirements in Directive 89/686/EEC. This guidance should not be taken to mean that PPE shall comply with the Directive 94/9/EC, nor should it be taken to mean that PPE that does not comply with Directive 94/9/EC, does not comply with Directive 89/686/EEC. Any item of PPE that has been certified by a Notified Body in accordance with Directive 89/686/EEC for use in explosive atmospheres has complied with all necessary legislation to be placed on the market in the EU territory. The meaning of the ATEX Guidelines on this issue is that a Notified Body, when examining the technical file of an item of PPE, may accept evidence of compliance with the Essential Health and Safety Requirements in Directive 94/9/EC, as being one form of evidence of compliance with Basic Health and Safety Requirements in Directive 89/686/EEC. The decision on whether such evidence is acceptable is entirely within the responsibility and authority of Notified Bodies operating under Directive 89/686/EEC.

4.2 Risk assessment

4.2.1 Explosive atmospheres

A risk assessment conducted in order to determine if electrostatic dissipative protective clothing and equipment is required should include the following:

a) identification of hazardous areas;

b) classification of hazardous zones (Zones 0, 1, 2, 20, 21 and 22);

NOTE It is not usual for people to work in a Zone 0.

c) classification of explosive atmosphere (Explosion Groups I, IIA, IIB, IIC, IIIA, IIIB and IIIC);

d) determination of minimum ignition energy of explosive atmospheres;

e) oxygen enrichment;

NOTE It is not usual for people to work in an oxygen-enriched atmosphere.

f) size (area or width) of clothing and other PPE;

g) mechanisms for and probability of charging clothing and other PPE; account should be taken of normal worker habits and working practices;

h) environmental factors (temperature and humidity).

Having conducted such a risk assessment, Table 2 can be used to determine if electrostatic dissipative protective clothing and other electrostatic dissipative PPE are required.

The subdivision of gases and vapours into explosion groups IIA, IIB and IIC is based on the maximum experimental safe gap (MESG) or the minimum ignition current ratio (MIC ratio) of the explosive atmosphere. Explosion group classification is widely used in industry and provides a simple way for electrical equipment manufacturers and users to determine the level of protection required. CLC/TR 60079–32–1 gives a more detailed account of the origin and development of explosion group classification.

When considering the risks of electrostatic discharges from non-electrical equipment such as protective clothing and other items of PPE, the relevant parameter is the minimum ignition energy (MIE) of the explosive atmosphere (see Annex A). There is a degree of correspondence between explosion groups and MIE. The range of MIE values for group IIC is lower than any MIE value in groups IIA and IIB. However, there is a significant overlap in the range of MIE values for groups IIA and IIB, as can be seen in Table B.3. For this reason, MIE should be used as the primary basis for determining ignition risk. The guidance given in Table 2 is based on MIE limits; explosion groups are shown for reference. If the explosive atmosphere is group IIB but the MIE is not known, the guidance given for 0,016 mJ ≤ MIE ≤ 0,2 mJ should be used.

The performance requirements for electrostatic dissipative protective clothing specified in EN 1149-5 are based on explosive atmospheres with MIE equal to or greater than that of the most easily ignitable mixture of hydrogen in air. For the purposes of this Technical Report, the lowest MIE of hydrogen/air is taken as 0,016 mJ, as quoted in CLC/TR 60079–32–1.

In standards for ATEX equipment, different levels of protection are specified to correspond to different levels of risk. On the other hand, electrostatic dissipative protective clothing is required to protect against worst case conditions. Table 2 provides guidance on when electrostatic dissipative protective clothing and other PPE is required, recommended or not required based on the overall risk, which is a combination of the probability of an explosive atmosphere occurring, the probability of a charging mechanism occurring and the sensitivity of the explosive atmosphere to ignition by electrostatic discharges. Table 2 represents different levels of risk in a similar way to standards for ATEX equipment. When “Required” or “Recommended” is indicated, it relates to PPE that has a single level of protection. However, as this level corresponds to worst case conditions, the PPE required or recommended is safe for use in all zones and for all MIE within the range specified in Table 2.

When “Not Required” is indicated, this means that electrostatic dissipative protective clothing or other PPE is not required, but other precautions for preventing electrostatic ignition sources are still required, specifically earthing of personnel and other conductors.

The present state of knowledge indicates that irrespective of MIE, powders and dusts (i.e. groups IIIA, IIIB and IIIC) cannot be ignited by brush discharges from insulators. Therefore, provided personnel and other conductors are earthed, PPE for use in explosive atmospheres where only dust or powder is present is not required to be electrostatic dissipative.

Table 2 — Requirement for electrostatic dissipative protective clothing and other PPE

<table>
<tr><th rowspan="2">Hazardous Zone</th><th rowspan="2">Probability of Charging</th><th rowspan="2">0,016 mJ ≤ MIE ≤ 0,2 mJ
Explosion Groups IIB, IIC</th><th colspan="2">MIE > 0,2 mJ</th></tr>
<tr><th>Explosion Groups IIA, IIB</th><th>Explosion Groups IIIA, IIIB, IIIC</th></tr>
<tr><td rowspan="2">Zone 0</td><td>High</td><td rowspan="4">Required</td><td rowspan="3">Required</td><td rowspan="6"></td></tr>
<tr><td>Low</td></tr>
<tr><td rowspan="2">Zone 1</td><td>High</td></tr>
<tr><td>Low</td><td rowspan="2">Recommended</td></tr>
<tr><td rowspan="2">Zone 2</td><td>High</td><td>Recommended</td></tr>
<tr><td>Low</td><td>Not Required</td><td>Not Required</td></tr>
<tr><td rowspan="2">Zones 20, 21, 22</td><td>High</td><td colspan="2" rowspan="2"></td><td rowspan="2">Not Required</td></tr>
<tr><td>Low</td></tr>
<tr><td colspan="5">The MIE of oxygen-enriched atmospheres may be less than the MIE of the flammable substance commonly found in literature. If it is determined that an oxygen-enriched atmosphere may occur, care should be taken to ensure the value of the MIE used for the purposes of risk assessment is that measured using the oxygen-enriched atmosphere.
Expert advice should be obtained before selecting electrostatic dissipative protective clothing for use in hazardous areas with MIE less than the lowest MIE for hydrogen/air (0,016 mJ).
Careful consideration should be exercised when comparing MIE values because there is some uncertainty inherent with the measurement of MIE, and different test methods may not give directly comparable results. For example, the lowest MIE of hydrogen/air is quoted as 0,011 mJ and 0,016 mJ by two different sources, and the lowest MIE of acetylene/air is quoted as 0,017 mJ and 0,019 mJ by another two different sources. Expert advice should be obtained if there is any doubt when comparing MIE values close to that of hydrogen/air.
If the explosive atmosphere is group IIB but the MIE is not known, the guidance given for 0,016 mJ ≤ MIE ≤ 0,2 mJ should be used.</td></tr>
<tr><td colspan="5">NOTE 1 There is a high probability of charging when clothing regularly comes into contact with external surfaces, particularly when the contacting materials are well separated in a triboelectric series.
NOTE 2 When “Not Required” is indicated, earthing personnel and other conductors is still required.
NOTE 3 Electrostatic dissipative protective clothing meeting the requirements of EN 1149–5 is safe for use in all hazardous areas shown in this table.
NOTE 4 The present state of knowledge indicates that powders and dusts cannot be ignited by brush discharges from insulators.</td></tr>
</table>

4.2.2 Explosives and pyrotechnic articles

The manufacture, storage and handling of explosives and pyrotechnic articles are subject to international, national and local regulations. Although most of the requirements of these regulations are common, there may be some variation and users are recommended to refer to the relevant regulations before selecting appropriate PPE. General guidance on avoiding electrostatic hazards when handling explosives is given in CLC/TR 60079–32–1:2015, Clause 10.

Explosives and pyrotechnic articles should be protected against electrostatic discharges under normal, foreseeable conditions of storage and handling. As in other applications, the primary defence against hazardous electrostatic discharges is to ensure that personnel are properly earthed. The acceptable resistance to earth is generally lower than the limit recommended for other applications (see 5.1).

The requirement for precautions in addition to earthing personnel is dependent on the sensitivity of the explosive or pyrotechnic articles to ignition.

If the spark ignition energy of the explosive, pyrotechnic article or ignition device is greater than 450 mJ, electrostatic dissipative protective PPE is not usually required.

Electrostatic dissipative protective PPE is recommended for spark ignition energies between 1 mJ and 450 mJ, and is required for spark ignition energies below 1 mJ.

4.3 Selection of electrostatic dissipative protective clothing

General guidance for the selection of protective clothing is given in CEN/TR 15321.

Electrostatic dissipative protective clothing should meet the design and performance requirements specified in EN 1149-5, and should form the outermost layer of clothing when worn in hazardous areas. A.4.4 of this Technical Report gives additional information on the different technologies used to make electrostatic dissipative protective clothing.

Clothing worn beneath, and entirely covered by electrostatic dissipative protective clothing does not need to be made from electrostatic dissipative materials provided that it does not interfere with the electrical continuity between the wearer's body and electrostatic dissipative protective clothing.

One of the minimum requirements specified in Annex II of Directive 1999/92/EC is "… appropriate measures must be taken to minimize the risks to workers from the physical effects of an explosion". This implies that protective clothing worn in hazardous areas should provide protection against heat and flame. The necessity for protection against heat and flame should be based on the results of a risk assessment.

An explosion produces several physical effects, including blast waves, expulsion of fragments, etc. PPE for use by civilians does not normally provide full protection against all such effects because the constraints imposed by the wearing of PPE that does provide full protection would prevent the wearer from carrying out their normal activity.

In order to protect workers from the thermal effects of a possible explosion, protection against heat and flame should be incorporated into electrostatic dissipative protective clothing. Alternatively, an ensemble may be worn where heat and flame protective clothing is worn in addition to electrostatic dissipative protective clothing, in which case the electrostatic dissipative protective clothing should form the outermost layer and should cover all insulating clothing. The outer layer should also have limited flame spread properties. User information supplied with electrostatic dissipative and heat and flame protective clothing should provide detailed instructions of how they should be worn together.

Although Directive 1999/92/EC may require employers to provide workers with suitable protective clothing, the requirements for such clothing are specified in Directive 89/686/EEC and associated standards. Protective clothing should not be marked as complying with Directive 1999/92/EC, and should not bear conformity marks reserved for ATEX equipment, unless the clothing contains electrical or electronic components.

EN 1149-5 specifies that thin, insulating external attachments to clothing such as labels, reflective stripes, etc., shall be permanently attached in such a way that separation between the attachments and clothing material is avoided. CLC/TR 60079–32–1:2015, Table 3 gives guidance on the maximum area and width of insulating materials in different zones. For example, for Zone 1, IIA and IIB the maximum width is 30 mm. However, this guidance assumes the material is used in isolation. In the case of a thin material backed by dissipative material it is possible to relax the limits. Insulating external attachments are acceptable provided the width does not exceed 50 mm and the thickness does not exceed 2 mm. Cords, drawstrings, etc. are generally narrower than the maximum width permitted for all zones except Zone 0, and therefore, can be used in these zones without restriction. For Zone 0, the width limit of 3 mm for Groups IIA and IIB, and 1 mm for Group IIC apply.

EN 1149-5 permits the use of metal and other conductive attachments such as zippers, buckles, buttons, etc. provided they are covered by the outer material, i.e. electrostatic dissipative material. At the time of writing, EN 1149-5 does not address the use of metal and other conductive attachments that cannot be covered. However, there is guidance in other standards documents. If metal or other conductive attachments need to be exposed for operational reasons, they need to be electrically connected to the earthing system of the clothing and person, unless it can be shown that the capacitance of isolated conductive attachments is less than limits specified in CLC/TR 60079–32–1:2015, Table 2 (also see Table A.2 of this Technical Report). Guidance on measuring capacitance is given in CLC/TR 60079–32–1 and EN 60079-32-2 and in A.3.3 of this Technical Report. It is important to measure capacitance of isolated conductive components when attached to clothing, especially when the clothing contains conductive yarns that are not in direct electrical contact with the conductive component because the presence of such yarns will affect the measured capacitance.

