BSI BS*CECC 00015:*PT*1 91 ■ 1624669 0271784 2 ■

BRITISH STANDARD

BS CECC 00015 : Part 1 : 1991

Harmonized system of quality assessment for electronic components

Basic specification: Protection of electrostatic sensitive devices

Part 1. General requirements

Système harmonisé d'assurance de la qualité des composants électroniques
Spécification de base: Protection des produits sensibles aux décharges électrostatiques
Partie 1. Règles générales

Harmonisiertes Gütebestätigungssystem für Bauelemente der Elektronik
Grundspezifikation: Schutz von Elektrostatisch Gefährdeten Bauelementen
Teil 1. Allgemeine Anforderungen

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BSI STANDARDS

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Electronic Components Standards Policy Committee (ECL/-) to Technical Committee ECL/23, upon which the following bodies were represented:

Association of Franchised Distributors of Electronic Components
British Electro-static Manufacturers' Association
British Electrostatic Control Association
British Plastics Federation
British Telecommunications plc
EEA (The Association of Electronics, Telecommunications and Business Equipment Industries)
Electronic Components Industry Federation
GAMBICA (BEAMA Ltd.)
Health and Safety Executive
Ministry of Defence
National Supervising Inspectorate

This British Standard, having been prepared under the direction of the Electronic Components Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on 20 December 1991

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National foreword

This British Standard has been prepared under the direction of the Electronic Components Standards Policy Committee. It is identical with CECC 00015/1 : 1991 'Basic Specification: Protection of Electrostatic Sensitive Devices Part 1 : General requirements', published by the CENELEC Electronic Components Committee (CECC).

This standard supersedes BS 5783 : 1987 which is withdrawn. It is envisaged that further Parts of CECC 00015 will be published as follows.

CECC 00015 : Part 2 : Particular requirements for low humidity areas;
CECC 00015 : Part 3 : Particular requirements for clean rooms;
CECC 00015 : Part 4 : Particular requirements for areas with high voltages present.

On publication of the further Parts of CECC 00015 equivalent Parts of BS CECC 00015 will be published in due course.

Cross-references

International standard	Corresponding British Standard
IEC 93	BS 6233 : 1982 Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials (Identical)

The Technical Committee has reviewed the provisions of ISO 2878 to which reference is made in the text and has decided that they are acceptable for use in conjunction with this British Standard. A related British Standard to ISO 2878 is BS 2050 : 1978 'Specification for electrical resistance of conducting and antistatic products made from flexible polymeric material'.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

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Förderverein für Elektrotechnische Normung (FEN) e.V.
Cenelec Electronic Components Committee

CECC

Système Harmonisé d'Assurance de la Qualité
des Composants Electroniques

SPECIFICATION DE BASE:

PROTECTION DES PRODUITS SENSIBLES AUX DECHARGES ELECTROSTATIQUES

PARTIE I:

REGLES GENERALES

Harmonized System of Quality Assessment for
Electronic Components

BASIC SPECIFICATION:

PROTECTION OF ELECTROSTATIC SENSITIVE DEVICES

PART I:

GENERAL REQUIREMENTS

Harmonisiertes Gütebestätigungssystem für
Bauelemente der Elektronik

GRUNDSPEZIFIKATION:

SCHUTZ VON ELEKTROSTATISCH GEFÄHRDETEN BAUELEMENTEN

TEIL I:

ALLGEMEINE ANFORDERUNGEN

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FOREWORD

The CENELEC Electronic Components Committe (CECC) is composed of those member countries of the European Committee for Electrotechnical Standardization (CENELEC) who wish to take part in a harmonized System for electronic components of assessed quality.

The object of the System is to facilitate international trade by the harmonization of the specifications and quality assessment procedures for electronic components, and by the grant of an internationally recognized Mark, or Certificate, of Conformity. The components produced under the System are thereby accepted by all member countries without further testing.

This basic specification has been formally approved by the CECC, and has been prepared for those countries taking part in the System who wish to issue national harmonized specifications for **the Protection of Electrostatic Sensitive Devices**. It should be read in conjunction with the current regulations for the CECC System.

At the date of printing of this specification, the member countries of the CECC are Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom, and copies of it can be obtained from the addresses shown on the blue fly sheet.

PREFACE

This specification was prepared by CECC TF - ESD.

The text of this specification was circulated to the CECC for voting in the document(s) indicated below and was ratified by the President of the CECC for printing as a CECC Specification.

Document	Date of voting	Report on the voting
CECC(Secretariat)2599	November 1990	CECC(Secretariat)2717

Section one. General

1 General

1.1 Scope

This standard specifies the general requirements for the protection of electrostatic discharge sensitive devices from electrostatic discharges and fields. It applies only to electronic devices and assemblies.

For areas with exposed conductors at potentials greater than 1,25 kV a.c. or 2,5 kV d.c., additional requirements specified in CECC 00 015: Part 4 shall apply (Part 4 is in course of preparation).

> CAUTION: Although this standard does not include requirements for personal safety, attention is drawn to the need for all concerned to comply with relevant local statutory requirements regarding the health and safety of all persons in all places of work including those covered by this standard. (Attention is drawn to the fact that electrical potentials in excess of 50 V a.c. or 120 V d.c. may be dangerous to personnel).

1.2 Definitions

For the purposes of this Standard the following definitions apply.

1.2.1 bonding: The connecting together of elements by means of a conductor.

1.2.2 earth bonding point: A dedicated point to which a wrist band cord or similar component can be connected.

1.2.3 electrostatic discharge (ESD): A transfer of electrostatic charge between bodies at different electrostatic potentials caused by direct contact or induced by an electrostatic field.

1.2.4 electrostatic discharge sensitive device (ESDS): A discrete device, integrated circuit or assembly that may be damaged by electric fields or electrostatic discharge encountered in routine handling, testing and transit.

> NOTE: Damage includes any degradation or malfunctioning of the device performance.

1.2.5 ESD earth facility: A common facility to which bonded elements in the ESD protected area are connected.

1.2.6 ESD protected area (EPA):. An area in which ESDS can be handled with minimum risk of damage as a result of electrostatic discharge or fields, and in which the operator is not exposed to additional risk.

1.2.7 ESDS voltage sensitivity: The maximum voltage at which the ESDS does not suffer any ESD damage.

NOTE: Where no sensitivity information is available, the sensitivity of the ESDS is considered to be < 2000 volts.

1.2.8 ESDS voltage sensitivity of an assembly: The most sensitive ESDS on an assembly will determine the assembly's sensitivity.

1.2.9 field work: Handling ESDS within a temporary EPA with permanently controlled boundaries.

NOTE: It includes installation, commissioning, site inspections, servicing and maintenance of ESDS together with packaging and unpackaging activities associated with these functions.

1.2.10 garment: A coat, jacket, smock, hood, trousers, overall or cap is regarded as a garment for the purpose of this standard.

1.2.11 ground: The uniform potential established in the work area which ensures that the potential of the device and of everything with which it is likely to come into contact is the same.

1.2.12 ground cord: An electrical connection between the earth bonding point and the ESD earth facility.

1.2.13 device hazardous voltage: Any voltage capable of damaging an ESDS.

1.2.14 materials

1) **antistatic material**: Materials exhibiting properties which minimize charge generation when rubbed against or seperated from the same or other materials.

2) **materials with resistivity properties**:

NOTE: For test conditions see annex A.

a) **electrostatic shielding materials.**

Materials which are capable of attenuating an electrostatic field and have one layer of surface resistivity less than 1×10^4 ohm/sq, or volume resistivity less than 1×10^3 ohm x cm per mm of material thickness.

b) **electrostatic conductive materials**

Materials with a surface resistivity of greater than 1×10^3 ohm/sq and less than 1×10^6 ohm/sq and volume electrostatic conductive materials with a volume resistivity of greater than 1×10^2 ohm x cm and less than 1×10^5 ohm x cm.

c) **electrostatic dissipative materials**

Materials with a surface resistivity equal to or greater than 1×10^5 ohm/sq and less than 1×10^{12} ohm/sq or a volume resistivity equal to or greater than 1×10^4 ohm x cm but less than 1×10^{11} ohm x cm.

d) **insulative materials**

Materials with a surface resistivity equal to or greater than 1×10^{12} ohm/sq or a volume resistivity equal to or greater than 1×10^{11} ohm x cm.

1.2.15 materials for packaging: Any material in which ESDS are packed for transportation or storage including bags, boxes, crates, wraps, magazines, cushioning, foams, loose fill, etc.

1)**intimate packaging**: Materials which make contact with an ESDS.

2)**proximity packaging**: Material not making contact with an ESDS, but which is used to enclose one or more devices.

3)**secondary packaging**: Material used primarily to give additional physical protection on the outside of a proximity package.

1.2.16 storage time: Short term storage is less than six months, medium term storage is between six months and five years, long term storage is longer than five years.

1.2.17 triboelectric charging: An electrical charge generated by the frictional movement or separation of two surface.

1.2.18 uncontrolled conditions: All conditions outside an EPA.

Section two. Design consideration to minimize the effects of ESD

2 Design

NOTE: Damage caused by electrostatic discharge can be minimized by using design practice in devices and assemblies to make them less susceptible to ESD damage.

2.1 Identification

When the equipment includes an ESDS during design, the presence of the ESDS shall be indicated at all subsequent stages up to and including layout, procurement and use. Drawings and parts lists shall be annotated in accordance with 3.4, and instructions given on the sequence of assembly, see section 4. Particular attention shall be drawn to protective components, the removal of which would leave the device unprotected.

2.1.1 Warning notices

The design of the equipment and its sub assemblies shall allow for the provision of warning notices or symbols.

NOTE: This information is of particular importance for maintenance and servicing personnel.

2.2 Design of electrostatic discharge sensitive devices (ESDS)

Devices shall be designed to minimize the possibility of damage by electrostatic discharge. For ESDS, a warning shall be given on sales literature, specification, design application notes, packaging and invoices. The voltage sensitivity of the device shall be stated in the manufacturer's sales literature, specification and design application notes.

2.3 Design of assemblies

2.3.1 Electronic assemblies shall be designed to minimize the damage due to ESD.

2.3.2 Consideration shall be given regarding the use of the least sensitive device possible which fits all the necessary parameters of the design.

2.3.3 Consideration shall be given regarding the use of guard tasks where ESDS are used.

2.3.4 To prevent charge and voltage build-up, consideration shall be given to the use of resistive and/or diode protection on edge connectors and other means of connecting inputs to and outputs from assemblies.

2.3.5 Consideration shall be given to the electrical connection of all unused ESDS inputs directly or indirectly to a suitable point, usually an appropriate power supply or ground as close as possible to the ESDS. Other inputs and outputs shall use this protection where appropriate.

2.3.6 Tracks leading to or from ESDS shall be kept as far as possible away from the edges of the printed wiring board except when they lead directly to edge connectors.

2.4 Packaging design

Consideration shall be given at the design stage to ESDS packaging in accordance with section 5.

2.5 System design

2.5.1 Design for service

All systems which contain ESDS and are liable to be serviced in a stand alone configuration shall be designed such that they can be maintained in accordance with this standard. Where size permits, an ESD bonding point shall be provided.

2.5.2 Electrostatic shield

Where possible, an electrostatic shield shall be incorporated to minimize the effect of electrostatic fields.

2.6 Design evaluation procedure

The design shall be formally evaluated with regard to ESD during the design process. This formal evaluation shall include:

a) design reviews;

b) evaluation of the product arising from the design;

c) evaluation of the management of the design procedure itself.

Records of the reviews and evaluations shall be maintained.

Section three. Labels, signs and marking

3.1 Labels

3.1.1 All packaging containing ESDS shall be labelled or marked with the appropriate and specified warning notice, see figs. 1 and 2.

3.1.2 Where possible all ESDS shall be marked. The marking shall be effective for the expected life of the ESDS.

NOTE: Normally embodied and assembled ESDS, in the form of assembled components for example need not be individually marked or labelled, provided the container, housing, carrier or packaging for such ESDS is marked or labelled.

3.1.3 The application of self adhesive labels and marking may generate an electrostatic charge. They shall only be used on proximity or shielding packaging. Self adhesive labels shall not be applied in circumstances which would place the ESDS at risk.

3.1.4 Each label shall show at least the basic warning symbol as shown in figs. 1A or 1B. Where space permits, the label or mark as shown in figure 2 shall be used, additional information may be added but not in a manner that detracts from the warning symbol.

3.1.5 Where an electronic assembly or housing contains one or more ESDS then it shall be marked or labelled, using labels as shown in figures 1 or 2, such that the warning can be clearly seen before the ESDS is placed at risk due to contact.