4.4 Selection of gloves

Gloves may be required to be worn in hazardous areas to either protect the wearer from a number of different hazards, to protect products being handled or to improve manual handling. If gloves are required to be worn for any of these reasons, the gloves should also protect against electrostatic hazards if they are worn in hazardous areas as recommended or required in Table 2.

Metal hand tools and other conductive objects that may be held in the hand, and are not otherwise earthed, rely on contact with the hand as their primary means of earthing. Gloves intended to be worn in hazardous areas should provide an electrical connection between the wearer's hands and any conductive object being held, such that the resistance to earth is within acceptable limits (see 5.1.2). Materials used to make the palms, fingers and any areas that extend above the wrist of the wearer should meet the requirements for electrostatic dissipative protective gloves specified in EN 16350.

In addition to providing electrical continuity between hand-held conductive objects and the wearer's hands, gloves that comply with EN 16350 are considered to present a low risk of creating hazardous electrostatic discharges.

The capacitance of any isolated conductive attachments should be less than limits specified in Table 2 of CLC/TR 60079-32-1 (also see Table A.2 of this Technical Report). Guidance on measuring capacitance is given in CLC/TR 60079-32-1 and EN 60079-32-2 and in A.3.3 of this Technical Report.

4.5 Selection of footwear and leg protection

General guidance for the selection of protective footwear and leg protection is given in CEN ISO/TR 18690.

Conductive and antistatic footwear as defined in EN ISO 20345, EN ISO 20346 and EN ISO 20347 is primarily intended to provide a means of earthing personnel (see 5.1.3.2). In many cases, it is only the soles of the footwear that are made from conductive or antistatic materials. However, areas of insulating materials that form the upper part of footwear, and which may extend up over the lower legs in the case of boots, can present an electrostatic risk if they are subjected to high charging. In such cases, the upper parts of footwear should be made from static dissipative materials as for other items of static dissipative clothing. EN 1149-5 or the general guidance on testing given in CLC/TR 60079-32-1 and EN 60079-32-2 should be used to evaluate upper parts of footwear.

Leg protection in the form of knee pads and shin guards are normally worn over clothing. If the outer layers are made from textile materials, these should be static dissipative materials as for other items of static dissipative clothing and may be evaluated with reference to EN 1149-5. Rigid materials that cannot be evaluated using the methods specified in EN 1149-1 or EN 1149-3 may be evaluated using the general guidance on testing given in CLC/TR 60079-32-1 and EN 60079-32-2 (see 4.6.1 below).

The capacitance of any isolated conductive attachments should be less than limits specified in Table 2 of CLC/TR 60079-32-1 (also see Table A.2 of this Technical Report). Guidance on measuring capacitance is given in CLC/TR 60079-32-1and EN 60079-32-2 and in A.3.3 of this Technical Report.

4.6 Selection of other items of PPE

4.6.1 General

Product standards for some items of PPE do not contain requirements for protection against static electricity. In the absence of a product standard, the requirements specified in EN 1149-5 may be used, provided the materials under test are of a suitable physical form to enable the measurement procedures specified in EN 1149-1 or EN 1149-3 to be carried out. Otherwise, the general guidance on testing given in CLC/TR 60079-32-1 and EN 60079-32-2, and summarized below, may be used as a basis for selecting PPE.

Material used in the construction of PPE should be conductive or static dissipative and should be capable of being earthed, either directly, or via the body of the wearer. Materials should have a surface resistance of less than 2,5 GΩ measured according to EN 1149-1, or less than 5 GΩ measured according to EN 60079-32-2:2015, 4.1.1. Surface resistance should be measured after conditioning at (25 ± 5) %RH.

NOTE 1 Surface resistivity is calculated by multiplying measured surface resistance by a factor derived from the geometry of the measuring electrodes. For the electrodes specified in EN 1149–1, the factor is approximately 20. For the electrodes specified in EN 60079-32-2:2015, 4.1.1, the factor is 10. Hence the limit values for surface resistance measured according to EN 1149–1 and for surface resistance measured according to EN 60079-32-2:2015, 4.1.1 both convert to a surface resistivity of 50 GΩ. The fact that the acceptance limit value is the same for both methods when expressed as surface resistivity does not necessarily mean that the actual measured values will be the same. Other factors, such as electrode material and hardness can affect results.

NOTE 2 Surface resistance is not an appropriate parameter to measure for some materials, e.g. textile materials containing core conductive fibres (see A.4.4). EN 60079-32-2 gives guidance on alternative measurements that can be used to evaluate electrostatic dissipative materials.

The area or width of any essential insulating material should be less than the limits given in CLC/TR 60079-32-1:2015, Table 3 and in Table A.3 of this Technical Report. If the area or width of insulating material exceeds these limits, an evaluation should be made of the propensity for charging and generation of incendiary discharges, either by charge transfer measurement or ignition testing, according to the procedures given in EN 60079-32-2:2015, 4.3. Testing should be done after conditioning at (25 ± 5) % RH.

For the purpose of evaluation, the area or width of insulating material should be taken as the area or width or material exposed to electrostatic charging.

The total system resistance between any metal or other conductive component (e.g. buckle, D-ring, fastener, bracket, etc.) and earth should be less than 10 GΩ, measured according to EN 60079-32-2:2015, 4.1.2 unless the capacitance is less than the limits given in CLC/TR 60079-32-1:2015, Table 2 and in Table A.2 of this Technical Report. Resistance to earth should be measured after conditioning at (25 ± 5) %RH.

If the form of the PPE under test does not permit the use of the electrodes specified in EN 60079-32-2:2015, 4.1.2, other suitable electrodes should be used, e.g. the application of conductive paint that does not adversely affect the surface of the material under test.

4.6.2 Selection of head protection

Electrostatic dissipative hats, caps, hoods, etc. made from flexible materials should comply with the requirements of EN 1149-5, and can be tested using the methods specified in EN 1149-1 or EN 1149-3.

Head protection made from rigid materials cannot be tested using the methods specified in EN 1149-1 or EN 1149-3. The general guidance on testing given in CLC/TR 60079-32-1 and EN 60079-32-2 should be used.

In the case of rigid helmets comprising an outer hard shell and an inner harness, the outer shell should be made from conductive or dissipative materials and the electrical continuity between the outer shell and the head of the wearer should be maintained by the use of conductive or dissipative materials for the harness and padding.

The capacitance of any isolated conductive attachments should be less than limits specified in Table 2 of CLC/TR 60079-32-1 (also see Table A.2 of this Technical Report). Guidance on measuring capacitance is given in CLC/TR 60079-32-1 and EN 60079-32-2 and in A.3.3 of this Technical Report.

4.6.3 Selection of hearing protection

Hearing protectors that fit inside the ear are too small to be considered an electrostatic hazard and no precautions against static electricity are required. Hearing protectors that fit over the ear and have continuous areas or widths of insulating materials less than the limits specified in CLC/TR 60079-32-1:2015, Table 3 may be used safely within corresponding hazardous areas. Otherwise, the general guidance on testing given in CLC/TR 60079-32-1 and EN 60079-32-2 should be used.

The capacitance of any isolated conductive attachments should be less than limits specified in Table 2 of CLC/TR 60079-32-1 (also see Table A.2 of this Technical Report). Guidance on measuring capacitance is given in CLC/TR 60079-32-1 and EN 60079-32-2 and in A.3.3 of this Technical Report.

4.6.4 Selection of eye and face protection

Eye protective equipment such as glasses and goggles that have continuous areas or widths of insulating materials less than the limits specified in CLC/TR 60079-32-1:2015, Table 3 may be used safely within corresponding hazardous areas. Otherwise, the general guidance on testing given in CLC/TR 60079-32-1 and EN 60079-32-2 should be used.

The capacitance of any isolated conductive attachments should be less than limits specified in Table 2 of CLC/TR 60079-32-1 (also see Table A.2 of this Technical Report). Guidance on measuring capacitance is given in CLC/TR 60079-32-1 and EN 60079-32-2 and in A.3.3 of this Technical Report.

4.6.5 Selection of respiratory protection

The general guidance on testing given in CLC/TR 60079-32-1 and EN 60079-32-2 should be used.

The capacitance of any isolated conductive attachments should be less than limits specified in Table 2 of CLC/TR 60079-32-1 (also see Table A.2 of this Technical Report). Guidance on measuring capacitance is given in CLC/TR 60079-32-1 and EN 60079-32-2 and in A.3.3 of this Technical Report.

4.6.6 Selection of hand and arm protection other than gloves

The general guidance on testing given in CLC/TR 60079-32-1 and EN 60079-32-2 should be used.

The capacitance of any isolated conductive attachments should be less than limits specified in Table 2 of CLC/TR 60079-32-1 (also see Table A.2 of this Technical Report). Guidance on measuring capacitance is given in CLC/TR 60079-32-1 and EN 60079-32-2 and in A.3.3 of this Technical Report.

4.6.7 Selection of protection against falls from a height including working belts

The general guidance on testing given in CLC/TR 60079-32-1 and EN 60079-32-2 should be used.

The capacitance of any isolated conductive attachments should be less than limits specified in Table 2 of CLC/TR 60079-32-1 (also see Table A.2 of this Technical Report). Guidance on measuring capacitance is given in CLC/TR 60079-32-1 and EN 60079-32-2 and in A.3.3 of this Technical Report.

4.6.8 Buoyance aids and personal floatation devices

Personal floatation devices that have the general appearance of clothing and may be made from similar outer materials can be tested using the methods specified in EN 1149-1 or EN 1149-3 and should comply with the requirements of EN 1149-5.

For other types of personal floatation devices, the general guidance on testing given in CLC/TR 60079-32-1 and EN 60079-32-2 should be used.

The capacitance of any isolated conductive attachments should be less than limits specified in Table 2 of CLC/TR 60079-32-1 (also see Table A.2 of this Technical Report). Guidance on measuring capacitance is given in CLC/TR 60079-32-1 and EN 60079-32-2 and in A.3.3 of this Technical Report.

4.7 Marking

Personal protective equipment that has been certified to provide protection against static electricity should be marked in accordance with EN ISO 13688 using the pictogram defined by ISO 7000-2415.

The distinctive Ex mark derived from Directive 84/47/EEC shall not be used to mark PPE unless the PPE incorporates equipment (electrical motors, electronic systems, etc.) that have been certified according to Directive 2014/34/EU.

At the time of writing this Technical Report, there is no pictogram defined within EN ISO 13688 or in ISO 7000 that can be used to indicate the intended application of PPE is for use in potentially explosive atmospheres, but a suitable pictogram is under consideration.

5 Use

5.1 Earthing and equipotential bonding

5.1.1 General

The purpose of earthing conductive and static dissipative objects and materials, including personnel, is to equalize their electrical potential with that of the Earth. In reality, there is a finite resistance between objects and the Earth and so a potential difference will exist. Nevertheless, by maintaining resistance to earth below an acceptable limit value, potential difference can be prevented from reaching a level where hazardous sparks can occur.

The purpose of equipotential bonding is to equalize the electrical potential between conductive and static dissipative objects with a large conductive body that is not necessarily at the potential of the Earth. Equipotential bonding is employed when earthing is impossible or impractical; on board an aircraft in flight, for example. For the purposes of this document, references to earthing include equipotential bonding as an alternative option, unless otherwise stated.

Earthing systems should provide secure and permanent connection to earth for all conductive and static dissipative objects and materials at all times in hazardous areas.

Specifications for items and components of PPE may include some form of electrical resistance or resistivity value. When designing and using systems, consideration should be given to the resistance of all components that make up the system, including the resistance of personnel. Any calculations should take account of parallel and series resistances. Verification of earthing systems is recommended by measuring the total resistance between designated earth points and personnel and/or items or components of PPE via whatever means of earthing is used.

5.1.2 Resistance to earth limits

5.1.2.1 Maximum limit value

The maximum limit value for resistance to earth depends on the rate at which charging occurs. of CLC/TR 60079-32-1:2015, Clause 13 provides an explanation of the considerations involved in determining the limit value for resistance to earth. For typical industrial situations the maximum limit value is given by:

$$R_e = 100/I_c$$

where

R_e is the maximum acceptable resistance to earth and I_c is the charging current. In practice, charging currents rarely exceed 1 µA and so a maximum resistance to earth limit of 100 MΩ is generally acceptable. The requirements for electrostatic dissipative protective clothing specified in EN 1149–5 are based on personnel being earthed via a resistance to earth of less than 100 MΩ.

Although rarely encountered in relation to personnel, electrostatic charging currents can be as high as 100 µA. In such cases, a maximum resistance to earth limit of 1 MΩ is required.

Regulations may require an even lower limit for some special applications. For example, the handling of explosives with spark ignition energy of less than 1 mJ requires a maximum resistance to earth limit of 100 kΩ.

5.1.2.2 Minimum limit value

If there is a possibility that personnel may inadvertently contact mains supply electricity, it is necessary to prevent the passage of harmful electric current through the body by maintaining resistance to earth above a minimum limit value. Different industries and applications may specify different minimum resistance to earth limit values; between 100 kΩ and 1 MΩ is typical.

In many situations where explosive atmospheres are present, exposure to mains supply electricity is not possible in normal operation because exposed current carrying conductors are a potential source of ignition and are, therefore, prohibited within explosion hazard zones. In such situations, lower resistance to earth limits are not normally specified.

Where there is a potential conflict between the need to prevent electrostatic hazards and the need to prevent electrocution, risk assessment should identify which is the greater risk. For example, in the case of explosives with spark ignition energy of less than 1 mJ, exposure to mains supply electricity is not possible under normal operation and may only occur under fault conditions. Therefore, the risk of electrocution is significantly lower than the risk of electrostatic discharge igniting the explosives. Hence, a maximum resistance to earth limit of 100 kΩ is specified with no minimum resistance to earth limit.

One example of where a minimum resistance limit is specified is clothing for use by electric arc welders. EN ISO 11611 specifies a minimum resistance of 100 kΩ. Two examples of where a minimum resistance to earth is sometimes specified are for emergency response personnel, i.e. fire fighters, etc., and utility workers. Emergency response personnel may have to operate in areas in which, through accident, both explosive atmospheres and exposed current carrying conductors may occur. Utility workers may be operating at one time with mains supply electricity and at another time with mains gas supply.

5.1.3 Earthing personnel

5.1.3.1 Means of earthing personnel

Earthing of personnel can be achieved by:

- the use of conductive or antistatic footwear, and conductive or static dissipative flooring;
- the use of earthing cords connected directly to the body of the wearer;
- the use of earthing cords connected indirectly to the body of the wearer via clothing or other items of PPE.

5.1.3.2 Use of conductive or static dissipative flooring and footwear

In situations where personnel need to move throughout an explosion hazard zone, the only practical means of earthing is the use of conductive or static dissipative flooring and footwear.

Standards that specify test methods for determining the electrical resistance of floor coverings, including resistance to earth measurements, are ISO 10965, EN 1081 and EN 61340-4-1.

EN ISO 20344 and EN 61340-4-3 specify test methods for determining the electrical resistance of footwear. EN ISO 20345, EN ISO 20346 and EN ISO 20347 specify requirements for both conductive footwear and antistatic footwear. Conductive footwear shall have a maximum resistance, measured according to EN ISO 20344, of 100 kΩ. No minimum resistance is specified. Antistatic footwear shall have a maximum resistance, measured according to EN ISO 20344, of 1 GΩ and a minimum resistance of 100 kΩ.

The maximum resistance for antistatic footwear specified in EN ISO 20345, EN ISO 20346 and EN ISO 20347 is greater than the maximum resistance to earth limit of 100 MΩ used in the derivation of requirements specified in EN 1149-5 for electrostatic dissipative protective clothing. Therefore, antistatic footwear complying with EN ISO 20345, EN ISO 20346 or EN ISO 20347 may not be suitable for earthing personnel when the resistance to earth is required to be less than 100 MΩ.

Footwear that has a resistance between 100 MΩ and 1 GΩ measured according to EN ISO 20344, may, in some cases, permit a resistance to earth of less than 100 MΩ when worn, but this is not always the case. EN 61340-4-5 specifies a test method for measuring the resistance to earth of footwear and flooring in combination with a person and it is recommended that this test standard be used to qualify personnel earthing systems.

In general, socks absorb sufficient perspiration so that the resistance through the socks between the wearer and the outer footwear does not increase significantly (see 5.2.3). However, if thick socks, or more than one pair of socks are worn (e.g. in cold conditions), or if socks with moisture impermeable membranes are worn, or if protective suits with integrated socks are worn, the resistance to earth may increase above acceptable limits. The test methods specified in EN 61340-4-5 should be used to verify that socks do not increase the resistance to earth of the footwear and flooring system.

Footwear and flooring can become contaminated with dirt, oil, etc. that can increase the resistance to earth. If such contamination is likely to occur, consideration should be given to specifying footwear and flooring with a lower resistance value when new and unused so that the resistance to earth stays below the acceptable limit even when contamination occurs.

One disadvantage of relying on footwear to protect personnel is that protection can be compromised during various activities. When kneeling or sitting, for example, feet may not be in contact with the floor and hence there may be a loss of earthing. On the other hand, when kneeling, the body may make electrical contact with the floor, lowering the resistance to earth below the acceptable safety limit.

Another disadvantage is that both footwear and flooring are subject to wear that could cause the resistance to earth to increase or decrease outside of acceptable limits.

5.1.3.3 Use of earthing cords

For seated operations and other operations where personnel are able to remain within a localized area, or where the hazardous area is small, earthing cords can be used to earth personnel and/or items of PPE.

Earthing cords typically comprise a flexible, coiled cord connected to earth at one end and to a person or item of PPE at the other end. Connection to a person is most commonly achieved via a closely fitting wristband or bracelet that ensures good electrical contact with the person's skin at the wrist. The cord is typically attached to the wristband or bracelet via a snap fastener. The cord should be long enough and sufficiently flexible to allow unrestricted movement of the person. The snap fastener should be secure enough to ensure good electrical contact, but shall separate easily in the event of the person having to evacuate the work station quickly in an emergency.

The resistance of earthing cord systems is typically between 100 kΩ and 1 MΩ, and this is usually achieved by the incorporation of a discrete resistor at one or both ends of the cord.

Earthing cords may be attached to items of PPE; for example at the cuff of a jacket. In such cases, it is important to ensure good electrical continuity between the item of PPE and the person.

5.1.4 Earthing PPE

5.1.4.1 Earthing electrostatic dissipative protective clothing

Single layer electrostatic dissipative protective clothing worn next to the skin, such as shirts, trousers, etc., is adequately earthed by direct contact with the wearer's body. Personnel should be advised not to wear undergarments that may compromise the electrical continuity between their body and electrostatic dissipative protective clothing. In situations where it is necessary to wear undergarments (e.g. in cold conditions), either undergarments should be worn that provide electrical continuity between the body and outer electrostatic dissipative protective clothing, or other means should be employed to ensure electrostatic dissipative protective clothing is earthed, such as those described for multi-layer clothing and multiple layers of clothing in the following paragraph.

Multi-layer clothing, in which only the outer layer is made from electrostatic dissipative materials, and clothing that is worn as an outer layer, such as jackets, coats, etc., should be designed to incorporate an electrical connection to the body of the wearer. A common approach is to incorporate elasticated cuffs made from conductive or static dissipative materials that contact the skin at the wearer's wrists and contacts the static dissipative layers of clothing. Another approach, which is particularly suitable for over-trousers and coveralls, is to provide a conductive connecting strap between static dissipative clothing and conductive or antistatic footwear.

As stated in 5.1.3.3, earthing cords can be used to directly earth static dissipative clothing.

The resistance to earth from any exposed conductors with a capacitance greater than the limits specified in CLC/TR 60079-32-1:2015, Table 2 should be less than 1 GΩ. If the electrostatic dissipative protective clothing is manufactured using materials containing core conductive fibres (see A.4.4), it may not be possible to achieve a resistance to earth from exposed conductors of less than 1 GΩ via the clothing material. In such cases, another form of connection between the exposed conductors and earth should be provided.

5.1.4.2 Earthing other items of PPE

Items of PPE that provide head protection, hearing protection, eye and face protection and respiratory protection normally have at least one part of the equipment in direct contact with the body of the wearer. The points of contact between PPE and the wearer's body should be used as the means of earthing the PPE. Parts of PPE that contact the body should be in electrical contact with the conductive or static dissipative parts of the PPE.

Personnel should be instructed not to wear clothing or anything else that might impede the electrical connection between the body and conductive or static dissipative parts of PPE, or be instructed to carefully check that electrically insulating layers of clothing are not coming between their skin and the conductive or static dissipative parts of PPE. For example, if a jacket is worn that is intended to be earthed by the cuffs contacting the wearer's wrists, the wearer should not wear a shirt made from insulating materials if the shirt sleeves extend around the wrists in such a way that they are likely to come between the jacket cuffs and the wearer's wrists. In this example, if a long sleeve shirt shall be worn, the cuff area at least should be made from conductive or static dissipative materials so that electrical continuity can be maintained between the wearer's body and the jacket, or the wearer should be instructed to make sure that the sleeves cuffs do not come between their wrists and the jacket cuffs.

Harnesses used to prevent falls from a height and other items of PPE, such as elbow pads, knee pads, etc., do not normally contact the body directly, but are worn over clothing. Provided the outer layer of clothing is static dissipative and earthed, and the items of PPE are made from electrostatic dissipative materials, adequate earth connection is provided during normal use. If electrostatic dissipative protective clothing is manufactured using materials containing core conductive fibres (see A.4.4), it may not be possible to use such clothing as a means of earthing other items of PPE. In such cases, another form of connection to earth should be provided.

Metal and other conductive items that are exposed on the surface of PPE should be earthed either directly or via the conductive or static dissipative materials of the PPE. Small conductive items, such as buttons and snap fasteners, can be used without being earthed provided the maximum capacitance of each individual item during normal use is less than the limits recommended in CLC/TR 60079-32-1 for the hazardous area in which the PPE is intended to be used (see A.3.3). In general, conductive items such as buckles and D-rings have capacitance greater than the acceptable limits recommended in CLC/TR 60079-32-1, and should, therefore, be earthed.

5.1.5 Verifying resistance to earth

Commercial personnel earthing monitors are available that measure the resistance between a person and the soles of their footwear. These monitors typically consist of an electrode that the person touches with their hand, and electrodes on which they stand. Similar monitors are also available that measure the resistance between an electrode that the person touches with their hand and an earth bonding cord attached to an item of PPE. Some equipment will also allow the resistance to earth from any item of PPE to be measured by connecting one electrode to the PPE via a suitable connecting cable. The result of the measurement can be displayed as a resistance value or as "go" or "no go" signal (e.g. a red or green light). A resistance value of 100 MΩ should be set for the maximum acceptable limit for a "go" signal. Personnel earthing monitors should be placed at the entrance to hazardous areas so that personnel can check the resistance of their footwear before entering the hazardous areas.

If gloves shall be worn in hazardous areas, the resistance through the gloves can also be checked by personnel wearing the gloves as they carry out checks using personnel earthing monitors. If a resistance greater than the maximum acceptable limit or a "no go" signal is indicated, checks should be made on footwear and gloves separately to determine which is at fault.

Whereas it may not always be practical to carry out resistance to earth tests on every item and component of PPE before personnel enter hazardous areas, it is recommended that resistance to earth verification tests are carried whenever it is practical to do so.

Users should be aware that even if the resistance of the person/PPE system is within acceptable limits, the resistance to earth of a system in use that is designed to be earthed via footwear relies on the resistance of flooring being within acceptable limits too. It is advisable for checks to be made on the resistance to earth of flooring when it is safe to do so, i.e. when there is no flammable atmosphere present in the area being checked.

Users should also be aware that verification tests can only verify resistance to earth at the point in time that tests are made, and that this does not guarantee that resistance to earth will always be within acceptable limits at all subsequent times.

5.2 Instructions for use

5.2.1 Use of electrostatic dissipative protective clothing and general instructions

General guidance for the use of protective clothing is given in CEN/TR 15321. Manufacturer's instructions and instructions given in product standards and other standards and technical reports relating to PPE should also be followed.

The guidance summarized in Table 2 of this Technical Report is based on clothing being in close proximity to the earthed human body, the presence of which will act to attenuate the electric field from any charge the clothing acquires. For this guidance to be valid, clothing, whether static dissipative or not, should be as close fitting as possible while still allowing normal unrestricted movement.