3.1.6 The highest level of marking or labelling shall be on the housing containing ESDS and on its intimate packaging.

3.1.7 The lowest level of marking on sub assemblies shall be based on the probability of the ESDS being maintained in service or replaced as an individual item.

3.1.8 The specified labelling or marking shall appear on at least the proximity packaging or any of the forms of specified ESDS packaging.

Packaging marking or labelling can take the form of labels, tapes or printing and stamping.

3.1.9 The specified warning labelling or marking shall appear on storage bins, trays, component sleeves and tubes and any specialised containers.

3.2 Signs for ESD protected area (EPA)

Signs as shown in figure 3 shall be clearly visible to personnel before they enter the EPA. At least one sign shall be visible from all normal working positions within the EPA.

The signs shall contain at least all elements shown in fig. 3, additional information may be added but not in a manner that detracts from the basic warning.

Signs shall have a minimum size of 300 mm x 150 mm.

3.3 Marking of earth bonding points, earth grounding points and ESD earth facilities

All earth bonding points, earth grounding points and all ESD earth facilities designated for use within the EPA shall be marked or labelled. The mark or label shall contain at least the elements shown in figs. 4, 5 or 6, additional information may be added but not in a manner that detracts from the basic information.

3.4 Marking of documentation

All documentation relating to the use, procurement, specification, design and movement of ESDS shall contain details to advise or warn the recipient that the subject matter is ESDS and shall be handled in accordance with this standard.

Figure 1A: ESDS basic symbol

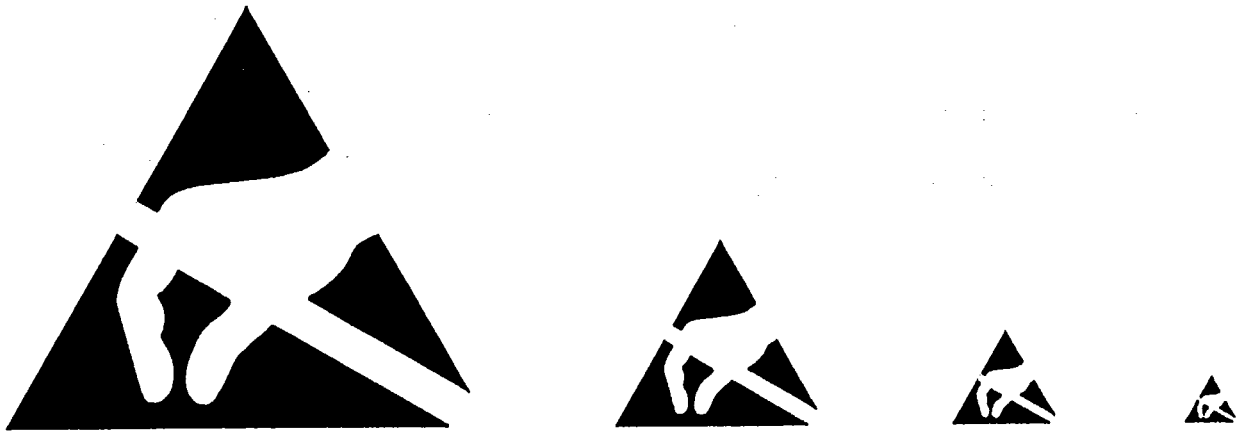


Figure 1B: ESDS simplified symbol

The smallest practical version of the symbol would have a side dimension of 4 mm.

Figure 2: Warning label for ESDS

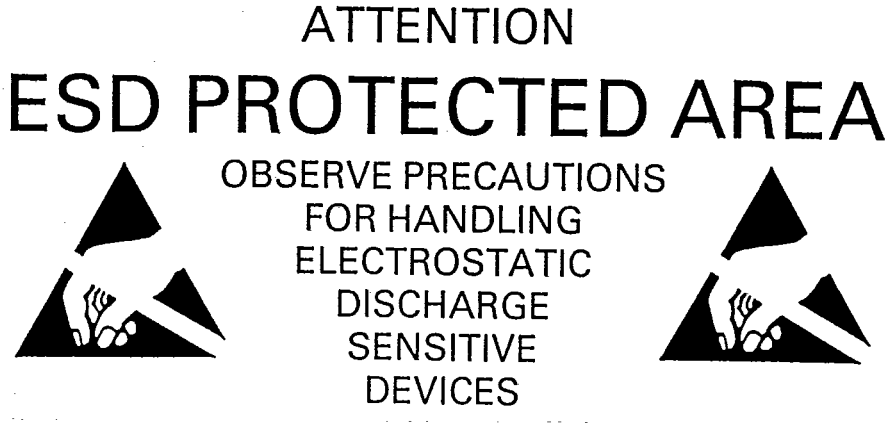


Figure 3: Warning sign for ESD protected areas

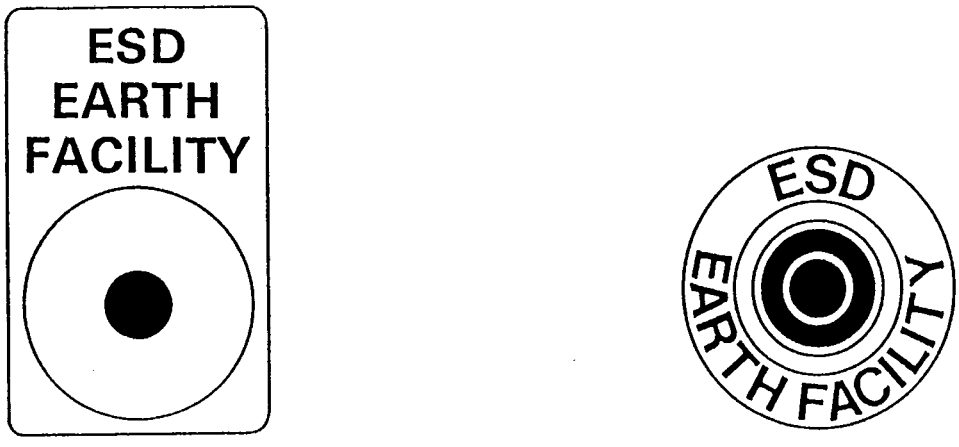


Figure 4: Examples of ESD earth facility labels

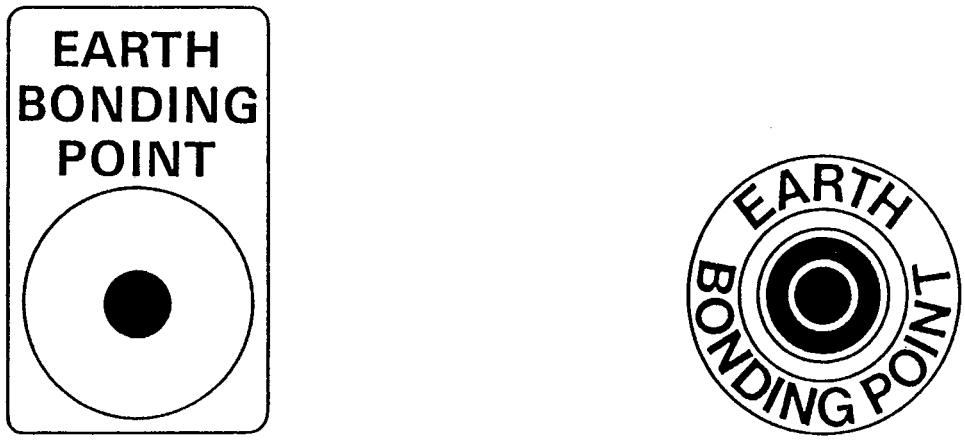


Figure 5: Examples of earth bonding point labels

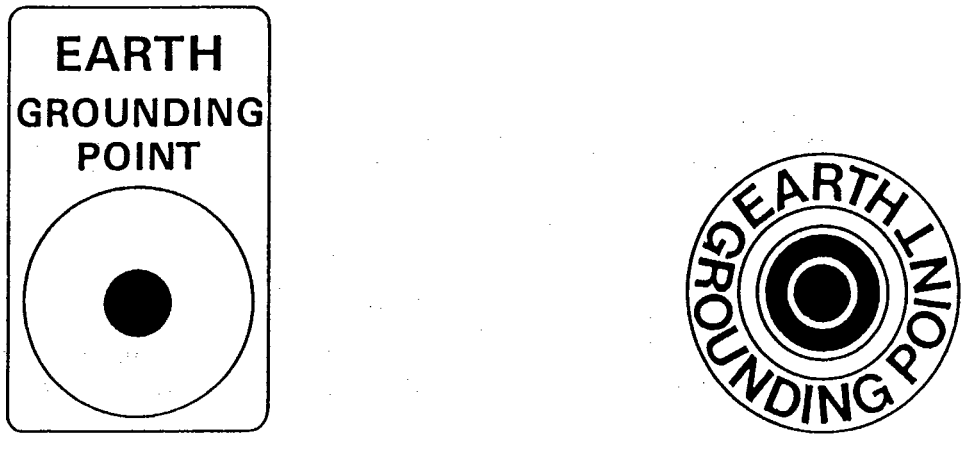


Figure 6: Examples of earth grounding point labels

Section four. ESD Protected Area (EPA)

4.1 Configuration

4.1.1 General

The EPA shall be designed to ensure that ESDS can be handled with minimum risk of damage as a result of electrostatic fields or discharge.

The EPA shall be constructed to ensure that the equipment used to control static electricity does not create any additional risk of electric shock to personnel, should energised conductors up to the level of 250 V a.c. (500 V d.c.) be exposed.

CAUTION: The normal risk of electric shock is not precluded by the use of EPA fittings.

NOTE: EPA may take many forms including the following:

a) a bench;

b) a store;

c) an area of work;

d) a field work area;

e) a work station and equipment (e.g. solder flow machine).

4.1.2 Additional protection against exposed high voltages

In EPA where exposed energised conductors exist for each 250 V a.c. (500 V d.c.) potential the minimum resistance of any working point to ground shall be $7,5 \times 10^5$ ohm. Maximum resistance values in excess of those specified in Section 4 clauses shall not be used.

4.2 Control boundaries

All EPA shall have defined boundaries such that whatever the configuration of the EPA, the requirements of this standard are maintained.

4.3 Basic material requirements for use within the controlled boundaries of all forms of ESD protected area (EPA)

4.3.1 General. All material procured for use within an EPA shall have the following characteristics which shall be measured at (25 ± 5) % r.h. Materials shall be acclimatized for a minimum of 24 hours.

NOTE: Suitable measuring methods for material parameters are given in annex A.

4.3.2 Working surfaces. All working surfaces shall be capable of being brought to ground potential and shall have a surface resistivity of between 1 x 10^4 and 1 x 10^9 ohm/sq.

4.3.3 Floors

All floor covering materials required for grounding personnel shall be capable of being brought to ground potential and shall have a surface resistivity of between 1 x 10^4 and 1 x 10^9 ohm/sq.

All floor covering materials not required for grounding personnel shall be capable of being brought to ground potential and shall have a surface resistivity between 1 x 10^4 and 1 x 10^{12} ohm/sq, see table 1.

Where an EPA has flooring for grounding personnel, the boundary between the types of floor shall be identified.

4.3.4 Seating

Seats shall be made of antistatic material. Seats shall have the back, seat and arm pads made of, or covered with materials that have a surface resistivity of between 1 x 10^4 and 1 x 10^9 ohm/sq, and a resistance from the surface of the back, seat and arm pads to the floor contact point or alternative ground connection of between 7,5 x 10^5 and 1 x 10^{12} ohm. There shall be a conductive path from each of the back seat and arm pads to at least one foot or ground connection of the seating of between 7,5 x 10^5 and 1 x 10^9 ohm, see table 1.

4.3.5 Garments

Coats, jackets, smocks and overalls shall be designed to completely enclose all outer clothing in the areas of the arms and chest as a minimum. These garments shall be capable of being bonded directly or indirectly to the operator's skin. There shall be electrical continuity of between 7,5 x 10^5 and 1 x 10^{12} ohm/sq between both sleeves and the body of the garment.

Caps and hoods shall be designed to completely contain the operator's hair, which may otherwise make contact with ESDS.

The material of the garment shall have a surface resistivity on both the outward facing and inward facing sides of between 7,5 x 10^5 and 1 x 10^{12} ohm/sq and be capable of being grounded. Additionally the materials shall be procured with decay characteristics as defined in table 1, and A.2.

Garments that comply with this standard shall have a visible label or tag indicating compliance.

NOTE: A label showing the ESD symbol shown in figure 1B is recommended.

4.3.6 Gloves and finger cots

Gloves and finger cots shall be made of volume conductive materials having a maximum surface resistivity of 1×10^6 ohm/sq and maximum volume resistivity of 1×10^5 ohm x cm, see table 1 and annex A.