Clothing and other items of PPE should be put on before entering hazardous areas. PPE should not be stored in hazardous areas and should not be removed from packaging in hazardous areas. Static dissipative clothing that is required to cover other clothing should be securely fastened so that coverage is always maintained before entering hazardous areas and during all operations in hazardous areas.

When PPE is worn that is required to be earthed via the body of the wearer, care should be exercised in the choice of other clothing and other items of PPE so that earth continuity can be maintained. For example, if a static dissipative shirt is worn that is designed to be earthed by direct skin contact, an electrically insulating vest worn beneath the shirt should still allow sufficient areas of the static dissipative shirt to contact the skin. So, in this example, wearing a long sleeve vest beneath the static dissipative shirt may be a problem, whereas a t-shirt or singlet may be acceptable. In another example, if a jacket that is designed to be earthed via conductive cuffs is worn such that the conductive cuffs are over gloves that extend above the wrist, the earth connection between the jacket and the wearer may be compromised. In this example, in order to maintain earth continuity, the glove material above the wrist should be made from conductive or static dissipative material, or the gloves shall be worn so that they are not between the jacket cuffs and the wearer's skin.

Except in the case of an emergency, and unless precautions are taken (see next paragraph) no item of clothing, including hoods, or other item of PPE should be removed or unfastened while in hazardous areas. If any item of PPE is required to be removed or unfastened, workers should first leave the hazardous area, remove or unfasten the item of PPE and then re-enter the hazardous area. If the item being removed is static dissipative clothing, the remaining outer clothing should also be static dissipative.

If the inside and outside materials of a hood are static dissipative, the hood can be removed from the head outside of a hazardous area and left off the head when returning to a hazardous area. If the inside material of the hood is not static dissipative, when the hood is removed from the head outside of a hazardous area, it should either be detached from the clothing (where the design allows for this) and left outside the hazardous area, or be stowed into a static dissipative collar.

If it is determined imperative that PPE should be removed while in hazardous areas, an evaluation should be undertaken before commencing operations to confirm that the removal of the items of PPE does not generate significant electrostatic charging and that the items, once removed, do not become a source of electrostatic hazard.

5.2.2 Use of gloves and hand and arm protection

When gloves are worn, care should be taken to maintain the connection between static dissipative clothing and the wearer's wrists if the clothing is designed to be earthed via contact with the wrists. If the upper parts of the gloves above the wrists have a vertical resistance less than $1{,}0 \times 10^8\ \Omega$, measured according to EN 16350, it is acceptable for these parts of gloves to be worn between the wearer's wrists and the cuffs and lower sleeves of static dissipative clothing, or outside the cuffs and sleeves. If the upper parts of gloves above the wrists are made from insulating materials, these parts should not be worn between the wearer's wrists and the cuffs and lower sleeves of static dissipative clothing that is designed to be earthed via contact with the wearer's skin at the wrists. Gloves with insulating upper parts should only be worn between the wearer's wrists and the cuffs and lower sleeves of static dissipative clothing, if the clothing can be earthed via alternative means.

The outer surfaces of arm protectors worn on the outside of static dissipative clothing should be made from static dissipative materials. If the outer surfaces of arm protectors are required to be earthed, it may not be possible to achieve this the clothing beneath the arm protectors is made using core conductive fibres (see A.4.4), in which case another direct form of earthing is required.

5.2.3 Use of footwear and leg protection

Instructions for the use of conductive and antistatic footwear specified in CEN ISO/TR 18690, and included in the leaflet required to be supplied to users by EN ISO 20345, EN ISO 20346 and EN ISO 20347 should be followed.

Footwear that is designed to be the primary means of earthing personnel should be put on before entering hazardous areas. If socks that are not classified as static dissipative or conductive are worn, or if medical or other insoles are use, it is advisable for personnel to wait at least five minutes after putting on footwear before entering hazardous areas. This waiting period allows socks and insoles to absorb sufficient moisture to maintain resistance to earth within acceptable limits, which can be checked using personnel earthing monitors (see 5.1.3.2) before entering hazardous areas. If the earthing monitor indicates "fail", either an additional period of waiting time should be taken before re-testing, or the footwear, socks and/or insoles should be replaced. Some people may not generate sufficient moisture through sweating to achieve the level of conductivity required. It is advisable for such people to wear conductive or static dissipative socks and/or use conductive or static dissipative insoles.

If static dissipative clothing is designed to be earthed via direct connection to footwear, these connections should be made before entering hazardous areas.

The outer surfaces of leg protectors worn on the outside of static dissipative protective clothing should be made from static dissipative materials.

5.2.4 Use of head protection, eye and face protection, hearing protection and respiratory protection

If static dissipative protective equipment is worn, care should be taken to avoid wearing anything between the wearer's skin and the protective equipment, such as a fabric cap, that might increase the resistance to earth from the protective equipment.

5.2.5 Use of protection against falls from a height

Fall arrest harnesses made from insulating materials can be used in some hazardous areas provided the webbing straps are all less than the width limits specified in CLC/TR 60079–32–1:2015, Table 3 and provided any metal components are either less than the capacitance limits specified in CLC/TR 60079–32–1:2015, Table 3 or are connected to earth. A good earth connection may be difficult to achieve if insulating materials are used to construct harnesses and so it is advisable to use static dissipative materials even when the width of webbing straps is within the limits specified in CLC/TR 60079–32–1:2015, Table 3.

Static dissipative fall arrest harnesses should be worn in direct contact with static dissipative clothing so as to maintain earth continuity.

5.2.6 Use of personal floatation devices

In general, the guidance given for the use electrostatic dissipative protective clothing also applies to the use of personal floatation devices when they are used out of water.

When immersed in water, electrostatic hazards are unlikely to be present.

6 Care

6.1 Care of electrostatic dissipative protective clothing

6.1.1 General

General guidance for the care of protective clothing is given in CEN/TR 15321. Manufacturer’s instructions for the care of specific items of electrostatic dissipative protective clothing should also be followed.

6.1.2 Storage

Factors that may affect the electrostatic properties of electrostatic dissipative protective clothing during storage include duration of storage, temperature, humidity, exposure to UV radiation (sunlight and artificial light), exposure to condensation and exposure to contamination (dust, chemical splashes, etc.). It is good practice to store electrostatic dissipative protective clothing for as short a time as is practical, in areas that are not exposed to extremes of temperature and humidity (storage between 15 °C and 25 °C is normally acceptable), free from condensation, away from direct sources of UV radiation and in packaging to protect against contamination.

The degree to which electrostatic properties may be affected depends on the type and intended use of clothing. Some single-use garments commonly derive their electrostatic protection from topically applied antistatic additives that may be particularly sensitive to high temperature, high humidity, condensation and exposure to UV radiation. Antistatic compounds may be added at the melt stage prior to extrusion of fibres or coatings that may be used to make clothing. Such compounds are often migratory and their effectiveness will degrade over time. Manufacturer’s instructions should be followed, but in the absence of clear shelf-life information relating to the electrostatic performance, it is recommended to use “fresh” or “recently produced” electrostatic dissipative protective clothing. In the absence of a documented product expiry date, products that derive their electrostatic protection from chemical additives should not be used if they have been stored for more than 2 years.

Clothing that derives its electrostatic protection only from the use of conductive or static dissipative fibres tends to be less sensitive to storage conditions, but it should still be protected from contamination by suitable packaging.

6.1.3 Cleaning

Laundering, drying and dry-cleaning of electrostatic dissipative protective clothing should be done according to manufacturer’s instructions. Clothing that derives its electrostatic protection from chemical additives may lose its electrostatic properties altogether or at least have reduced service life if manufacturer’s cleaning instructions are not followed.

Specialist cleaning procedures that may be required to remove excessive dirt or contamination should only be used if it has been determined that electrostatic protection is not significantly degraded by such cleaning.

Some electrostatic dissipative protective clothing, typically supplied through contract laundries, needs to be re-finished with antistatic additives after laundering. Personnel issued with such clothing should be instructed not to launder the protective clothing themselves, but should return it for professional laundering.

6.2 Care of footwear and leg protection

6.2.1 General

General guidance for the care of footwear and leg protectors is given in CEN ISO/TR 18690. Manufacturer’s instructions for the care of specific items of footwear and leg protectors should also be followed.

6.2.2 Storage

Factors that may affect the electrostatic properties of footwear and leg protectors during storage include duration of storage, temperature, humidity, exposure to UV radiation (sunlight and artificial light), exposure to condensation and exposure to contamination (dust, chemical splashes, etc.). It is good practice to store footwear and leg protectors for as short a time as is practical, in areas that are not exposed to extremes of temperature and humidity, free from condensation, away from direct sources of UV radiation and in packaging to protect against contamination.

Some antistatic compounds that may be added to footwear and leg protectors, either as a topical coating, or as an additive in polymers, are subject to the same storage requirements as similar compounds used in electrostatic dissipative protective clothing (see 6.1.2).

Carbon black is commonly used in the outsoles of conductive and antistatic footwear. The electrostatic properties of carbon black loaded soles are generally quite stable over time, so a longer shelf-life can be expected.

6.2.3 Cleaning

Cleaning of footwear and leg protectors should be done according to manufacturer’s instructions.

If footwear is used as the primary means of earthing personnel, it is very important to clean the outsoles to remove any material that increases the resistance to earth. Care should be taken with the use of cleaning agents to ensure they do not remove antistatic additives from the outsoles.

6.3 Care of other items of PPE

6.3.1 General

Manufacturer’s instructions for the care of other items of PPE should also be followed.

6.3.2 Storage

Factors that may affect the electrostatic properties of PPE during storage include duration of storage, temperature, humidity, exposure to UV radiation (sunlight and artificial light), exposure to condensation and exposure to contamination (dust, chemical splashes, etc.). It is good practice to store PPE for as short a time as is practical, in areas that are not exposed to extremes of temperature and humidity, free from condensation, away from direct sources of UV radiation and in packaging to protect against contamination.

Some antistatic compounds that may be added to PPE, either as a topical coating, or as an additive in polymers, are subject to the same storage requirements as similar compounds used in electrostatic dissipative protective clothing (see 6.1.2).

6.3.3 Cleaning

Cleaning of PPE should be done according to manufacturer's instructions. Care should be taken with the use of cleaning procedures to ensure they do not adversely affect electrostatic protection.

7 Maintenance

7.1 Visual inspection

Characteristics that contribute to the connection to earth should be visually inspected. Clothing should be inspected to check that seams are intact and that there are no tears that may cause significant areas of clothing to become isolated from earth. Earth bonding points on clothing and other items of PPE should be checked to ensure they are not missing or damaged.

Attachments such as labels, pockets, reflective tape, etc. should be inspected to ensure that they are securely attached across the whole area. Any item of PPE that is found to be damaged should be withdrawn from service and either repaired in an approved manner or disposed of.

Surfaces that are intended to form earth continuity contacts should be inspected for any signs of contamination that may increase the resistance to earth. Such surfaces include outsoles of footwear, cuffs of garments, headbands of hats and visors, gaskets on respiratory protectors, pads on over ear hearing protectors, etc. Any surface that is found to be contaminated should be cleaned in an approved manner.

7.2 Testing

The electrical resistance of the personnel earthing system, which includes footwear or an earthing cord, the user and gloves, if worn, should be checked using a personal earthing monitor, or other suitable apparatus, prior to entering hazardous areas. If the resistance to earth is found to be outside of acceptable limits, items of PPE should be replaced. Additional testing may need to be done in order to identify the item at fault. PPE that is found to be faulty should be withdrawn from service and either repaired in an approved manner or disposed of.

If the user considers it necessary, testing of PPE may be undertaken at appropriate intervals during the life of the PPE to ensure electrostatic properties are within acceptable limits. The interval between testing should be determined in consultation with PPE manufacturers and with reference to any previous experience within a facility. Testing may be as used in qualification (see Clause 4) or in a manner chosen by the user. PPE that is found to be out of specification should be withdrawn from service and either repaired in an approved manner or disposed of.

7.3 Repair

See CEN/TR 15321 and EN ISO 13688.

8 Disposal

Unless it is contaminated with hazardous substances, static protective PPE may be disposed of or recycled by any commons means, subject to local and national regulations. If PPE is contaminated with hazardous substances, it should either be decontaminated before disposal, or it should be disposed of by incineration or by specialist disposal contractors in accordance with local and national regulations.