Hand barrier creams shall conform to the same requirements.

NOTE: Users of creams shall be made aware of the possibilities of product contamination.

4.3.7 Wrist straps

A wrist strap shall consist of a band that fits snugly around the wrist and a cord to connect the band to an earth bonding point.

The wrist strap shall be made with a quick release connection with a preference for releasing at the wrist first in the event of an emergency.

1) The wrist band shall be made from materials that provide for the inner surface (next to the skin) a surface resistivity of not more than 1×10^7 ohm/sq with the intention of making permanent full contact with the wrist, see table 1 and annex A1.

The band shall be made such that there is a means of connecting the inner (contacting) surface to the cord. The conducting parts of the connecting system shall be shrouded in insulating material when the band and cord are in place and use.

The outer visible surfaces of the wrist band and profile edges, shall be insulating.

2) The connecting cord shall be made of conducting cable covered with insulating material and provided with a means of compatibly connecting the cord to the earth bonding point, see 4.6.9. The cord shall incorporate at least one insulated 1×10^6 ohm (min. 9×10^5 ohm max. 5×10^6 ohm) current limiting resistor at the identified wrist end of the cord, and the total resistance from end to end shall not be greater than 5×10^6 ohm, see table 1. This resistor shall have at least a 0,25 watt per 1×10^6 ohm rating. The completed cord shall withstand a voltage test of 250 V a.c. or 500 volts d.c. between ends for each 1×10^6 ohm for 20 seconds. Materials that depend on their length to provide the minimum necessary resistance shall not be used.

3) The total resistance from the hand to the remote end of the cord (including the wrist band and cord) shall be minimum of 9×10^5 ohm and a maximum of $3,5 \times 10^7$ ohm.

Cords designed for use at a potential above 250 V a.c. or 500 V d.c. shall have the maximum rated potential identified on the cord.

Where the wrist band cord uses the same type of connection for both wrist band and earth bonding point, the end of the cord containing the current limiting resistor shall be identified on the cord housing for the wrist band connection.

4.3.8 Leg straps, toe and heel straps and electrostatic dissipative footwear

The resistance from a contact with the hand to a metal plate on which both feet are standing shall be less than $3,5 \times 10^7$ ohm, see annex A.

Leg straps, toe and heel grounders and electrostatic dissipative footwear shall be constructed such that the contact made with both feet and legs meet the requirement for an electrical path from the wearer to contact points on each foot of the footwear in both toe and heel regions.

NOTE: A discrete resistor need not be incorporated in the leg strap, toe and heel strap or dissipative footwear, as there is no minimum resistance requirement for this path. Adequate current limiting resistance is incorporated in the prescribed floor, see table 1.

4.4 Ionization

4.4.1 Ionizers shall be considered as an additional method for charge neutralization in cases where insufficient neutralization can be achieved by equipment bonding. When used, ionizers shall meet the requirements of 4.4.2 to 4.4.9.

4.4.2 Ionizers used to neutralise electrostatic charges on non-conductive items shall supply constant and equal streams of both negative and positive ions except where an automatic means of identifying the polarity and strength of the charge is employed and dictates a temporary imbalance.

4.4.3 Ionization shall not be used in an attempt to eliminate the use of either wrist bands, or protective work surfaces and floors.

NOTE: Ionization may be applied in a number of ways appropriate to the requirements of the work situation. These may include localised (bench) ionized air blowers, compressed air ionizers, spot ionizers, tape dispenser ionizers and total room ionizers.

4.4.4 Any ionizer type considered for use shall be approved for safety with the appropriate national body.

4.4.5 The limit of ozone from any ionizer shall not exceed 0,1 ppm (0,2 mg per m^3) or as defined by national requirements for tolerable doses.

4.4.6 Nuclear ionizers shall be manufactured and controlled in their use in accordance with the national legislation.

NOTE: Nuclear ionizers may produce a radiation hazard.

4.4.7 Within the EPA the concentration and mobility of all categories of the ionization shall enable either polarity of static charge on the working surface to be held to less than 100 V within 20 s.

4.4.8 Within the EPA the volume concentration of negative and positive ions shall be maintained sufficiently well balanced that the maximum space potential generated shall be less than 100 V within 20 s.

4.4.9 Within the EPA the ionizing equipment and connections to the equipment shall not generate either continuous or pulsed electric fields outside the equipment greater than the equivalent to a worksurface potential 100 V.

4.5 Humidity

4.5.1 The relative humidity shall be maintained above 20 %, see annex A.5. For areas below 20 % r.h. additional requirements specified in CECC 00 015 Part 2 shall apply. (Part 2 is in course of preparation).

The provision of environments with high relative humidity shall not be used as a prime means of controlling electrostatic discharge.

NOTE 1: Increasing the relative humidity in the local environment can reduce the risk of damage due to electrostatic discharge by increasing the mobility of charges.

NOTE 2: Excessive humidity can cause problems such as corrosion, possible leakage paths for high voltages and moisture contamination within equipment.

NOTE 3: Low humidity severely reduces the dissipation effectiveness of materials used in certain types of worksurfaces, packaging and clothing.

4.6 Construction of the ESD Protected Area (EPA)

NOTE: An example of an EPA with typical facilities is shown in figure 8.

4.6.1 ESD earth facility

1) Every form of EPA shall be provided with a designated ESD earth facility. The ESD earth facility shall be constructed in such a way as to ensure that no sudden changes in potential occur within the EPA that could cause unacceptable voltages or discharges to be applied to ESDS.

2) When available, the mains earth shall be the ESD earth facility.

3) The ESD earth facility shall be connected to and provide a low resistance [< 1M ohm] path to earth.

4) The provision of a low resistance path to earth may be distributed by a dedicated ESD earth facility, so that it is accessible at various points in the EPA.

5) A distributed ESD earth facility shall, where visible, be provided in a insulated conductor.

6) The dedicated point of accessing the ESD earth facility for connection to the facilities of the EPA shall be labelled, see fig. 4.

4.6.2 All forms of EPA shall be constructed such that the materials used shall be electrically bonded together and have a minimum value of resistance to ground that limits the current to ground produced by voltages accessible to the operator to 0,5 mA nominal, 0,67 mA maximum, see 4.1.2 and A.1.3.

NOTE: Personnel movements in conjunction with working surfaces and flooring could result in parallel paths to ground. Caution shall be observed in the resulting parallel paths to ground that could arise which may reduce the equivalent resistance of operators to ground to unsafe levels.

4.6.3 The basic construction configuration, using the **minimum** specified requirements for values of resistance to ground and limited current to ground shall be as shown in fig. 7, which is suitable for a highest accessible voltage of 250 V a.c. (500 V d.c.). Where higher values of accessible voltages are present the value of the resistors A, B and C or D shall be increased so that the current from operator to ground is limited to a safe value.

The resistance to ground figures shown in fig. 7 for working surface and floor materials are assumed to be inherent in the material construction or added as a discrete resistance in series with the working surface or flooring. Where additional resistance is required to limit current to a safe value, the value of the discrete resistor shall be increased as identified in 4.1.2.

For floors used for grounding personnel and for all work surfaces, the resistance to ground shall be between 7,5 x 10^5 and 1 x 10^9 ohm. For floors not used for grounding personnel, the resistance to ground shall be between 7,5 x 10^5 and 1 x 10^{12} ohm, see table 1.

NOTE: It is recommended that flooring adjacent to EPA should meet the same requirements for non grounding floors within EPA.

4.6.4 Seating within the declared boundaries of the EPA shall not be considered as a primary means of grounding an operator.

4.6.5 Suitable garments shall be made available for all personnel, including vistors, see 4.3.5 and 4.11.6.

4.6.6 Where leg straps, toe and heel grounders and electrostatic dissipative footwear are used as a prime or only means of grounding personnel, the floor shall be suitable for grounding personnel, see table 1 and shall be within the controlled boundaries of the EPA.

4.6.7 Each working surface shall be individually grounded or connected to an earth facility in an EPA.

4.6.8 Earth bonding points

1) A dedicated earth bonding point for the wrist band cord shall be established adjacent to each working area, or working surface, such that it is easily accessible without obstructing the work in hand nor presenting a possible hazard in the working environment.

NOTE 1: The wrist band cord may be connected to earth via the worksurface conductive element provided that the total resistance to ground does not exceed 3,5 x 10^7 ohm.

NOTE 2: The earth bonding point may be connected to ground via the working surface earth grounding point.

2) Each wearer shall be provided with an earth bonding point. Additional earth bonding points for any vistors to the EPA shall be provided. No more than two earth bonding points for the wrist band cord shall be connected via the working surface earth grounding point.

3) The earth bonding point shall consist of an electrical connecting system which in turn provides for a continuous electrical path to the ESD earth facility for the wrist band cord, see fig. 6.

4) The connecting system interface between the wrist band cord and the subsequent path to ESD earth facility shall be such that the mating parts of the wrist band cord connection and the earth bonding point connection are totally mechanically compatible by design and intention.

5) The earth bonding point system shall not be compatible with any other connecting system used for any purpose other than grounding in the EPA.

6) The electrical conducting parts of the connecting interface shall be such that they are shrouded by insulating material when the cord is connected to the earth bonding point and in use.

7) The connecting interface shall be of sufficient mechanical pull strength to minimise the possibility of inadvertent disconnection.

8) The earth bonding point shall be clearly marked in accordance with fig. 5.

NOTE: The use of mating snap connectors and specialised miniature sockets is recommended, whereas the use of crocodile clips is not.

4.6.9 Ground cords

1) An electrical connection shall be effected between the earth grounding point, the ground cords, and the ESD earth facility.

2) The ground cord connections from work surfaces or floors to the ESD earth facility, whether containing a discrete resistor or not, shall be continuous and may be permanent or detachable.

3) Any discrete resistance required in the ground cord shall be located on or near the point of contact with the work surface or flooring. The electrical specification of resistors and voltage identification of the cord shall be the same as those specified in 4.3.7 2).

4) When the ground cord is connected to the earth grounding point, the electrical conducting parts of the connecting interface shall be shrouded by insulating material.

NOTE: The use of mating snap connectors and permanent terminals is recommended, whereas the use of crocodile clips is not.

5) All the connecting interfaces shall be of sufficient mechanical pull strength to minimise the possibility of inadvertent disconnection.

4.6.10 Earth grounding points

1) An earth grounding point shall be established, on all worksurfaces and non-permanent flooring.

NOTE 1: A separate earth grounding point is not required for permanent flooring which has a resistance to ground value within the limits specified in 4.6.3.

NOTE 2: The connecting interface between the ground cord and the ESD earth facility may be uninsulated.

2) The earth grounding point shall be clearly marked in accordance with fig. 6.

3) Where materials for work surfaces or flooring contain an inner or subsurface layer (material with two or more layers), which is more conductive than the surface layer, the earth grounding point shall be connected to the more conductive layer.

Where the material for work surfaces or flooring is homogeneous in its resistive attributes, the ground cord shall be connected to, and through, the body of the material.

Where homogeneous materials are used as a permanent flooring, then this flooring shall be connected to ground and an earth grounding point and ground cord is not required.

In all cases, the materials used shall conform to the requirements of table 1.

4) When materials that possess a more conductive inner or subsurface layer are used, this layer shall not contact any furnishings and fittings in the EPA that have a direct path to ground.

NOTE: Such contact may short out any additional resistance that may be required within the grounding cord.

4.6.11 Temporary work surfaces and flooring

1) For temporary work surfaces and flooring, the requirement for the earth grounding point, ground cords and bonding points given in 4.6.8 to 4.6.10 shall apply together with the following additions:

a) The ground connecting terminal shall be attached to the temporary work surfaces or flooring such that the grounding cord is connected to the top working surface. The connecting method for the earth ground point to the work surface or flooring shall be such that it does not permit any non insulated earth grounding point component on the underside of the temporary work surface or flooring.

b) The material for temporary work surfaces and flooring shall be such that the surface resisitivity and resisitence to ground requirements given in table 1 are met.

4.6.12 Electrostatic fields

Electrostatic fields that are generated internal or external to the EPA shall be such that the maximum potential at any unprotected point inside the EPA shall be 100 V.

4.6.13 Certification

Once the EPA is constructed, then the local co-ordinator (see 8.2) shall be satisfied that the requirements of 4.6.1 to 4.6.12 are met, and formal certification be issued before use.

4.7 Field work

4.7.1 Where an EPA with a permanently controlled boundary is not available, all work necessitating the handling of unprotected ESDS shall be considered as field work. Field work in this context shall include such activities as the service and maintenance, installation, site inspections and commissioning of components and assemblies classified as ESDS together with the packaging and unpackaging activities associated with such functions.

4.7.2 All field work shall adhere to the requirements specified for permanent EPA with respect to the material quality and personal responsibilities, training, labelling and packaging.

4.7.3 Where necessary, temporary work surfaces and flooring shall be used. A means of equipotentially bonding the operator and any work surface and flooring to ground shall be used.

4.7.4 The work surface and wrist bands shall be bonded to one of the following:

a) the earth bonding point;

b) the equipment being serviced as shown in fig. 9.

4.7.5 Non moveable equipment intended for service and containing ESDS shall either:

a) be situated such that there is an ESDS earth facility available for bonding

or

b) shall be provided and fitted with a designated earth bonding point, which incorporates a resistance to earth of not greater than 1 Mohm.

4.7.6 The operator shall arrange the field work area such that there is a temporary controlled boundary of at least 1 metre from the unprotected ESDS to any situation that would be likely to invalidate the specified requirements for EPA.

4.7.7 Sign(s) as shown in fig. 3 shall be placed at the temporary controlled area boundary during the duration of the field work.

4.7.8 All operators working within a temporary EPA area shall wear as a minimum requirement, a jacket complying with 4.3.5.

4.7.9 If the extent of the temporary controlled area is such that the operator needs to walk and move as required in the area, then the floor of that area shall meet the requirements of a permanent EPA.

4.7.10 Where field work necessitates the removal of ESDS from equipments and transfer to a temporary work surface away from the equipment, the ESDS shall be given protective packaging unless equipotential bonding of the operator is maintained, see fig. 10.

4.7.11 The operator shall be bonded at all times when handling ESDS. ESDS shall be placed directly into protective packaging on removal from equipment. Replacement ESDS shall be kept in its protective packing until required for immediate installation into equipment, see fig. 9.

4.7.12 Where field work is a permanent feature of any discipline involved in the handling of unprotected ESDS, the field service operator shall ensure that the necessary materials and tools to maintain and control the requirements of this form of EPA are available at the place of the field work.

4.7.13 Work surfaces and flooring for field work shall comply with 4.6.11

4.8 Tools

4.8.1 All tools intended for use within the EPA shall as far as is practical be so constructed that they do not generate or hold an induced electrostatic charge.

The insulated handles of tools which generate or hold an electrostatic charge shall be treated with a suitable antistat or be replaced with static dissipative handles.

NOTE: Small hand tools (tweezers, screwdrivers etc.) may be constructed totally of conductive materials however care should be taken when used in powered equipment.

4.8.2 All tools, including electrical, mechanical and pneumatic, shall be so constructed that any part of the tool which may touch an ESDS is at earth potential using methods in section 4.

4.8.3 All electric solder irons used within the EPA shall be fitted with earthed tips or bits. The resistance between the tip and earth shall not be greater than 5×10^6 ohm. Non temperature controlled electric solder irons shall regularly be checked to ensure that the bit is adequately earthed.

NOTE: The use of temperature controlled electric solder irons are a particular hazard, as the switching of the current to the tip can generate high induced charges. The use of electronically controlled zero current switching irons is recommended.

It is essential that the test voltage for tip to earth resistance measurements is specified to be approximately 10 V d.c. as the insulation by oxide between the tip and heating element will break down at 5 to 10 V. If the tip is grounded through the heating element, no transients or electrostatic charges of more than 10 V will occur on the tip if the resistance is tested in this way.

4.9 Fittings

4.9.1 The surface of racking, shelving, carrousels, and dispensers which are used to hold unprotected ESDS shall meet the requirements of a working surface material as specified in table 1 and shall be grounded.

4.9.2 Trolleys, carts and wagons

1) Trolleys, carts and wagons that are used to hold ESDS in the EPA or across the boundaries of EPA shall be constructed as given in 4.9.2 2) to 4.9.2 5).

2) Platforms and shelves shall be constructed from material complying with 4.3.2 and summarized in table 1.

3) The main constructional frame shall be manufactured from materials giving a surface to ground resistance of between $7,5 \times 10^5$ and 1×10^9 ohm. The resistance between the platform or shelves to ground shall be between $7,5 \times 10^5$ and 1×10^{10} ohm. There shall be a minimum of two contact points to connect the trolley, cart or wagon to the floor, these contact points may be formed from wheels, chains or wipers, see table 1.

4) With the exception of small piece parts, the use of insulating plastics and finishes shall be prohibited.

5) Trolleys, carts and wagons intended for use on non-grounding floors, as defined in 4.3.2, shall additionally contain an earth grounding point such that it can be bonded using a grounding cord connected to an ESD earth facility when stationary for loading, unloading or being used as a working surface.

4.10 Test and process equipment

Test and process equipment which generate electrostatic charges shall be suitably screened to prevent damage to ESDS.

NOTE: The following equipment examples are known to cause the generation of electrostatic charges and it is essential that precautions are taken to ensure compliance with clause 4.6.12 of this standard.

- Latexes and similar materials used in vacuum assist processes.

- Compressed air or other gases used to move ESDS.

- Air circulating chambers used for process and testing of ESDS.

- Flow soldering equipment and solder pots.

- Conveyor belts and similar transit systems.

- VDU screens.

4.11 EPA working practices

4.11.1 No non-essential electrostatic generating materials shall be allowed in an EPA, e.g. untreated plastic bin-liners, cups, cosmetic bottles, boxes.

4.11.2 The consumption of food and drink, smoking or garment changing shall not be allowed inside an EPA.

4.11.3 Paperwork inside the EPA shall either made from antistatic material or shall be kept inside antistatic containers.

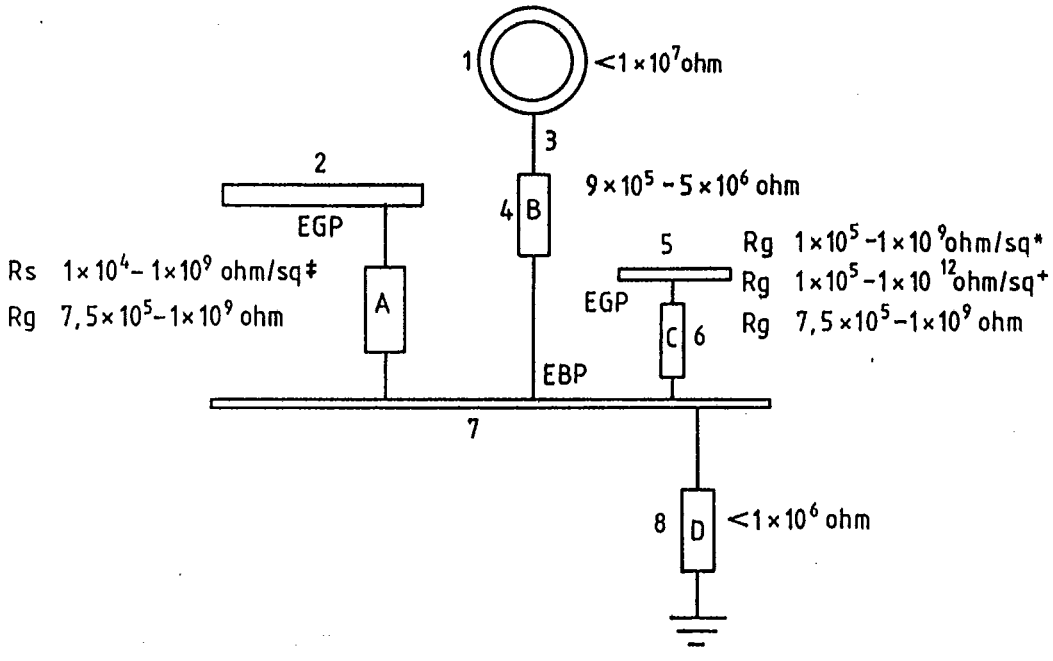
4.11.4 Working surfaces and floors shall be kept clean and tidy. Only cleaning materials which will not affect the properties of worksurfaces and floors as given in table 1 shall be used.

4.11.5 Wrist straps (4.3.7) connected to an earth bonding point (4.6.8), or approved footwear (4.3.8) with an approved floor (4.3.3), shall be worn at all times when unprotected ESDS are being handled. If a wrist band is worn it shall be in direct contact with the wearers skin.

4.11.6 Garments specified in 4.3.5 shall be worn in an EPA at all times. Garments shall be properly fastened to ensure that other clothing does not come in contact with unprotected ESDS. Personnel with long hair shall have this contained so that it does not contact unprotected ESDS.

4.11.7 ESDS found to be faulty shall be protected in the same manner as any other ESDS in order that satisfactory failure analysis procedures may be performed.

1 Wristband bonding system
2 Worksurface
3 Wristband cord
4 Discrete resistor
5 Bonded flooring
6 Ground cable
7 ESDS earth facility
8 Solid earth



EBP = Earth Bonding Point
EGP = Earth Grounding Point

Rs = surface resistivity
Rg = surface to ground resistance

* Flooring required for bonding personnel
+ Flooring not intended for grounding personnel, but within the controlled boundaries of the EPA
‡ Resistance value inherent in material of worksurface or flooring or added as discrete resistor

For requirements of A, B, C and D see 4.6.3.

The value of resistances shown shall not contravene national safety regulations.

Figure 7: Schematic of typical EPA

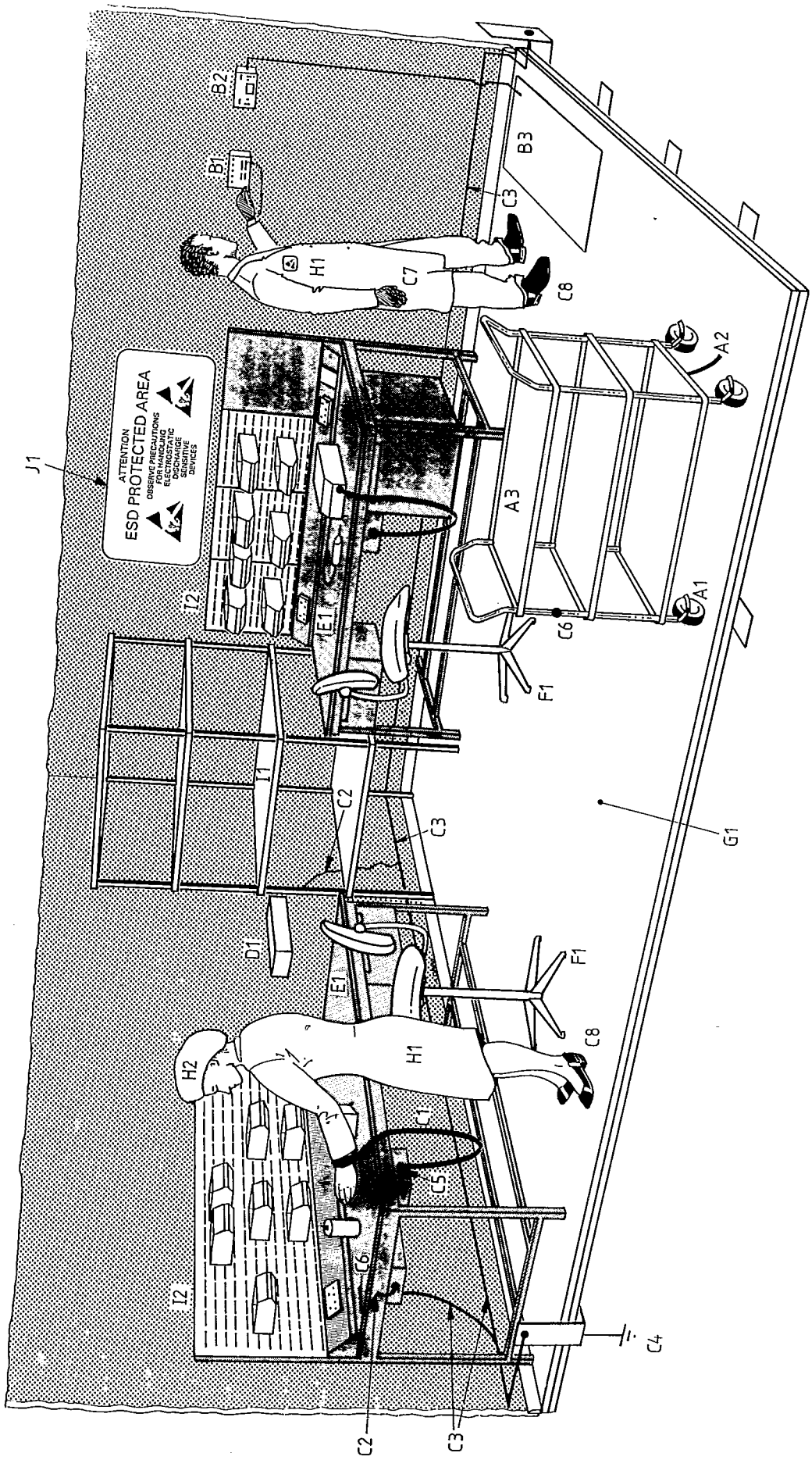
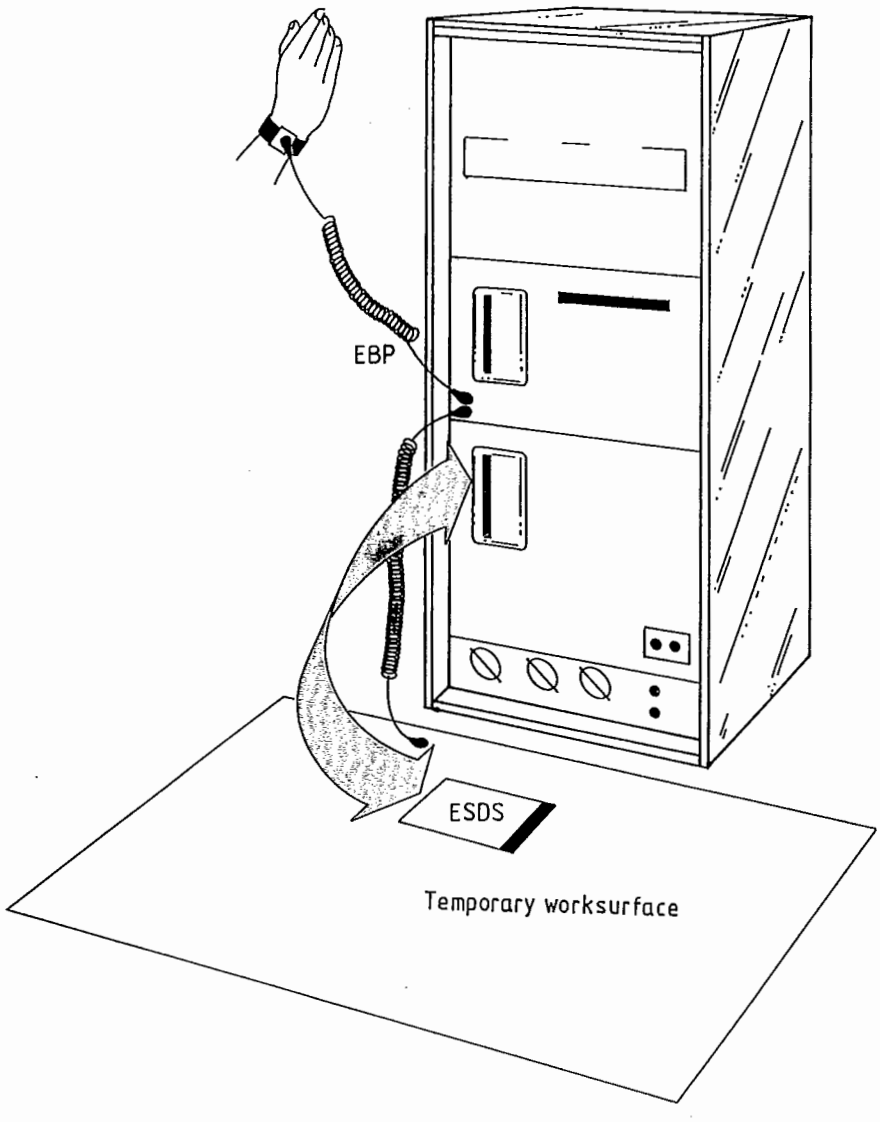