Annex A
(informative)

Introduction to electrostatics and electrostatic hazards

A.1 How static electricity is generated

When flammable liquid vapours or dusts are mixed with air, a flammable atmosphere may arise that could be ignited if an ignition source is present. Potential ignition sources can include electrical discharges arising from static electricity built up on people, their clothing, or equipment they use, or on plant, equipment or materials or products being manufactured or processed.

Static electricity can easily build up in a very wide range of situations. When two material surfaces touch, some charges (present in the atoms of each material) move from one material to the other. When the materials are separated, one material is left with a positive charge and the other has an equal negative charge. Examples of ways in which this can happen are a person's shoe soles in contact with the floor, clothing rubbing against a seat cover, a web in contact with a roller, polythene sheet on a roll, or impact of a dust particle on a pneumatic transport duct wall.

If these charges are free to move, they will attempt to recombine or dissipate to earth. If they succeed, no electrostatic effects will be noticed. Electrically conducting materials like metals, water and alcohols allow such free charge movement.

Insulating materials such as plastics and many hydrocarbon liquids prevent free movement and dissipation or recombination of charge. Any process that involves contact between materials will cause charging of the materials. Increasing contact areas or movement, such as increasing web speeds or flow rates, turbulence or splashing in liquids, can generate higher electrostatic charge levels. As charge builds up, the surface electrical voltage can rise until an electrostatic discharge (ESD) occurs that could ignite a flammable atmosphere.

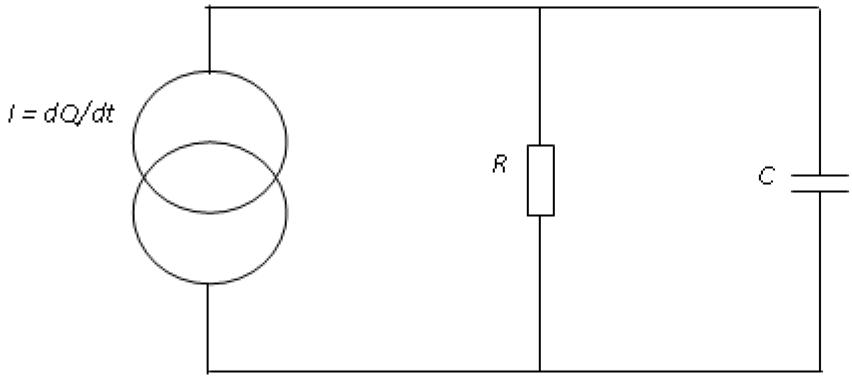
Conductors can accumulate charge if they are not provided with a conducting path to earth to allow the charges to dissipate. Earth paths are often fortuitously present, but for safety often shall be provided deliberately in the form of a wire or electrically conductive path to earth. This is known as earthing or grounding the conductor. Insulating materials cannot be earthed, because they do not allow the charge to freely move from their surfaces.

The electrical resistance of a material indicates the ease with which charge can travel within it. A high resistance (low conductivity) material impedes the movement of charge within and across it. A simple electrical model of charge build-up in many situations is given in Figure A.1. Triboelectric (contact and frictional) charge generation acts as an electrical current source. A conductor on which charge is generated has charge storage properties, equivalent to capacitance, C, in an electrical circuit. The charge also tries to recombine via an external circuit that has a resistance, R.

The voltage build up, U, will be the product of the charge generation current, I, and the circuit resistance, R:

$$U = I.R$$

If, for example, the charge generation current is around 0,1 µA and the resistance is 10 MΩ, the voltage built up is only 1 V. If the resistance is increased to 10 GΩ the voltage built up would be 1 kV. If resistance is increased to over 100 GΩ, a voltage of over 10 kV would be expected.



Key

C capacitance

R resistance

I charge generation current (i.e. rate at which charge, Q, is generated)

Figure A.1 — A simple electrical model of electrostatic charge build up

A.2 Flammable atmospheres and minimum ignition energy

For ignition of a flammable atmosphere to occur, the energy in an electrostatic discharge shall equal or exceed the ignition energy of the atmosphere. Ignition energy depends on the relative concentrations of fuel and oxygen present in the mixture. The most efficient burning occurs when the fuel and oxygen are near the stoichiometric mixture and this also approximately corresponds to the minimum ignition energy (MIE), as shown in Figure A.2.

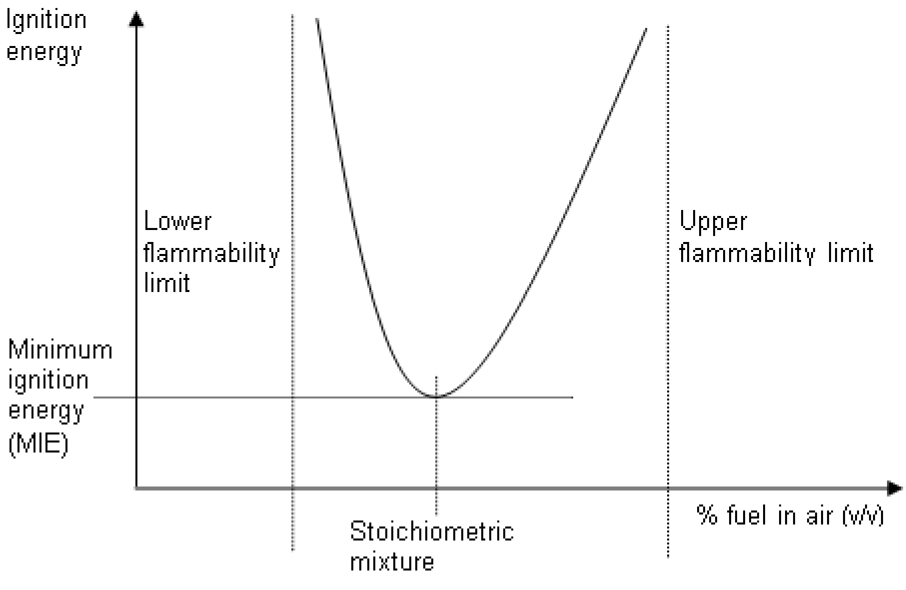


Figure A.2 — How ignition energy varies with flammable mixture composition

Many hydrocarbons form vapour mixtures with MIE around 0,2 mJ. Some materials such as hydrogen, acetylene and oxygenated hydrocarbons can form mixtures with MIE less than 0,1 mJ. Dust clouds have very variable MIE, depending on the materials and particle size distribution and other factors. Dust cloud MIE can range from around 1 mJ to hundreds of mJ. Dust fines generally have much lower MIE than coarser particles of the same material.

A.3 Electrostatic discharges

A.3.1 Types of electrostatic discharge

Electrostatic discharge (ESD) are classified into several types. The two main types (spark and brush) associated with ignition risks from personnel are summarized in Table A.1. Other types (corona, propagating brush and cone discharges) are not considered here.

Table A.1 — Summary of electrostatic discharges and their relevance to ignition risk

Type of discharge	Energy range	Occurrence	Ignition risks
Spark	Up to several J	Between conducting objects	Incendive to gas/vapour and to dust
Brush	Up to a few mJ	From surface of insulator to a conductor	Incendive to gas/vapour but not to dust clouds

A.3.2 Spark discharges from charged conductors

Electrostatic spark discharge from a charged conductor to another conductor is one of the most common sources of incendive ESD. All the stored charge on the conductor can dump its energy quickly and efficiently into the discharge.

Examples of conductors found in the workplace are metal parts and equipment, hand tools and personnel. Personnel may form a particular risk as they continually move and generate charge, and can store significant electrostatic charge and energy, before eventually coming into contact with a earthed conductor and causing an ESD event.

An isolated (unearthed) conductor also poses a hidden risk. Even if the conductor is not itself charged, it can have a high voltage induced on it by the electrostatic field due to a nearby charged object. No contact is necessary to achieve this high voltage, but the metal part may then easily become the source of an incendive ESD event. In some types of Personal Protective Equipment, small metal items such as buckles are commonplace.

The energy, E, stored in a spark source of capacitance, C, at voltage, U, before discharge, can be derived from a simple formula:

$$E = 0{,}5 \times C \times U^2$$

It can be assumed that all the stored energy is dissipated in the spark and contributes to ignition. This has led to use of spark sources to measure the MIE of flammable gas/vapour mixtures and dust clouds.

A.3.3 The capacitance of conductive objects and ignition risk

It can be seen that the capacitance of a conductive object, as well as the voltage which it may attain, are highly important in determining electrostatic ignition risk. Small capacitances shall attain higher voltages before the MIE of a flammable mixture is approached. CLC/TR 60079–32–1 recommends that where small, isolated conductors are permitted, the maximum capacitance of the conductors should be 3 pF, 6 pF or 10 pF depending on the hazard zone, as defined in EN 60079-10-1 and EN 60079-10-2, and the gas or dust group, as defined in IEC 60079-0.

Capacitance is related to the size of objects. A small bolt on equipment or button on PPE may have capacitance of only a few picofarads (pF) and it may be practically impossible to generate sufficiently high voltage on such an object to give a incendive spark energy. A metal beverage container might have capacitance around 10 pF and exceed the MIE of typical hydrocarbon vapours at only a few kV, quite a moderate voltage by electrostatic standards. Table A.2 shows the capacitance of some small objects typical of those found in PPE, measured by various test methods with, and without a Correx®

spacer simulating a 4 mm thickness of clothing separating them from the body. It can be seen that the range of results of such measurements can be considerable, and the introduction of a spacer leads to a large reduction in capacitance. In practice, the capacitance of a conductive item that is part of PPE is likely to change as its position in relation to the wearer's body changes. For example a buckle may swing away from the body as the wearer leans in one direction, or towards the body if they lean in another direction. The buckle capacitance is likely to decrease or increase respectively as this occurs.

The capacitance of a conductor is merely the relationship between the charge, Q, on the conductor and its voltage, U:

$$C = Q/U$$

For a given charge on the conductor, if the capacitance is varied, the voltage will also vary. If the capacitance is halved, the voltage will be doubled. In practice the capacitance of objects can be changed by more than an order of magnitude by this effect.

Combining the above formulae for energy and capacitance by substituting for U gives

$$E = 0{,}5 \times Q^2/C$$

From this it can be seen that for a constant Q, if C is halved the energy is doubled. The greatest hazard is, therefore, not necessarily the condition of greatest capacitance. The voltage and stored energy on a conductor, initially charged to a low voltage under a high capacitance condition may increase to hazardous levels as the capacitance is reduced during everyday actions. If the capacitance is reduced by an order of magnitude then the stored energy can be increased by an order of magnitude and ignition risk could result.

Table A.2 — Capacitance of small objects found on PPE measured by various test methods with, and without a 4 mm spacer (Holdstock and Smallwood [19])

Item	Measured capacitance, pF	
	No spacer	With 4 mm spacer
Zip fastener	5 – 20	1 – 11
D-ring	16 – 26	4 – 8
Buckle, O-form	54 – 95	6 – 10
Buckle, Φ-form	49 – 83	6 – 10
Snap fastener	2 – 8	1 – 2

A.3.4 Brush discharges from insulating surface

Brush discharges from insulating surfaces to conductors are less incendive than discharges between conductors, but can still be energetic enough to present an ignition risk to flammable vapour or gas. Charge on the insulator surface cannot move quickly to the discharge, so, only a small part of the surface may act as the ESD source, leaving surrounding areas still charged for further ESD events. Insulating materials are commonplace as packaging and engineering materials in modern environments and also in Personal Protective Equipment and clothing. Brush discharges can occur from the insulating surface to nearby metal plant parts or to personnel.

A.4 How to avoid electrostatic ignitions

A.4.1 General

The first step in any evaluation is to correctly identify where flammable atmospheres may be present, and what the MIE is likely to be. The MIE of many vapours have been documented but for dusts this may well mean having the MIE of the dust fines measured by a specialist.

For dust clouds in the absence of flammable gases or vapours, it may be sufficient to consider the possibility of spark discharges. These may be avoided by making sure all conductors of significant size are earthed. What is “significant size”? The answer depends in part on the MIE of the material. It is essential that items are earthed if they have sufficiently large capacitance that there may be a risk of the electrostatic stored energy approaching the MIE.