Figure 8: Example of an EPA showing typical facilities

Index of facilities shown in figure 8

A1	Grounding wheels	(4.9.2.(3))
A2	Grounding wiper	(4.9.2.(3))
A3	Grounding surface	(4.9.2.(3))
B1	Wristband tester	(A.1.4.3)
B2	Heel grounder tester	(A.1.4.3)
B3	Heel grounder foot plate	(A.1.4.3)
C1	Wristband cord and wristband	(4.3.7)
C2	Ground cord	(4.6.9)
C3	ESD earth facility	(4.6.1)
C4	Ground	(1.2.9: 4.6.1 3))
C5	Earth bonding point	(4.6.9)
C6	Earth grounding point	(4.6.10)
C7	Gloves	(4.3.6)
C8	Toe and heel strap	(4.3.8)
D1	Ionizer	(4.4)
E1	Working surfaces	(4.3.2)
F1	Seating with grounding feet and pads	(4.3.4)
G1	Floor for grounding personnel	(4.3.3)
H1	Garments	(4.3.5)
H2	Cap	(4.3.5)
I1	Shelving with grounding surfaces	(4.9)
I2	Grounded racking	(4.9)
J1	EPA sign	(3.2)



Only handle unshielded ESDS when bonded to system

Bond mat to system as wristband cord

Only rest ESDS on bonded mat

Figure 9: Field work implementation of EPA

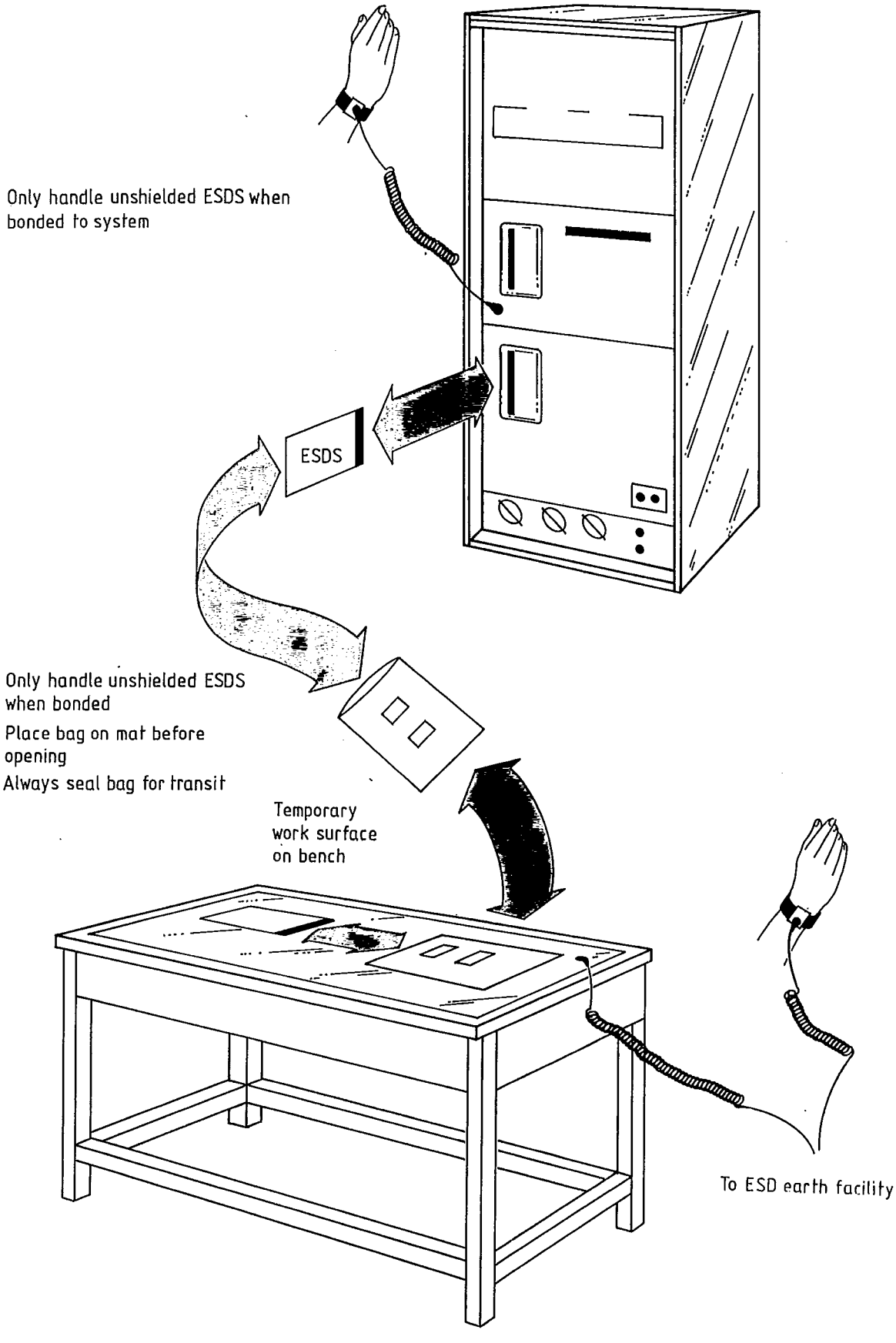


Figure 10: Field work implementation of EPA with bench

Section five. Protective packaging, marking and identification for ESD

5.1 Packaging materials

5.1.1 Charge dissipation and the prevention of tribo electric charging

Packaging materials which are in intimate contact with ESDS shall be antistatic and electrostatic dissipative with surface resistivity values given in table 2.

5.1.2 The provision of an electrostatic shield

ESDS shall be shielded, as given in table 2, from electrostatic charges by enclosure in an electrostatic shielding package whilst being transported or stored in uncontrolled conditions.

5.1.3 Grounding the package

All proximity packaging materials which surround or enclose an ESDS shall be capable of dissipating electrostatic charges and provide a path to ground.

NOTE: Packaging materials may be constructed in a manner to fulfil the requirements of 5.1.1, 5.1.2 and 5.1.3 (e.g. electrostatic shielding bags) or use separate components (e.g. electrostatic dissipative foam lined conductive boxes).

5.1.4 The maintenance of antistatic, resistivity and shielding properties

Packaging material shall maintain their antistatic, resistive and shielding properties during storage, transit, distribution, application or use to the point of re-use or disposal.

5.1.5 Restrictions for use

All generators of electrostatic charges such as untreated plastic films, foams, synthetic fibres, adhesive tapes etc shall be prohibited for use as intimate or proximity packaging materials and shall be excluded from the EPA.

Exposed metal foils, laminates and other packaging materials with a surface resistivity of less than 1×10^3 ohm/sq shall not be used as intimate packaging or be allowed to make contact with ESDS, see annex A.

Humidity dependent intimate packaging materials shall not be used as part of a desiccated (silica gel) package.

NOTE: The useful life of humidity dependent materials delivered or in store may vary. These materials may be used provided that they are tested and meet the requirements of this standard over the time of use.

5.1.6 Other precautions

Any packaging materials, equipment or tools which are not antistatic, static dissipative or electrostatic conductive, including non-electrostatic sensitive devices shall be packed in antistatic or static dissipative materials before being taken into an EPA.

5.2 Intimate packaging materials

5.2.1 Unpowered ESDS

ESDS shall be packed in accordance with table 2.

NOTE 1: ESDS with leads may be mounted on electrostatic conductive foam to 'short out' the pins.

NOTE 2: Care should be taken when using large shunts which may cause induced voltages to occur.

5.2.2 Powered ESDS

These devices which may contain batteries, charge capacitors or other energy sources shall be packed using either of the following methods:

- intimate packaging materials with surfaces which are both anti static and electrostatic dissipative;

- electrostatic protective container specifically designed to avoid contact with individual leads or circuit tracks.

Powered ESDS shall not be packed in direct contact with surfaces or materials which have a surface resistivity of less than 1×10^8 ohm/sq.

5.3 Proximity packaging material

5.3.1 Inhouse transportation and storage

The grounding of electrostatic protective boxes or closed containers shall be as given in 5.1.3.

5.3.2 External transit packaging in uncontrolled conditions

ESDS shall be contained in electrostatic shielding packaging or electrostatic conductive materials according to their sensitivity, as given in table 2.

Loose fill, if required, shall be procured with both antistatic and electrostatic dissipative properties.

5.4 Secondary packaging material

Secondary packaging shall be chosen to include all additional packaging requirements for mechanical protection, etc.

NOTE: Electrical properties are not a major consideration, provided the intimate and proximity packaging gives protection in accordance with 5.1 and the secondary packaging is not taken into a EPA or where the environmental conditions are controlled.

5.5 Marking and identification

5.5.1 Warning symbols

The packaging material shall be marked and labelled in accordance with section 3.

5.5.2 Identification

Packaging material shall be identified with the following information:

a) prime function, e.g. electrostatic shielding, electrostatic conductive, electrostatic dissipative.

b) manufacturer's name or logo.

c) batch number.

d) date of manufacture (month and year).

Where space or other limitations do not allow some or all of the listed information to be marked on individual items, the priority in which the information is marked shall be in the order given. When all of the information is not marked on the individual item, a certificate of conformity shall accompany each batch giving the details required.

5.6 Packaging/component compatability

In the selection of packaging materials to ensure that electrostatic protection is maintained, the user and/or supplier shall ensure that the integrity of the component is not compromised.