Where flammable gas or vapours are present, then spark and brush discharges should be considered. Earthing of conductive parts is a primary requirement, including personnel, mobile equipment and all metallic parts of equipment that might be used in a flammable atmosphere. Even small isolated items having capacitance as low as a few pF can pose a risk in some circumstances. The capacitance of an item also changes with the proximity of earthed conductors, personnel or other materials.

It is often not necessary to earth bond items using cables or wires; a resistance to earth of 100 MΩ or even higher may be acceptable based on a hazard evaluation. An example of this is in earthing personnel working in hazardous areas. This is achieved using antistatic footwear to EN ISO 20345, EN ISO 20346 or EN ISO 20347, and a conductive floor. CLC/TR 60079-32-1 recommends that the resistance from the person’s body to earth should be less that 100 MΩ. This means that the floor should also have resistance to earth less than this value. Fortunately many concrete floors will achieve this.

A.4.2 Restriction of area of insulating materials

It is recommended that insulating materials may only be used where flammable gases or vapours may be present if the surface area is restricted, as shown in Table A.3 (further information is given in CLC/TR 60079-32-1). In general it is good practice to replace insulating materials with earthed dissipative or conductive materials where practical, unless it can be shown that the risk incurred due to possible electrostatic charging is negligible.

Table A.3 — Restrictions on areas or widths of insulating materials used in hazard zones

Zone[a]	Group I[b]		Group IIA[c]		Group IIB[c]		Group IIC[c]	
	Max area (mm^2)	Max width (mm)	Max area (mm^2)	Max width (mm)	Max area (mm^2)	Max width (mm)	Max area (mm^2)	Max width (mm)
0	10 000	30	5 000	3	2 500	3	400	1
1			10 000	30	10 000	30	2 000	20
2			No size limit					

[a] See Annex B for classification of zones.
[b] Group I are gases and vapours typically found in underground mines.
[c] Group II subdivisions:
IIA: a typical gas is propane, a typical vapour is hexane;
IIB: a typical gas is ethylene, a typical vapour is diethyl ether;
IIC: a typical gas is hydrogen, a typical vapour is carbon disulphide.

In practice, of course, the variability of ways in which conductors and insulators are part of the manufacturing processes, product and environment, can make evaluation and avoidance of ESD risk a far from simple task. For fuller details of common recommended precautions CLC/TR 60079-32-1 should be consulted.

A.4.3 Earthing conductive objects

A.4.3.1 General

In hazards evaluation, it has been found that the charging current is unlikely to exceed 1 microamp and is often orders of magnitude less. Consideration of the formula in A.1 shows that limiting the resistance to less than 100 MΩ will lead to voltages no greater than 100 V, which is a safe level for electrostatic ignition prevention in most circumstances.

The circuit of Figure A.1 gives us another useful insight into electrostatic risks. The capacitance, *C*, and resistance, *R*, form a circuit in which the voltage stored on *C* drops to about 37 % of its initial value in a characteristic time, τ, given by the product $\tau = RC$. An initial voltage of 1000 V would drop to about 50 V in 3τ . If τ is much less than a second, then we are unlikely to see electrostatic charge build-up unless we have continuous charge generation at high charging currents. If τ is much greater than a second we start to see residual charge even for short-term charge generation. In some materials like polymers and hydrocarbon liquids, τ exceeds hundreds of seconds and the material can retain high charge levels for minutes or hours. Clearly these materials are much more likely to become ESD sources.

A.4.3.2 Earthing personnel

Personnel have a capacitance around 100 pF to 300 pF and energy stored on the body can exceed the MIE of hydrocarbons when charged to about 1 kV to 2 kV. For this reason, personnel working in flammable atmospheres should always be earthed. In process industries, the main way of earthing personnel is via conductive or antistatic footwear and a conductive floor. CLC/TR 60079-32-1 recommends that when operating in hazardous areas, the electrical resistance from a person’s body to earth should be less than 100 MΩ.

A.4.3.3 Earthing small items on PPE

Small conductive items on PPE can be prevented from reaching a high voltage by earthing them via the wearer’s body. The wearer should be earthed as described in 5.1.3. Where risk assessment has shown that continuous generation of significant charging currents would not normally be expected with these items, resistance above 100 MΩ may be acceptable.

As described in A.3.3, small conductive objects could provide additional risk if they can reduce in capacitance by rapid movement away from the body. This movement could occur relatively quickly in a fraction of a second. They should, therefore, be earthed so that a charge decay time of the order 0,1 s or less is possible. From the arguments in A.4.3.1 this leads to a requirement for an item of the order 100 pF capacitance to be earthed via resistance of less than 1 GΩ.

If electrostatic dissipative protective clothing is manufactured using materials containing core conductive fibres (see A.4.4), it may not be possible to achieve a resistance to earth from conductors of less than 1 GΩ via the clothing material. In such cases, another form of connection between the exposed conductors and earth should be provided.

A.4.3.4 Grounding of hand tools

Metal hand tools can become electrically isolated if insulating gloves are worn. When the intended path to earth for conductive objects or tools held in the hand is via a person wearing gloves, the electrical resistance measured through the gloves should be less than the overall resistance to earth limit (see 5.1.2.1). For general use the resistance to earth via the gloves should be less than 100 MΩ, and for more critical applications (e.g. handling sensitive explosives) the resistance to earth via the gloves should be less than 100 kΩ.

A.4.4 Methods of making electrostatic dissipative protective clothing

Many fabrics used to manufacture electrostatic dissipative protective clothing derive their antistatic properties from the integration of conductive fibres or filaments into their structure. Conductive fibres may be distributed homogeneously throughout the fabric or incorporated as a stripe or grid pattern. Conductive fibres can be distinguished and described as either surface conductive or core conductive. Surface conductive fibres are entirely conductive (e.g. stainless steel), or have a conductive outer layer (e.g. carbon or metal). Core conductive fibres consist of a polymer shell (sheath) with an internal conductive carbon core, which can have various cross-sections. In the case of woven fabrics, conductive fibres or filaments are often combined with carrier yarns to form conductive threads for weaving.

The electrostatic properties of fabrics with surface conductive fibres can be evaluated either by measuring electrical resistance (EN 1149-1), or by measuring shielding and charge decay (EN 1149-3).

For fabrics with core conductive fibre systems, only measurements of shielding and charge decay (EN 1149-3) are applicable. Surface resistance measurements are not appropriate because a galvanic contact between the measuring electrodes and the conductive core is not possible.

Resistance measurement methods do not take account of the concentration of conductive fibres within a fabric. For example, a fabric with a 20 mm stripe of conductive threads may have a similar measured resistance as a fabric with a 10 mm grid of conductive threads. Shielding and charge decay measurements are more likely to distinguish between materials with different conductive fibre concentrations. An accurate specification for the concentration of conductive fibres required to achieve a safe dissipative functionality is not possible because there are many variables on which static dissipation is dependent, including the type of the conductive fibres, the textile structure (e.g. woven, knitted, nonwoven, weave/knit patterns, etc.), mass per unit area, topical finishes, etc. Nevertheless, EN 1149-5 does specify that if conductive threads are present in a stripe or grid pattern, the distance between conductive threads in any one direction shall not be greater than 10 mm.

Another process for making electrostatically dissipative fabrics is to use topical chemical finishes, i.e. antistatic agents. The use of antistatic agents is most common in nonwoven fabrics that are intended for single use, disposable garments. As most antistatic agents applied as surface finishes are not resistant to washing, use for woven and knitted clothing is limited to systems in which the surface finish can be re-applied regularly after washing.

The electrostatic properties of fabrics treated with antistatic agents can be evaluated either by measuring electrical resistance (EN 1149-1), or by measuring shielding and charge decay (EN 1149-3).

The way in which electrostatic charge is dissipated, or its harmful effects neutralized, is dependent on a number factors (fabric composition, type of conductive fibre, antistatic agents, earthing protocols, etc.) and may include a number of complex physical mechanisms such as galvanic discharge, induction, corona, shielding and neutralization effects. It is not possible with simple testing to clearly identify which mechanisms are operating in a given material, but the test methods and requirements specified in EN 1149-5, ensure that one or more of these mechanisms will operate to eliminate the risk of hazardous electrostatic discharges from the material itself.

Whereas the performance requirements in EN 1149-5 do not distinguish between the different technologies used to make electrostatic dissipative protective fabrics, it may be necessary to identify and understand which mechanisms are operating in order to evaluate protective clothing as part of a system. Therefore, when evaluating systems of protective clothing or protective clothing in combination with other items of PPE, particularly when the clothing is intended to be part of the earthing system, it may be necessary to carry out additional laboratory investigations that are not presently addressed in the relevant standards.

Annex B
(informative)

Classification of hazardous areas and zones

Table B.1 — Classification of hazardous areas in EN 60079–10–1 and EN 60079–10–2

Classification	Description of the area	
I	Mines susceptible to firedamp	
II	Places with an explosive gas atmosphere other than mines, consisting of	
	A	Normal incendive gases and vapours, e.g. hexane, methane, acetone
	B	Highly incendive gases and vapours, e.g. diethyl ether, ethylene, cyclopentane
	C	Very highly incendive gases and vapours, e.g. hydrogen, ethyne, carbon disulphide
III	places with an explosive dust atmosphere other than mines, consisting of	
	A	Combustible flyings
	B	Non-conductive dust
	C	Conductive dust
NOTE 1 A substance classified with a specific explosion group produces an area of the same explosion group in its vicinity. NOTE 2 The ignition hazard increases from A to C.		

Table B.2 — Classification of Zones in EN 60079–10–1 and EN 60079–10–2

Zone	Description of the Zone
0	Place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is present continuously or for long periods or frequently
1	Place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is likely to occur in normal operation occasionally
2	Place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is not likely to occur in normal operation but, if it does occur, will persist for a short period only
20	Place in which an explosive atmosphere, in the form of a cloud of combustible dust in air, is present continuously, or for long periods or frequently for short periods. NOTE Places where piles of dust are present, but where dust clouds are not present continuously, or for a long period, or frequently are not included in this Zone.
21	Place in which an explosive atmosphere, in the form of a cloud of combustible dust in air, is likely to occur occasionally in normal operation
22	Place in which an explosive atmosphere, in the form of a cloud of combustible dust in air, is not likely to occur in normal operation but, if it does occur, will persist for a short period only

Table B.3 — Examples of some substances to explain the relationship between explosion groups and minimum ignition energy (MIE)
(Data taken from CLC/TR 60079–32–1)

Substance	**Minimum ignition energy (mJ)**	**Explosion group**
High MIE		
Trichloroethylene	510	IIA
Normal MIE		
Benzene	0,20	IIA
Methanol	0,20	IIA
Xylene	0,20	IIA
2-Butanone	0,27	IIB
Ethanol	0,28	IIB
Low MIE		
Cyclopropane	0,13	IIB
Ethylene	0,082	IIB
Ethylene oxide	0,061	IIB
Very low MIE		
Carbon disulphide	0,009	IIC
Ethyne (acetylene)	0,019	IIC
Hydrogen	0,016	IIC

Annex C
(informative)

Questions and Answers

C.1 Introduction

During the development of this Technical Report, a number of questions were submitted from interested parties. The questions and the answers to them helped to develop the guidance that is contained within this Technical Report. Whereas the guidance given in the main document is by necessity of a general nature, the questions and answers relate to quite specific situations. Nevertheless, the questions and answers are a valuable resource to help users in understanding how the guidance given in this Technical Report can be applied.

In this annex, each question is followed by an answer and then references to the relevant clauses in the main document.

C.2 General questions and answers

Question 1: Do employees always need to be earthed in hazardous areas?

> **Answer**: Yes, employees should always be earthed in hazardous areas.
>
> **Reference**: Subclauses 4.1 and 5.1.1.

Question 2: How can we be sure employees are always earthed?

> **Answer**: Visual inspection and testing can be done to check that PPE meets performance requirements. Personnel earthing monitors can be used to ensure employees and items and components of PPE are properly earthed before entering hazardous areas. However, it is very difficult to ensure that employees are earthed 100 % of the time.
>
> **Reference**: Subclause 5.1.5 and Clause 7.

C.3 Questions and answers relating to selection

Question 3: Can garments that are certified to the requirements of EN 1149-5 be used in hazard Zone 0 and Zone 1?

> **Answer**: Yes, provided the MIE of the explosive atmosphere is not less than the lowest MIE for hydrogen in air. The ignition testing that was used to validate the performance requirements of EN 1149-5 were done using the most easily ignitable mixture of hydrogen in air (MIE = 0,016 mJ).
>
> **Reference**: Subclause 4.2.1 and Table 2.

Question 4: Does a shirt with short sleeves (uncovered arms) that is both antistatic and flame retardant provide adequate protection to the wearer?

> **Answer**: EN 1149-5 (4.2.2 Design Requirements) requires that electrostatic dissipative protective clothing cover all non-complying materials. An electrostatic dissipative short sleeve shirt complying with the performance and design requirements of EN 1149-5 would provide adequate static protection if the wearer’s arms are bare. However, if the wearer’s arms are left bare, there will not be adequate protection against heat and flame.

Reference: Subclause 4.3.

Question 5: What garments should be worn in oxygen enriched environments?

Answer: The selection of garments depends on the MIE of the oxygen enriched atmosphere that is likely to be present. If the MIE is not less than the lowest MIE for hydrogen in air, garments complying with EN 1149-5 may be worn. The ignition testing that was used to validate the performance requirements of EN 1149-5 were done using the most easily ignitable mixture of hydrogen in air (0,016 mJ).

If the MIE of the oxygen enriched environment is less than the lowest MIE for hydrogen in air, garments complying with EN 1149-5 may not provide adequate static protection; expert advice should then be obtained.

Reference: Subclause 4.2.1 and Table 2, two paragraphs at the bottom of the table about the MIE of oxygen-enriched atmospheres and the expert advice.

Question 6: If the PPE is flame retardant and antistatic, can it be worn in a Zone 2 hazardous area?

Answer: Yes, provided the PPE complies with the relevant electrostatic protection standards and limited flame spread or heat and flame protection standards, and provided the MIE of the Zone 2 atmosphere is not less than the lowest MIE for hydrogen in air. The ignition testing that was used to validate the performance requirements of EN 1149-5 were done using the most easily ignitable mixture of hydrogen in air (0,016 mJ).

Reference: Table 2 and Subclause 4.3.

Question 7: Can we use a flame retardant, antistatic PPE in an environment with gases or chemicals?

Answer: Yes, provided the PPE complies with the relevant flame retardant, electrostatic protection and chemical protection standards, and provided the MIE of the explosive atmosphere is not less than the lowest MIE for hydrogen in air. The ignition testing that was used to validate the performance requirements of EN 1149-5 were done using the most easily ignitable mixture of hydrogen in air (0,016 mJ).

Reference: Table 2.

Question 8: My boiler suit is flame retardant and antistatic, so I don't need antistatic waterproofs do I?

Answer: Yes you do. If you wear your waterproof clothing in a hazardous area they, as the outer layer, should comply with EN 1149-5. Waterproof footwear should comply with the antistatic or conductive requirements of EN ISO 20345, EN ISO 20346 or EN ISO 20347 if the footwear is the primary means of earthing.

Reference: Subclauses 4.3 and 5.1.3.

Question 9: Do I need flame retardant, antistatic underwear?

Answer: For static protection no, only the outer layer of clothing is required to comply with EN 1149-5. The outer layer of clothing should also have limited flame spread properties. Underwear may be required to meet relevant heat and flame protection standards if the outer clothing only provides limit flame spread protection.

Reference: Subclause 4.3.

Question 10: What about antistatic clothing with detachable hoods?

Answer: The hood should comply with EN 1149-5 and should not be detached inside a hazardous area.

Reference: Subclauses 4.3 and 5.2.1.

Question 11: Are metal components on the exterior of the garments completely banned (for instance, plastic zip pullers have a metal spring inside)?

Answer: EN 1149-5 states that conductive parts are permissible provided they are covered by the outer material. Very small metal items such as the spring inside a zip puller are not normally a hazard because the capacitance is low.

Reference: Subclauses 4.3 and A.3.3.

Question 12: Can I have antistatic only garments, or do I need flame retardant properties too?

Answer: Clothing for use in explosive atmospheres should provide protection against electrostatic hazards and against heat and flame. This can be achieved with a single garment complying with all the relevant standards, or by using electrostatic dissipative protective outer clothing with limited flame spread properties, and under garments that meet relevant heat and flame protection standards.

Reference: Subclause 4.3.

Question 13: Is my EN 1149 certified garment safe to handle acetylene and oxygen gas mixtures?

Answer: Not necessarily; acetylene/air has MIE that is similar to hydrogen/air as used in the validation of EN 1149-5. However, oxygen enriched mixtures will have lower MIE and so EN 1149-5 certified garments may not be safe in such environments; expert advice should then be obtained.

Reference: Subclause 4.2.1 and Table 2, two paragraphs at the bottom of the table about the "MIE of oxygen-enriched atmospheres" and the "expert advice".

Question 14: Can this garment be used when filling oxygen bottles?

Answer: Yes, provided there are no other combustible gases or dust present, a garment complying with EN 1149-5 should be safe when filling oxygen bottles. There is a warning in CLC/TR 60079-32-1 about oxygen becoming entrapped in clothing and making the clothing itself combustible. Risk assessment should determine if this is likely and if so, what the MIE is. If it is determined that the MIE is likely to be less than the lowest MIE of hydrogen in air (0,016 mJ), expert advice should be obtained.

Reference: Subclause 4.2.1 and Table 2, two paragraphs at the bottom of the table about the "MIE of oxygen-enriched atmospheres" and the "expert advice".

Question 15: Does the garment need to be antistatic if the employee is correctly earthed?

Answer: Employees should always be earthed in hazardous areas. The selection of garments depends on the risk assessment. In most cases where explosive atmospheres are present, electrostatic dissipative protective clothing is recommended.

Reference: Subclauses 4.1, 4.2.1 and 5.1, and Table 2.

Question 16: What is the best solution: using a garment complying with EN 1149-5 made using a fabric with a grid of core conducting yarn or using a fabric with a grid of stainless steel yarn?

Answer: In terms of electrostatic risks, provided both types of garment meet the requirements of EN 1149-5 and are used in accordance with manufacturer's instructions, and provided the wearers are properly earthed, both types of garment are the same.

Reference: Subclause 4.3.

Question 17.a: Can a garment which is certified for live working (i.e. complying with EN 50286 [12], EN 60895 [13] or EN 60984 [14]) also be worn in an ATEX environment?

Question 17.b: If we have employees which need PPE with flame retardant and antistatic properties, because sometimes they shall work in an ATEX environment, but in other cases they are working on electrical parts - will the antistatic property (conductivity) of the garment be a risk for the employee working on live electrical parts?

Answer: Static electricity is not the same as current electricity and the two should not be confused. In this case, the garment would need to comply with EN 1149-5 and the relevant standard(s) for live working. For example, if a garment shall be worn in a hazardous area and also meet the insulation requirements for live working, the outer layer should be made from electrostatic dissipative material, and inner layers from insulating materials. The electrostatic dissipative material should be prevented from contacting the skin of the wearer when live working, but should be connected to earth when working in a hazardous area. This would require some form of direct earth connection to the electrostatic dissipative material when operating in hazardous areas, but which remains isolated from the wearer's body when live working. In practice, meeting all these requirements in a single garment may be difficult to achieve.

Conductive clothing complying with EN 60895 [13] may also comply with EN 1149-5, but the opposite may not be true. EN 1149-1, which specifies the test method for measuring resistance required by EN 1149-5 is not considered reliable for measuring the resistance of conductive clothing for live working.

Reference: Subclauses 4.3 and 5.1.2.2.

Question 18.a: Can a garment which is certified according to IEC 61482-2 be worn in an ATEX environment and during working on a live line with a voltage of 1000 Volt?

Question 18.b: Can I wear antistatic products near electricity power (high voltage) cables and transformers?

Answer: There are two concerns here: the possibility of a workers body coming into contact with a live electrical system; and the possibility of an electric arc. In order to protect workers in the first case, clothing needs to be insulating. As explained in the answer to Question 17, it is possible for clothing to provide electrical insulation for the wearer and still incorporate electrostatic dissipative material, but this may be difficult to achieve in practice.

In the second case, protection against electric arc, the main properties required for clothing are for protection against intense heat, and protection against debris projected at high velocity by electric arcs. It is a common misconception that an electric arc is some form of electrostatic discharge. This is not the case. Electrostatic discharges occur when static electricity is discharged to earth and involves energies of the order of micro-joules up to a few joules. Electric arcs involve current electricity and can involve energies in the kilo-joule or even mega-joule range. Clothing that is designed to dissipate static electricity, i.e. complying with EN 1149-5, cannot safely dissipate such high energies. It is possible that electrostatic dissipative protective clothing can also provide protection against heat and projectile debris provide it complies with both EN 1149-5 and IEC 61482-2.

It has been reported by some persons wearing electrostatic dissipative clothing containing antistatic fibres that a “tingling” or “pins and needles” sensation is felt at the interface between clothing and skin when operating in the vicinity of high voltage systems. It is thought that such sensations are caused by the antistatic fibres becoming inductively charged by high electric fields and then discharging to the wearer. This is indicative that the network of antistatic fibres is not adequately bonded to earth.

Reference: Subclauses 4.3 and 5.1.2.2.

Question 19: Is it required to use antistatic garments at petrol stations?

Answer: An employee who is required to pump petrol is operating in Zone 1. Petrol vapour has MIE greater than 0,2 mJ. If risk assessment has shown that high charging is probable, electrostatic dissipative protective clothing is required. If high charging is not probable, electrostatic dissipative protective clothing is recommended.

Reference: Table 2.

Question 20: Of which type of material are antistatic gloves made?

Answer: Textile gloves are often made with the same conductive or quasi-conductive yarns that at used in other garments. Polymeric gloves often have a dissipative agent added to the polymer. Polymer coated textile gloves may have both.

Gloves are used as disposables more often compared to other PPE. Furthermore, a glove shall be very flexible, tactile and shall offer predominately chemical or/and mechanical protection for the hand. Gloves in use are either supported gloves or unsupported gloves.

Thus, in many cases no special material is used. To manufacture an antistatic supported cut and sewn glove, cotton for the liner is a very common solution. To increase the antistatic quality of the liner it is possible to choose a special treatment, e.g. the dipping of the liner in a solution with dissipative agents. In terms of the protective coating in many cases Nitrile or Butyl are suitable and also in many cases PVC or PUR. To achieve a special anti-static quality the manufacturer adds some special dissipative compounds to the coating mixture before dipping or coating the liner. For example for Butyl it could be carbon.

For supported knitted gloves more and more manufacturers use special yarns such as carbon fibres or copper treated fibres which are also in use in electronics applications.

Reference: Subclause 4.4.

Question 21: Applications for antistatic gloves: in which cases do we need antistatic gloves?

Answer: Gloves are not required just for electrostatic protection. Provided a person is earthed, there is no risk of hazardous electrostatic discharges from bare hands, and any conductive object held in bare hands will be connected to earth via the person.

Subject to the requirements identified in risk assessment, gloves complying with EN 16350 should be worn in hazardous areas where there is also a need to wear gloves for the following reasons:

— to protect the wearer’s hands from chemical hazards, mechanical hazards, heat and flame, cold, water, or other hazards;

— to protect products from contamination or damage during manual handling;

— to improve manual handling (enhanced grip, comfort, etc.).

Reference: Subclauses 4.1 and 4.4.

Question 22: When shall I use antistatic gloves, e.g. in case you handle wood, will it be necessary?

Answer: If gloves are required for the reasons given in the answer to Question 21, they should comply with the requirements of EN 16350 if they shall be worn in hazardous areas with high probability of charging, irrespective of what is being handled. This will ensure that the gloves themselves do not present an electrostatic hazard.

The use of gloves complying with EN 16350 will also ensure that there is electrical continuity between the wearer's hands and any conductive objects held in the hands, thereby enabling the hand-held conductive objects to be earthed via the person.

Wood is not a good conductor unless it is wet; therefore, it is not usually required to be earthed in hazardous areas. If wood is used as the handle material for metal hand tools, the required connection to earth of the metal components may be lost in dry conditions and this will present a significant risk in hazardous areas, whether or not gloves are worn. This is an issue for hand tool design, which is beyond the scope of this Technical Report.