Section six. Purchase, receipt, storage and handling

6.1 General

Electrostatic handling precautions shall be applied at all stages from goods inward to final dispatch.

In undertaking routine control and monitoring of the storage of ESDS, the local co-ordinator, see 8.2, shall be responsible for ensuring that:

a) the requirements in section 6 are met at all times;

b) the requirements of sub-clause 8.7 are met with respect to the storage environment under their control.

In addition, the requirements for daily visual checking of electrostatic precautions (8.4) and for periodic auditing (section 9) shall apply to all ESDS storage areas and facilities.

Storage equipment shall comply with 4.9.

NOTE: Any relaxation in following the requirements of this standard may cause damage to components and seriously affect the reliability of the end products, and is to be strongly discouraged.

6.2 Purchase

All procurement orders for components and items related to electrostatic special handling activities shall quote the requirements of this standard. Both packaging materials and packaging actions shall be covered by these requirements. All procurement personnel shall receive appropriate training, see 7.2.

6.3 Receipt

6.3.1 All receipt EPA shall meet the requirements of section 4.

6.3.2 All known ESDS received without packaging in accordance with this Standard, including warning labels, shall be treated as non compliant and appropriate action shall be taken.

6.3.3 On receipt, packages shall have secondary packaging removed down to warning labels. This material shall not be taken into an EPA, see table 2.

6.3.4 Packages showing ESDS warning labels shall be taken to an EPA before removing any further wrapping.

6.4 Unpacking within an EPA

6.4.1 In addition to the training requirements of section 7, all goods inward personnel shall be instructed how to recognize and handle ESDS. Labels and signs to this standard shall be made known to all personnel.

6.4.2 Where tape is acting as a seal, it shall be cut to open the box or bag and NOT stripped away.

NOTE: The stripping of adhesive tapes or labels may generate severe electrostatic potentials.

6.4.3 Warning labels shall be used on all packages containing ESDS. Where these have been removed (by cutting) to gain access to the contents, fresh warning labels shall be used to re-seal the packages.

6.5 Goods inward inspection

6.5.1 ESDS shall be retained in their original protective packaging until the individual contents are to be inspected. The packs shall then be opened in an EPA with inspectors and other personnel bonded as defined in 4.11.5.

6.5.2 Where ESDS have to be batched, care shall be taken to ensure that all the individual ESDS remain protected.

Antistatic shipping tubes shall only be used when they meet the requirements of this Standard and shall not be cut and re-used under any circumstances. Antistatic shipping tubes have a limited life, due to age and use, and shall be tested at suitable intervals for compliance.

Electrostatic conductive and electrostatic dissipative tubes may be cut when empty and closed off with a suitable peg. Adhesive tape shall not be used.

Individual ESDS shall not be left unprotected.

6.5.3 ESDS that are received for medium or long term storage, as defined in 1.2.16, shall be packaged in electrostatic conductive or electrostatic shielding, electrostatic dissipative containers, as defined in table 2.

6.5.4 If it is necessary to lay the ESDS on a working surface without the leads being protectively shorted, it shall be placed on the specified surface in such a way that all leads are in contact with the bonded specified work top. Shorting connections where used shall be restored to the ESDS on completion of inspection and test BEFORE devices are moved from an EPA.

6.6 Movement and handling

6.6.1 Precautions as given in 6.5.2, 6.5.3 and 6.6.8 shall be observed for the handling or internal moving of packages.

6.6.2 Electrostatic conductive or electrostatic dissipative bins, racks, tote boxes, trays, bags, etc shall be used to transport ESDS to provide protection from contamination and mechanical damage as well as electrostatic protection. Such containers shall be labelled in accordance with section 3.

6.6.3 When possible, ESDS shall be transported in house in their original protective packaging.

6.6.4 Specified containers, as in 6.6.2, shall be loaded and unloaded in an EPA. Suitable electrostatic conductive or electrostatic dissipative material shall be used to prevent ESDS from abrading each other.

6.6.5 When not being actively worked on, ESDS shall be stored either in containers which comply with this standard, with well fitting lids, ideally dust proof, or in sealed bags.

6.6.6 If an unprotected ESDS is dropped, it shall be considered damaged.

6.6.7 All ESDS in surface coated astatic tubes shall be regarded as unprotected ESDS and given additional protection as defined in table 2.

6.6.8 ESDS shall be transported between sections (goods receiving, inspection, stores, kitting, assembly, test, etc) in the original protective packaging or in other approved containers.

NOTE: It is essential that the handling of ESDS be kept to an absolute minimum and then only in an EPA with bonded personnel.

Section seven. Training

NOTE: The skill level of trainees will have a bearing on the level of training to be given.

Technical engineering disciplines will require a more theoretical approach than some manufacturing disciplines, whereas management levels require generalities, such as those relating to reliability, risk management and costs.

Even the most elaborate or expensive EPA, shielding protection, or documented procedures will not work if people are not properly trained in their correct use.

7.1 Relevant structured training shall be provided for all personnel who specify, procure, design, mark or handle ESDS in any way or are likely to do so including those who manage and supervise them. Special emphasis shall be placed on training of personnel who are to undertake field work.

7.2 The training shall be orientated to facilities and methods and the types of protective materials and equipment that have been found to be most effective in specific applications.

7.3 Personnel shall be trained to employ effectively the materials, equipment and procedures provided in accordance with this standard and to understand why electrostatic precautions are needed.

7.4 Training shall be part of employee induction courses. Training shall be given on the use of equipment by employees and customers.

7.5 Training shall include appropriate personnel safety requirements, the identification of ESDS in equipment, some basic electrostatic discharge theory, electrostatic special handling precautions and the need for the use of protective packaging.

7.6 Training shall be provided for the cleaning personnel, if they are likely to come into contact with EPA environments.

7.7 Retraining shall be provided at intervals of not more than 12 months for all concerned to heighten the awareness of personnel to changes in techniques developed and to maintain specified electrostatic protection procedures.

7.8 A register shall be maintained of those personnel who have been trained in accordance with the requirements of this standard.

7.9 Training shall be supplemented by readily available guides, handbooks, audio-visual aids or appropriate documented procedures.

Section eight. Quality responsibilities

8.1 Personnel responsibilities

8.1.1 In the working environment, PEOPLE are the greatest source of electrostatic generation and therefore ALL personnel shall have a prime responsibility to take the precautions set in this standard.

8.1.2 It shall be the responsibility of all those involved with ESDS to be aware of the electrostatic threat to the reliability of electronic products. They shall notify the local co-ordinator, see 8.2, of any aspect of electrostatic special handling that is considered to be unsatisfactory, and when appropriate make suggestions for corrective action.

8.1.3 A consistent and continuous protection for ESDS to at least the requirements of this standard shall be maintained.

8.1.4 A copy of this standard or an in-house procedure meeting the requirements of this standard shall be available to all relevant staff.

8.2 Local co-ordinator

At all sites there shall be a named local co-ordinator responsible for all matters relating to the protection of ESDS and the implementation of this Standard.

8.3 Selection of ESD materials

8.3.1 The responsibility for the selection criteria for ESDS protective materials shall be defined:

a) that all ESD protective material and products being considered for use shall comply with the requirements of this standard;

b) that the materials actually delivered comply with the requirements of this standard and are capable of performing the required task under the unique conditions existing within a given facility;

c) that the products in use continue to perform in accordance with this standard during their intended lifetime.

8.3.2 Materials may be qualified by any of the methods below:

a) user's in house qualification;

b) third party qualification.

c) supplier's qualification testing and the provision of certificates of conformance;

d) confidence in suppliers supported by data.

8.4 Procurement records

The procurer shall maintain a register of the current selected ESDS protective materials and of their selected sources. Materials shall have been selected by the process in 8.3 prior to inclusion in this register.

8.5 Procurement of ESDS and subcontracted work

8.5.1 Those responsible for the procurement of ESDS shall ensure that:

a) the requirements of this standard are incorporated in all acquisitions relating to the handling of all ESDS.

b) all subcontracts and suppliers of ESDS comply, in the areas of their individual responsibilities, with the requirements of this standard.

8.6 Design

The reviews, evaluations and procedures of 2.6 shall be followed.

8.7 Checking of electrostatic precautions

The minimum checks given in 8.8 to 8.12 shall be made at the specified periodicity.

In undertaking routine control and monitoring of the working environment, a trained and nominated person shall be responsible for ensuring that the requirements of 8.8 to 8.12 are met and that records of the required checks are maintained.

Any non compliance with these requirements that cannot be corrected immediately through the resources available to the person(s) responsible for this routine monitoring and control shall be reported to the local co-ordinator (8.2) who shall ensure that prompt corrective actions are undertaken.

Checks shall be made in accordance with either clauses 8.8 to 8.12 or by relevant constant monitoring or statistic process control techniques.

8.8 Frequent checks

8.8.1 When relative humidity is specified, a check shall be made that it conforms to the requirements of 4.5. This shall be checked at the start of every work period, and then at suitable intervals.

8.9 Daily checks

8.9.1 All personnel are conforming to the requirements for personal grounding.

8.9.2 Wrist band and ground cord

Each wearer shall check that their wrist band and ground cord meets the requirements of 4.3.7 2) and for high voltage applications 4.1.2. When in daily use, the checks shall be made before use. Each check shall be made with the wrist band worn on the wearers wirst and in contact with the wearers skin. A record of the check and its result shall be maintained.

8.9.3 Leg straps, toe and heel straps and electrostatic dissipative footwear

The resistance from the foot to the surface of the grounder/shoe making contact with the floor is as defined in 4.3 and 4.1.2 for high voltage applications.

The wearer shall check each grounder/shoe daily, or before use if not in daily use, and a record of such checks shall be maintained. Each check shall be undertaken with the grounder(s)/shoe(s) worn by the wearer.

8.9.4 Garments required for use shall be checked to determine that the types specified in 4.3.5 and 4.3.6 are in use, or if non compliant, they are replaced.

8.9.5 If used, ionizers and ionizing systems shall meet the requirements of 4.4.

8.9.6 Worksurfaces shall be clean and tidy and free from unnecessary packaging materials.

8.9.7 All floors shall be clean and free from contamination.

8.9.8 A visual check shall be made that storage facilities are properly bonded in accordance with 4.9.

8.9.9 Acceptable and rejected/faulty ESDS shall be adequately segregated.

8.9.10 A visual check shall be made that all trolleys have complete earth bonding system and that all connections are in place in accordance with 4.9.2.

8.9.11 Each wriststrap tester and grounder/shoe tester shall be in a working condition.

8.9.12 No non-essential electrostatic charge generating materials shall be present in the EPA.

8.9.13 A visual check shall be made that benches are fitted with identified undamaged ESD grounding points.

8.10 Weekly checks

8.10.1 There shall be no electrostatic fields greater than defined in 4.6.12.

8.10.2 The earth bonding system shall be checked to determine that it has not been damaged by movement or wear and that it is electrically continuous.

The electrical continuities of the earth bonding of benches, floors, chairs, trolleys, field service kits, mats, work stations, racks, separately grounded equipment or anything that grounds operators permanently or temporarily shall be checked.

If any of these items is subjected to a change (configuration) it shall be checked immediately after that change.

8.11 Monthly checks

8.11.1 Signs and labels shall be of the specified types and in specific places.

8.11.2 The EPA, including boundaries, entrances and exits shall be clearly identified by specified signs.

8.11.3 Grounding systems for benches shall be satisfactory, e.g. grounding links are properly connected and all joints are tight.

8.12 Six monthly checks

8.12.1 A register of trained personnel shall have been maintained and is up-to-date.

8.12.2 All relevant personnel shall have been trained.

8.12.3 The training shall be appropriate and has been proved to be effective within particular fields of applications.

8.12.4 The periodicity of refresher training shall be in accordance with clause 7.7.

8.12.5 Appropriate ESDS guides, handbooks and this standard or sections appropriate to the particular work area shall be available.

Section nine. Periodic audit instructions

9 Periodic audit instructions

9.1 Periodic audits of facilities, procedures and practices in accordance with the instructions given in 9.2 to 9.20 and in conjunction with the periodic checks of section 8 shall be undertaken by a nominated responsible person or team using appropriate measuring equipment where required. All records shall be checked. When appropriate, random tests shall be made.

All audit measurements shall be made under normal operating environment.

9.2 Checks shall be made that EPA are defined with notices as specified in section 3.

9.3 Checks shall be made that wrist band disciplines are being observed.

Checks shall be made that no defective wrist bands, cords or grounder/shoes, etc. are available.

Random tests shall be carried out on operator's wristbands.

9.4 Training records shall be checked to verify that all relevant staff have received training to the requirements of this standard.

9.5 A check shall be made that the specified requirements of 8.8 to 8.12 are being undertaken and recorded, and that any necessary remedial action has been undertaken promptly and recorded.

9.6 Wriststrap testers shall be checked for condition and upper and lower resistance thresholds.

9.7 A Visual inspection shall be made of bonding and grounding systems in EPA for integrity, e.g. on machines, solder and desoldering stations and trolleys.

9.8 An electrical test shall be made on the relevant resistivities and resistance to ground of existing work surfaces, flooring, seating and clothing in accordance with section 4.

9.9 An electrical test shall be made on the relevant resistivities of protective packaging materials, transit boxes and any other protective racking or shelving, see section 4.

9.10 A check shall be made that the identities and usage of all electrostatic protective materials and equipment meet the requirements of this standard.

9.11 A check shall be made that discarded packaging and any other materials that may not be electrostatically protective are disposed of promptly in a way that does not put ESDS at risk.

9.12 A check shall be made that the electrostatic fields are not greater than that specified in 4.6.12.

9.13 A check shall be made that humidity control when provided is in accordance with 4.5.

9.14 A check shall be made that ionization control when provided is in accordance with 4.4.

9.15 A check shall be made that tools comply with 4.8.

9.16 A check shall be made that the design controls in 2.6 have been applied.

9.17 A check shall be made that the product selection procedures in 8.3 have been applied.

9.18 A check shall be made that the procurement records in 8.4 have been maintained.

9.19 An audit report for circulation shall be completed, see tables 3 and 4 for guidance.

The audit report shall include identification of any non-compliance with this standard, and it shall give recommendations for corrective actions relating to these non-compliances and any other risks noted.

9.20 A follow-up audit shall be undertaken to check the effectiveness of any corrective actions arising from these recommendations (9.19) and the related report shall be completed and circulated.

Annex A

Test procedures

The following test procedures are included for information. Test requirements within this standard may use appropriate tests listed or relevant alternatives.

A.1 Surface resistivity and resistance to ground

A.1.1 General apparatus

A means of measuring resistance in ohms over the range of 1×10^3 to 1×10^9 or in certain applications 1×10^{12} at a nominal 500 V d.c. or for some lower resistance applications 5 V d.c. together with appropriate probes or electrodes in A.1.2.2 and A.1.3.2 is required for most measurements.

A.1.2 Surface resistivity

A.1.2.1 General

Where surface resistivity requirements are specified, surface resistivity measurements shall be made using one of the following methods as appropriate:-

a) ISO 2878
b) IEC 93
c) method described in A.1.2

Special procedures are required for the measurement of the surface resistivity of floors and bags.

Some materials, particularly many with higher surface or volume resistivities in the electrostatic dissipative range, are unable to maintain a constant resistivity under different voltages, relative humidities, long term life, and other conditions. Where this could apply materials may additionally be procured with decay characteristics a charging voltage of 1000 volts that decays to not more than 50 volts in less than two seconds, see A.2. In all cases where the material has a surface resistivity > 1×10^{10} ohm/sq or volume resistivity of > 1×10^9 ohm x cm this charge decay characteristic is mandatory.

A.1.2.2 Probe

The probe to be used shall consist of two non-corrosive metal electrodes made of, for example, gold plated brass or stainless steel, see note 1. The electrodes shall be of equal length and they shall be attached to one face of an insulating rigid plate. The long axes of the electrodes shall be parallel with the face and with one another. The distance between their long axes shall be equal to their individual length.

Each electrode shall have a width of 5 mm ± 1 mm and stand a minimum of 5 mm off the plate. In choosing the length, account shall be taken of the smallest area to be measured, see note 2. Flexible leads shall be connected to the electrodes and have their free ends suitably terminated for connection to a meter. When the probe is on a face plate, it shall not be capable of being rocked about either diagonal of the square plate.

A weight shall be attached to the top surface of the probe of sufficient size to increase the combined mass of the probe and weight to 2,5 kg ± 0,5 kg.

NOTE 1: Aluminium is not a suitable material;

NOTE 2: 65 mm length is suitable for most applications.

A.1.2.3 Measuring procedure

Mark out measuring sites within the boundary, see note 1 below. Place the probe on the surface of the first site with the probe electrode parallel to the long edge of the surface and take a resistance reading. If the reading fluctuates, then the lowest resistance value over a 15 s period shall be taken. Rotate the probe through 90° and take a second reading. Repeat the procedure for all sites. Readings in both planes should be within the specified values.

NOTE 1: The number and spacing of sites taken should be such as to give confidence in the area. For working surfaces between 2 and 4 sites per square metre, flooring within 1 m of working surfaces 1 site per square metre, and other flooring areas 1 site between every 2 and 4 square metres will normally be satisfactory. Seating and garment material should have sites chosen appropriate to the product.

NOTE 2: On certain materials a totally flat surface may not be available. When this applies a resilient conducting material should be used under each electrode to ensure that good electrical contact is made over the full area of the electrode.

A.1.3 Resistance to ground

A.1.3.1 General

NOTE: Under some conditions, this measurement may be made in two parts; from the site to the EGP, and from the EGP to the earth facility terminal, see fig. 7. Where this applies, individual measurements shall comply with the figures in table 1.

A.1.3.2 Probe

The probe to be used shall consist of an electrode of non-corrosive metal made of, for example, gold plated brass or stainless steel, with a smooth base surface 75 mm diameter, see note. The mass of the probe shall be 2,5 kg ± 0,5 kg. The electrode shall be connected by flexible leads to a terminal which shall be suitable for connecting to a meter.

NOTE: Aluminium is not a suitable material.

A.1.3.3 Measurement procedure

Measure the resistance at the sites as specified in A.1.2.3, note 1. If the value is fluctuating, then the lowest value over a 15 s period shall be taken.

A.1.3.4 Measurement procedure for wrist/cord and footwear

Measure the resistance between the operator's hand and ground using suitable equipment. The equipment should be labelled with its function and have an audio and/or visual indication of resistance value obtained. Acceptance values of resistance are given in the table below.

Type	**Wrist band/cord**	**ESD footwear**	
	Off line or continuous Note 2	Plate type Note 2, 3	Ground type Note 2, 4
Hand to	remote end of cord or ESD Earth facility	Plate	ESD Earth Facility
	> 7,5 x 10^5 ohm Note 1 < 3;5 x 10^7 ohm	> 0 ohm < 3,5 x 10^7 ohm	> 7,5 x 10^5 ohm Note 1 < 3,5 x 10^7ohm

NOTE 1: Where exposed, energized conductors in excess of 250 V a.c. (500 V d.c.) are envisaged (4.1.2), an additional resistance of 7,5 x 10^5 ohm for each additional 250 V a.c. (500 V d.c.) should be included. Maximum resistance values are unchanged.

NOTE 2: A suitable non-corrosive metal, (not aluminium), or other material with a resistance of less than 1 x 10^4 ohm, hand plate should be touched to complete the circuit and give a reading when the wrist band/cord or conductive footwear is worn.

NOTE 3: A suitable non-corrosive metal, (not aluminium), or other material with a resistance of less than 1 x 10^4 ohm, footplate of minimum size 300 mm x 300 mm should form part of the equipment. The wearer should stand with both feet on this footplate.

NOTE 4: Ground style ESD footwear testers should only be used when the floor resistance to ground is < 1 x 10^7 ohm.

NOTE 5: The visual and/or audio signal should indicate conformance to the specified value indication.

A.2 Charge decay

Where a charge decay is specified, unless otherwise stated, it shall have decay characteristics of 1000 V to 50 V in a maximum of two seconds.

NOTE: These procedures should only be used to evaluate electrostatic dissipative materials. These do not include electrostatic conductive materials or materials that are laminated, plated or metallised with conductive materials or certain conductive layers.

A.3 Measurement of antistatic properties

A.3.1 Measurement procedure for general packaging materials

A suitable apparatus is shown in figure A1. Place a 14 pin dual-in-line plastic encapsulated package (or a device similiar to that requiring protection) in the conductive clamping system which is mounted in the pivot arm attached to the apparatus base. The device should be held in an inverted orientation and the clamp should make contact only with the non-conductive portion of the package.

Clamp the test material in the grounded carriage.

Apply a constant downward force of 0,25 N ± 0,01 N onto the clamping system.

Move the carriage back and forth over a distance of 100 mm at a rate of (100 ± 5) cycles per minute for 20 cycles. Drop the device into a faraday pail and record its generated charge. Neutralize the material under test with ionized air to reduce its residual charge to < | 0,01 | nanocoulombs.

Replace the device in the clamp.

Repeat the complete test ten times.

NOTE: The charge should be expressed in nanocoulombs/cm^2 and this result can be used to calculate the maximum allowable value with reference to the threshold voltage of the device requiring protection.

A.3.2 Measurement procedure for magazines

Place a device similiar to that requiring protection into the magazine using tweezers. Insert stops at both ends of the magazine.

Rotate the magazine through 90° from 45° above the horizontal to 45° below the horizontal, allowing the device to slide from one end stop to the other.

After six rotations, remove one endstop and allow the device to drop into a faraday pail.

Record the charge generated on the device.

Neutralize the magazine with ionized air to reduce its residual charge to < | 0,01 | nanocoulombs.

Replace the device in the magazine.

Ten complete tests should be performed.

NOTE: The charge should be expressed in nanocoulombs/cm^2 and this result can be used to calculate the maximum allowable value with reference to the threshold voltage of the device requiring protection.

A.4 Additional tests

NOTE: Additional tests may be carried out by mutual agreement of the supplier and procurer. It should be emphasized that the tests in this section should be only carried out by personnel with the appropriate skills and the results interpreted by experts.

A.4.1 Electrostatic shielding

A.4.1.1 General

The following test can be used to evaluate the relative performance of electrostatic shielding products. The recommended test voltage is 1000 V however other voltages may be used at the user's discretion. In selecting the test voltage, the user should be aware of the voltage breakdown limitations of the material under test and of the components of the test system.

A.4.1.2 Method

Place a parallel plate capacitive sensor, as shown in fig. A.2, with conductive plates 22,23 mm diameter in the shielded container. The spacer between plates should be made of 12,7 mm ± 2,54 mm thick insulating material, such as polycarbonate or acrylic. With the container on a ground plane, place a metallic electrode sufficiently large on the outside of the container to cover the top plate of the capacitive sensor placed inside the container. Using a suitable oscilloscope and probes attached to the conductive plates of the capacitive sensor, make a differential voltage sensor when the outside of the test specimen above the capacitive sensor is charged by an electronic circuit which simulates human contact. The simulator should be as shown in fig. A.3.

Containers having a surface resistance to ground exceeding 10 megohms should be discharged between pulses. Residual charge can remain on or near the contact plate when the relay returns to its normally open condition. Such charge will reduce the observed pulse amplitude. The contact plate should be grounded for at least five seconds just before each simulated discharge is applied to the container. The resistance to ground via the container can be measured with an ohmeter connector between the contact plate and ground plate.

Since shielding is a function of the resistance around the container, pulse amplitude will be dependent on where in the bag or container the sensor is placed, especially in large bags or containers. Therefore, the centre of the conductive plate of the sensor should be 50,8 mm ± 12,7 mm inside a bag's open end, centred laterally.

NOTE: The oscilloscope and differential amplifiers should have a band-width of at least 50 MHz. The probes should be of high impedance (at least 10 megohms) and low capacitance (5pF or less).

The probes and amplifier should be carefully matched and balanced so that a common input pulse produced little or no signal. Two single pole - single throw (SPST) relays or one double pole - single throw (DPST) should be used. Bounceless and non-arcing relays are required.

A.5 Measurement of relative humidity

The measuring instrument shall be a direct reading hygrometer calibrated in relative humidity percent, and having an accuracy of better than 3 % over the range (25 to 80) % r.h. It shall be mounted within the EPA not more than 1 metre above the level where ESDS are handled. Where more than one EPA is contained in a single area which has the same environment, then a single hygrometer may be used to monitor the whole area.

NOTE: A suitable type of instrument is a precision hair hygrometer with 185 degree scale 100 mm diameter.