Reference: Subclauses 4.1 and 4.4.

Question 23.a: What's its surface resistivity, what's its vertical resistivity, what's the shielding factor? And what is the right or maximum value to have an antistatic glove (ex-zones)?

Question 23.b: What is the maximum vertical resistivity for gloves in ex-zone 0?

Question 23.c: What is the maximum surface resistivity for gloves in ex-zone 0?

Question 23.d: For what kind of ex-zones are the gloves we have in use tested or suitable?

Answer: Previously there was no standard that specified requirements for gloves for use in hazardous areas. EN 1149-1, EN 1149-2 and EN 1149-3 were sometimes used and the requirements were taken from EN 1149-5. There is now a standard, EN 16350 that does specify requirements. The only parameter that is required to be measured is vertical resistance and the acceptable vertical resistance is less than $1,0 \times 10^{8}$ Ω. This is compatible with the earthing recommendations given in CLC/TR 60079-32-1 for Zone 0, Zone 1 and Zone 2.

For special applications, for example when handling explosives with spark ignition energy less than 1 mJ, a vertical resistance of less than $1,0 \times 10^{5}$ Ω is required.

Reference: Subclauses 4.4 and 5.1.2.1.

Question 24: Are your gloves classified according to the defined ex-zones; do you have gloves for zone 0, for zone 1 and zone 2?

Answer: Gloves complying with EN 16350 are not classified according to zones; the requirements are the same for all hazardous areas.

Reference: Subclause 4.4.

Question 25: Is your glove still antistatic in winter time having very dry and cold conditions?

Answer: The atmosphere for conditioning and testing specified in EN 16350 is (23 ± 1) °C and relative humidity (25 ± 5) %. For many materials this represents the worst case conditions. However, if risk assessment shows that workers are likely to be exposed for prolonged periods to drier conditions than this, testing should be done under correspondingly lower humidity conditions.

Reference; Subclauses 4.1 and 4.4.

Question 26: A French website says that hook and loop fastener renders an antistatic garment non-conforming to EN 1149? Are hook and loop fasteners forbidden? What about hook and loop fasteners that can only be partially opened but stay permanently attached to the antistatic garment?

> **Answer**: Hook and loop fasteners can be used on clothing complying with EN 1149-5 provided the width of the fasteners or the area of each piece of fastener complies with the width or area recommendations given in CLC/TR 60079-32-1. Hook and loop fasteners should be permanently and securely attached to electrostatic dissipative materials and should not be opened when operating in hazardous areas.
>
> **Reference**: Subclauses 4.3 and 5.2.1.

Question 27: Are there any antistatic hook and loop fasteners and does this change the answer to the previous questions?

> **Answer**: There are antistatic hook and loop fasteners that can be used without width or area restrictions, but evaluation of such fasteners is not covered adequately by EN 1149-5. In any case, such fasteners, even if proven to be antistatic, should still not be opened when operating in hazardous areas.
>
> **Reference**: Subclauses 4.3 and 5.2.1.

Question 28: Non dissipative materials should be permanently attached to garments complying with EN 1149-5. Are there any size or surface limitations to the use of these materials (reinforcements, labels, …)?

> **Answer**: CLC/TR 60079-32-1 gives guidance on the maximum area and width of insulating materials in different zones. For example, for Zone 1, IIA and IIB the maximum width is 30 mm. However, this guidance assumes the material is used in isolation. In the case of a thin material backed by electrostatic dissipative material it may be possible to relax the limits quoted in the guidance.
>
> **Reference**: Subclause 4.3.

Question 29: Are permanently attached non dissipative materials (cords, elastics, …) coming out of the garment (or hanging out from the bottom hem, …) allowed?

> **Answer**: The guidance mentioned in the answer to Question 28 is also useful here. Provided the person is not working in Zone 0, then the maximum width for any explosion group is 20 mm, which would allow most cords to be used.
>
> **Reference**: Subclause 4.3.

Question 30: A certain Notified Body during type examination requires that clothing which is dedicated for use in explosive atmosphere needs to have limited surface of dielectric materials e.g reflecting tapes. If the manufacturer does not want to cut the dielectric material then it is required to write in the manufacturer’s information to the user that the garment should be used only in an environment where minimum ignition energy is over 0,3 mJ. Is it possible to certify a garment for fire fighters as antistatic if it includes reflecting tapes of surface area more than 50 sq. cm, and can it be used in explosive atmospheres?

> **Answer**: It is possible to certify a garment for use in hazardous areas with insulating attachments, such as reflecting tapes and labels, greater than the width or area limits given in CLC/TR 60079-32-1 provided a Notified Body for PPE is satisfied that there is test data to show that incendiary discharges are not possible under the expected conditions of use. Guidance on suitable testing is given in CLC/TR 60079-32-1 and EN 60079-32-2.

Reference: Subclauses 4.3 and 4.6.1.

Question 31: Is it possible to request certification for respiratory protective equipment according to ATEX Directive 94/9/EC (or 2014/34/EU)?

Answer: Yes, if the respiratory protective equipment contains electrical equipment within the meaning of Directive 94/9/EC (or 2014/34/EU) then it should be certified as electrical equipment in accordance with that Directive. The equipment is PPE; therefore, it should also be certified according to Directive 89/686/EEC. If the respiratory protective equipment does not contain electrical equipment, it only needs to be certified according to Directive 89/686/EEC.

Reference: Subclause 4.1.

Question 32: Is it possible to request certification for personal protective equipment such as helmets or safety shoes according to the ATEX Directive 94/9/EC (or 2014/34/EU)?

Answer: No, such items are considered simple apparatus within the meaning of Directive 94/9/EC (or 2014/34/EU) because they do not contain their own potential ignition sources. Nevertheless, such PPE may be at risk from other ignition sources, i.e. electrostatic discharges and impact induced sparks, that shall be evaluated according to Directive 89/686/EEC. A competent body for testing ATEX equipment or for testing PPE may evaluate the risk of potential ignition sources, but certification can only be carried out by a Notified Body for PPE.

C.4 Questions and answers relating to use

Question 33: When you wear a parka or a rain jacket, is it an obligation to have the jacket or the parka closed? And if you can wear it when it is open, is it an obligation that all the components inside the PPE shall be antistatic?

Answer: EN 1149-5 (4.2.2 Design Requirements) requires that dissipative protective clothing cover all non-complying materials. It also states that all closures shall be fastened. Electrostatic dissipative outer garments, such as parkas and rain jackets should be worn closed when operating in hazardous areas.

Reference: Subclauses 4.3 and 5.2.1.

Question 34: If you wear a jacket which is flame retardant and antistatic and the underwear, for example a fleece, is not antistatic or flame retardant, is that a problem?

Answer: It is not a problem for electrostatic protection provided the jacket entirely covers the underwear and is properly fastened. Protection against heat and flame may require flame retardant under garments in addition to flame retardant outer garments, depending on the level of protection provided by the inner and outer layers and the type of under garments (e.g. polyester) – see CEN/TR 14560 [8] for further guidance.

Reference: Subclauses 4.3 and 5.2.1.

Question 35: Can I combine your glove with a protective suit? What are the points which shall be considered?

Answer: Gloves complying with EN 16350 can be worn with protective suits complying with EN 1149-5 provided the gloves do not compromise the electrical connection between the wearer and the electrostatic dissipative components of the protective suits.

Reference: Subclause 5.2.2.

Question 36: Multi-layering of garments and wearing of other non-compatible garments - how does this affect performance?

Answer: Multi-layer clothing systems are safe provided the outer layer complies with EN 1149-5 and covers all non-complying layers.

Reference: Subclauses 4.3 and 5.2.1.

Question 37: Can I wear a jacket only or do I need over trousers?

Answer: If trousers that do not comply with EN 1149-5 are worn, over trousers that do comply shall be worn.

Reference: Subclauses 4.3 and 5.2.1.

Question 38: Can an apron or vest be antistatic according to EN 1149-5 providing it is worn with other antistatic garments that cover the body?

Answer: Yes, provided that the apron or vest meets the performance requirements of EN 1149-5 and that the user information about how to wear the garments clearly states that any clothing left exposed by the apron or vest shall also comply with EN 1149-5.

If the vest or apron contains conductive elements that should be earthed, the clothing over which the vest or apron is worn should provide a connection to earth, otherwise another direct form of earthing is required.

In the case of aprons, both inside and outside surfaces should be made from electrostatic dissipative materials.

Reference: Subclauses 4.3 and 5.2.1.

Question 39.a: What are the correct ways to be earthed if you are wearing the correct trouser and jacket or overall which are antistatic according to the EN 1149-5 and flame retardant according to EN 531? How can you be sure that the connection with the earth is reliable and sustainable?

Question 39.b: When wearing flame retardant Index 3 coveralls (that comply with EN 1149-5 when tested to EN 1149-1) are we sure the wearer is grounded through the body/shoes? Such coverall shall not be in contact anywhere with the skin, and shall be worn on top of Index 1 or Index 2 flame retardant workwear.

Answer: The best way of earthing is very much dependent on the design of clothing and it is left to manufacturers to design an earthing system and provide users with information on how to wear garments in order to maintain proper earthing.

The most common and practical way to earth people is via conductive or antistatic footwear and flooring. Wrist straps can also be used either to earth people, their clothing or both, but these have obvious practical limitations. Jackets are normally earthed via contact with the wearer’s skin at the wrists. If the electrostatic dissipative material of the main parts of the jacket is unsuitable for skin contact, then a material that is suitable for skin contact can be used as an intermediary layer to provide electrical continuity.

Trousers can be earthed using conductive or static dissipative straps that connect to footwear or to jackets.

NOTE EN 531 has replaced by EN ISO 11612.

Reference: Subclauses 4.3, 5.1.3 and 5.1.4.1.

Question 40: Is it possible to provide practical guidance on how workers who wear chemical protective clothing with integral socks (fabric surface complies with EN 1149-5 when tested to EN 1149-1) could be earthed, preferably without using grounding cables?

Answer: One possible solution is to use a material for the soles of the integral socks that has a vertical resistance of less than $1,0 \times 10^{8}\ \Omega$ and wear conductive or antistatic footwear.

Reference: Subclause 5.1.3.

Question 41: What happens if the employee is working on a scaffold?

Answer: The scaffold itself should be earthed but wooden or plastic planking may not provide adequate earthing to a person relying on footwear to be earthed. Direct earth connection using a tether may be possible.

Reference: Subclause 5.1.3.

C.5 Questions and answers relating to care

Question 42.a: What is the effect of “the use” on the antistatic properties of a garment?

Question 42.b: What is the life-span of garments from the perspective of reduction of antistatic properties over a period of time?

Answer: EN 1149-5 requires that manufacturers include a warning that properties may be affected by wear and tear, laundering and contamination.

The testing required for EN 1149-5 (i.e. EN 1149-1 or EN 1149-3) specifies 5 cycles of washing in accordance with EN 340, prior to testing. The main reason for this is to ensure that a topical finish has not been applied just to get through testing.

NOTE EN 340 has been replaced by EN ISO 13688.

Dissipation in many garments is achieved using conductive or quasi-conductive yarns and these are not really affected too much by laundering or by use. Some conductive fibres can be degraded by repeated laundering and wear and tear, but it normally takes many cycles before they cease to comply with EN 1149-5. There may also be a finish applied that will survive the five washes prior to testing but may degrade with repeated use and washing.

Reference: Subclause 6.1.3.

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[4] Guidelines on the application of Directive 94/9/EC of the European Parliament and the Council of 23 March 1994 on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres

[5] Directive 1999/92/EC of the European Parliament and of the Council of 16 December 1999 on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres

[6] ASTM E582, *Standard test method for minimum ignition energy and quenching distance in gaseous mixtures*

[7] ASTM E2019, *Standard test method for minimum ignition energy of a dust cloud in air*

[8] CEN/TR 14560, *Guidance for selection, use, care and maintenance of protective clothing against heat and flame*

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[11] EN 13821, *Potentially explosive atmospheres — Explosion prevention and protection — Determination of minimum ignition energy of dust/air mixtures*

[12] EN 50286, *Electrical insulating protective clothing for low-voltage installations*

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