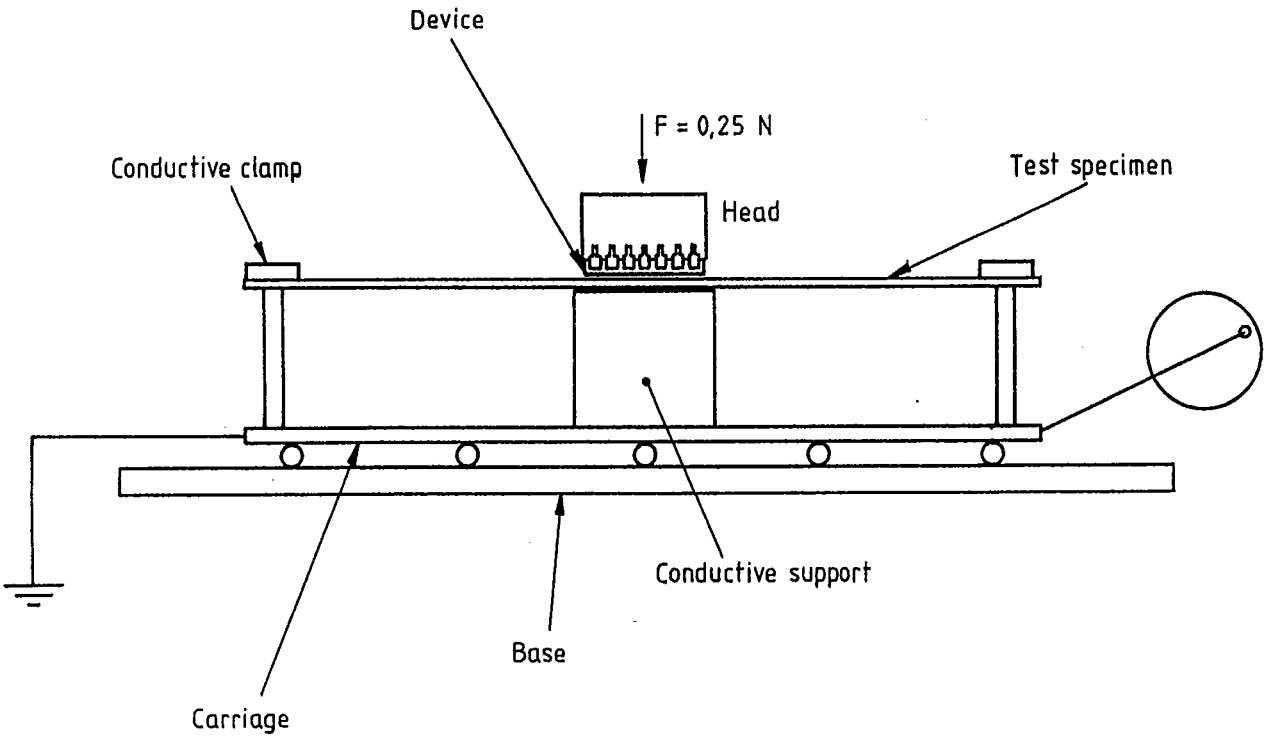


Figure A.1: Charge measuring equipment

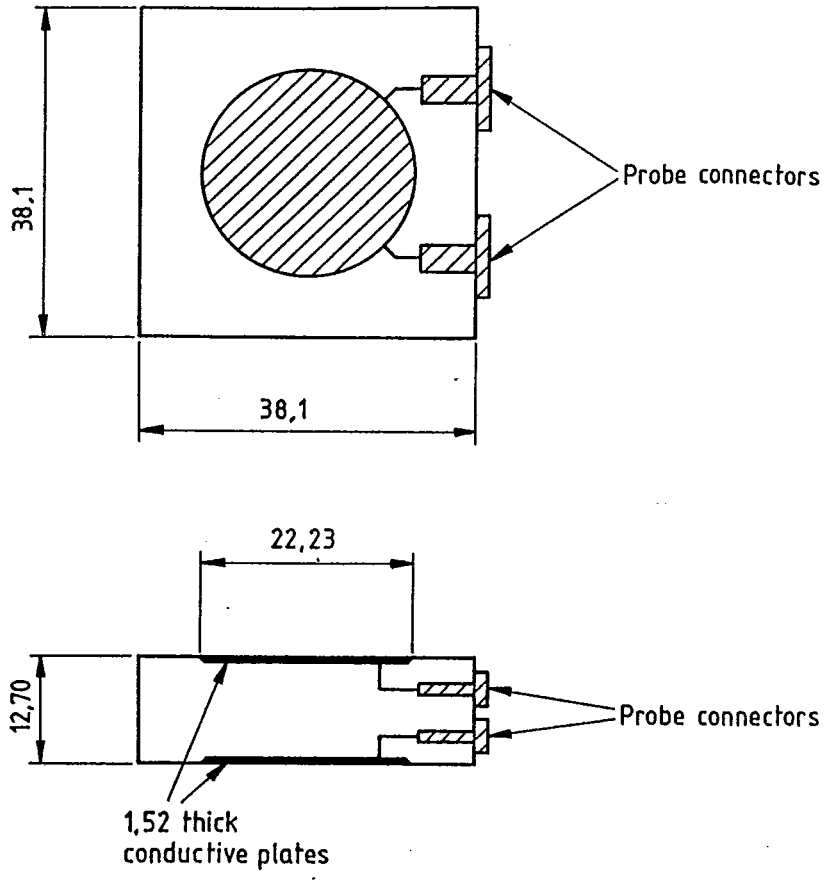


Figure A.2: Capacitive sensor

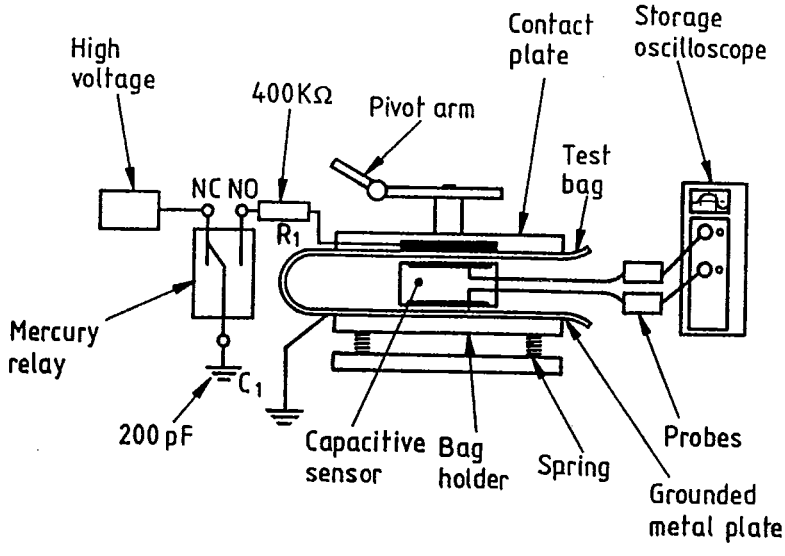


Figure A.3: Electrode shielding test apparatus

Table 1: User guide chart resistance, resistivity and charge decay in ESD protected areas

This table shall be used in conjunction with section 4.

	Surface resistivity Note 4	Volume resistivity Note 4	Resistance to ground	Charge decay
Working surfaces including storage racks and floor (required for grounding personnel)	> 1×10^4 ohm/sq < 1×10^9 ohm/sq	> 1×10^3 ohm x cm < 1×10^8 ohm x cm	> $7{,}5 \times 10^5$ ohm < 1×10^9 ohm	
Floor (not required for grounding personnel)	> 1×10^4 ohm/sq < 1×10^{12} ohm/sq	> 1×10^3 ohm x cm < 1×10^{11} ohm x cm	> $7{,}5 \times 10^5$ ohm < 1×10^{12} ohm	1000 to 50 volts in less than 2 seconds. Note 3
Trolley carts and wagons	> 1×10^4 ohm/sq < 1×10^9 ohm/sq (Platform only)	> 1×10^3 ohm x cm < 1×10^8 ohm x cm (Platform only)	> $7{,}5 \times 10^5$ ohm < 1×10^9 ohm (Frame) < 1×10^{10} ohm (Platform)	
Seating	> 1×10^4 ohm/sq < 1×10^9 ohm/sq	> 1×10^3 ohm x cm < 1×10^8 ohm x cm	> $7{,}5 \times 10^5$ ohm < 1×10^{12} ohm Note 1	1000 to 50 volts in less than 2 seconds Note 3
Garments	> $7{,}5 \times 10^5$ ohm/sq < 1×10^{12} ohm/sq			1000 to 50 volts in less than 2 seconds Note 3
Gloves and fingers cots	< 1×10^6 ohm/sq	< 1×10^5 ohm x cm		
Wrist bands	< 1×10^7 ohm/sq			
Cords			(end to end) > 9×10^5 ohm < 5×10^6 ohm	
Hand to remote end of cord			> 9×10^5 ohm < $3{,}5 \times 10^7$ ohm	
Footwear (required to ground personnel)			< $3{,}5 \times 10^7$ ohm	

NOTE 1: < 10^9 ohm from seat back and arm pad to at least one foot.

NOTE 2: Surface and volume resistivity measurements shall be taken at (25 ± 5) % r.h.

NOTE 3: Only mandatory where surface resistivity is > 10^{10} ohm/sq, volume resistivity > 10^9 ohm x cm or surface to ground resistance > 10^{10} ohm.

NOTE 4: Depending on the type of material, surface resistivity or volume resistivity figures shall be used.

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Table 2: User guide chart for packaging materials

The packaging of ESDS

This table shall be used in conjunction with Sections 1 and 5.

	Surface resistivity ohm/sq (volume resistivity ohm cm in brackets)				
	Intimate packaging material (see note 1)		Proximity packaging materials (Note 1)		Secondary packaging material
Voltage sensitivity (see Note 3)	Unpowered ESDS	Powered ESDS	Within EPA	Uncontrolled conditions	Secondary packaging material including loose fill shall have no special requirements provided that:
0-3,999	10^3 to 10^{12} (10^2 to 10^{11}) Antistatic Note 2	10^8 to 10^{12} (10^7 to 10^{11}) Antistatic Note 2	Electrostatic shielding or 10^3 to 10^6 (10^2 to 10^5)	Electrostatic shielding	a) ESDS remain in their promixity packaging when placed in or taken out of the secondary packaging.
4000-14,999			10^3 to 10^{12} (10^2 to 10^{11}) Note 2	10^3 to 10^6 (10^2 to 10^5)	and
15,000+			Antistatic	Antistatic	b) The secondary packaging is not brought into an EPA.
					If either of the above conditions are not satisfied, then antistatic secondary packaging materials shall be used.

NOTE 1: A single shielding bag with antistatic and static dissipative inner surface may be used as both intimate and close proximity packaging, provided that the outer surfaces are not capable of holding a static charge and a box is provided for physical protection which will not generate an electrostatic charge.

NOTE 2: Where surface resistivity is > 10^{10} or volume resistivity of > 10^9 is used then the material shall be procured with a static decay characteristic of 1000 V to 50 V in under 2 secs. See A.2

NOTE 3: Unless specified by the ESDS manufacturer, requirements for voltage sensitivity of 0-3999 V shall be used.

NOTE 4: These are minimum requirements and improved levels may be used if required. In particular, packaging appropriate to more sensitive ESDS may be used.

NOTE 5: Test procedure for surface resistivity are included in A.1.

NOTE 6: Antistatic and tribo-charging are defined in section 1 and A.3.

NOTE 7: Surface and volume resistivity measurements shall be taken at (25 ± 5) % r.h.

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Table 3: Suggested format for report (front sheet)

Report on audit of electrostatic protection facilities

Date ..... Report No ..... Previous report No .....

Location .....

Operation .....

Date of audit ..... Next audit due .....

General

Protective procedures and practices for ESDS and equipment as required by CECC 00 015: Part were audited

by ..... Authority .....

Summary of audit

Status codes		
Satisfactory	Unsatisfactory	Not applicable
S	1 Critical 2 Major 3 Minor	N/A

Electrostatic precautions audit check list	Status	Rec. number
a) Identification of EPA	.....	.....
b) Floor	.....	.....
c) Wristband/heelgrounder tester and records	.....	.....
d) Wristband, cords, earth leads and usage	.....	.....
e) Storage	.....	.....
f) Component/sub-assembly trays boxes and packaging	.....	.....
g) EPA 1) work surface	.....	.....
2) grounding	.....	.....
3) ESD ground terminal	.....	.....
4) seating	.....	.....
h) Transport	.....	.....
i) Emissions of electrostatic fields	.....	.....
j) (Where supplied) 1) Humidity	.....	.....
2) Ionization	.....	.....
k) Clothing	.....	.....
l) Production aids/fixtures	.....	.....
m) Production and test/inspection machinery and equipment		
n) Housekeeping	.....	.....
o) Training records	.....	.....
p) tools	.....	.....
q) design controls	.....	.....
r) product selection	.....	.....
s) procurement records	.....	.....

Table 4: Suggested format for report (continuation sheets)

			Report No	
			Page No	
Rec. No.	Recommendations	CECC 00 015 Part Clause	Recommendations completed	
			Date	Initials

Publication(s) referred to

See national foreword.

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