

Electrostatics —

Part 5-2: Protection of electronic devices from electrostatic phenomena — User Guide

The European Standard EN 61340-5-2:2001 has the status of a
British Standard

ICS 29.020; 31.020

National foreword

This British Standard is the official English language version of EN 61340-5-2:2001. It is identical with IEC 61340-5-2:1999.

NOTE The purpose of this document is to provide additional information on how BS EN 61340-5-1:2001 should be applied. It is therefore strongly recommended that both document be considered together.

The UK participation in its preparation was entrusted by Technical Committee GEL/101, Electrostatics, to Subcommittee GEL/101/1, Handling of electrostatic sensitive devices, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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

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Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled “International Standards Correspondence Index”, or by using the “Find” facility of the BSI Standards Electronic Catalogue.

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Summary of pages

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Electrostatics
Part 5-2: Protection of electronic devices
from electrostatic phenomena -
User guide
(IEC 61340-5-2:1999)

Electrostatique
Partie 5-2: Protection des dispositifs
électroniques contre les phénomènes
électrostatiques -
Guide d'utilisation
(CEI 61340-5-2:1999)

Elektrostatik
Teil 5-2: Schutz von elektronischen
Bauelementen gegen elektrostatische
Phänomene -
Benutzerhandbuch
(IEC 61340-5-2:1999)

This European Standard was approved by CENELEC on 2000-11-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of the technical specification IEC 61340-5-2:1999, prepared by IEC TC 101, Electrostatics, was submitted to the Unique Acceptance Procedure and was approved by CENELEC as EN 61340-5-2 on 2000-11-01 without any modification.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
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with the EN have to be withdrawn (dow) 2003-11-01

This part 5-2 is to be read in conjunction with EN 61340-5-1.

Subclauses, tables or figures which are additional to those in EN 61340-5-1 are numbered starting from 101. Additional annexes are lettered DD, EE, etc.

Annexes designated "normative" are part of the body of the standard.

Annexes designated "informative" are given for information only.

In this standard, annexes A and ZA are normative and annexes B, C, DD, EE and FF are informative.

Annex ZA has been added by CENELEC.

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Electrostatique –

**Partie 5-2:
Protection des dispositifs électroniques
contre les phénomènes électrostatiques –
Guide d'utilisation**

Electrostatics –

**Part 5-2:
Protection of electronic devices
from electrostatic phenomena –
User guide**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTROSTATICS –

**Part 5-2: Protection of electronic devices
from electrostatic phenomena – User guide**

FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
- 3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications or guides and they are accepted by the National Committees in that sense.
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- 6) Attention is drawn to the possibility that some of the elements of this Technical Specification may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- The subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 61340-5-2, which is a technical specification, has been prepared by IEC technical committee 101: Electrostatics.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
101/19/CDV	101/40/RVC

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

This technical specification is to be read in conjunction with IEC 61340-5-1. The clause numbering system follows the numbering system of IEC 61340-5-1. Not all clauses or subclauses need explanation in this user guide. Where this is the case, they have been omitted.

Subclauses, figures or tables which are additional to those in IEC 61340-5-1 are numbered starting from 101; supplementary annexes are entitled DD, EE, etc.

Annex A forms an integral part of this technical specification.

Annexes B, C, DD, EE and FF are for information only.

IEC 61340 consists of the following parts, under the general title *Electrostatics*:

- Part 1 *General*
- Part 2-1 *Measurement methods in electrostatics – Chargeability*
- Part 2-2 *Measurement methods in electrostatics – Resistances and resistivities*
- Part 3-1 *Methods for simulating electrostatic effects – Electrostatic discharge simulation – Human Body Model (HBM)*
- Part 3-2 *Method for simulating electrostatic effects – Electrostatic discharge simulation – Machine Model (MM)*
- Part 3-1 *Methods for simulating electrostatic effects – Electrostatic discharge simulation – Charged Device Model (CDM)*
- Part 4-1 *Standard test methods for specific applications – Electrostatic behaviour of floor coverings and installed floors*
- Part 4-2 Under consideration
- Part 4-3 *Standard test methods for specific applications – Test methods for the characterization of electrostatic protective footwear*
- Part 5-1 *Protection of electronic devices from electrostatic phenomena – General requirements*
- Part 5-2 *Protection of electronic devices from electrostatic phenomena – User guide*

INTRODUCTION

Electrostatic Discharge (ESD) has been known to man for a very long time, but apart from the relatively few who have been unlucky enough to have been struck by lightning, it has had very little impact on our lives. Developments over more recent times have changed this, and today electrostatic discharge affects more areas of our lives. In particular, those working with explosives, high technology medical care and electronics need to have an awareness of the effects, and how these may be prevented.

Risks of damage to semiconductor devices and some other electronic components arise in two main ways from static electricity:

- discharges of static electricity from conductors or charged insulators causing melting and evaporation of fine tracks on integrated circuit chips;
- electric fields from charged conductors and insulators causing electrical breakdown on insulation between features on integrated circuits.

To avoid these risks, it is necessary to ensure that no high voltages will arise on surfaces in proximity or coming into contact with sensitive devices and that there will be no discharge to such devices.

In writing IEC 61340-5-1, consideration has been given to its use by companies of all sizes. Factors including economics (cost effectiveness) and ease of use, in addition to the traditional considerations such as technical effectiveness, have been considered. All attempts have been made to ensure it is scientifically correct, but the practicalities of its use have always been the prime consideration.

Safety to personnel has been a consideration in the writing of IEC 61340-5-1, with the emphasis being that in setting up an electrostatic discharge protected area (EPA), no additional safety risk will be caused by the use of this technical specification. It is not intended that the application of IEC 61340-5-1 alone will guarantee a safe area or working environment. Therefore, in addition to following IEC 61340-5-1, all local relevant legislation and working practices need to be followed.

Many users of IEC 61340-5-1 will need or want to implement it in full. There will, however, be some cases where parts of it are not relevant to, or needed by, the processes carried out. Where this is the case then only the relevant parts of the technical specification need to be followed. However, in cases where only partial compliance is achieved or attempted, this should be made clear to all concerned.

IEC 61340-5-1 and this user guide are aimed purely at electronics. Many people, including some within the semiconductor and electronics industry, have been sceptical about the effects of ESD damage. This applies particularly where the ESD charges and potentials have been below those which are normally detected by human senses (between 2 kV and 5 kV) with many devices suffering damage down to the 1 kV level or lower. Through an ongoing education process, most of the industry is now fully aware of the consequences of ESD damage and appreciate that damage is very costly.

Where no ESD handling precautions are taken, a high proportion of electronic apparatus failure can be attributed to ESD damage. This figure could in theory be reduced to zero by adopting the precautions described in IEC 61340-5-1 in all areas. Currently, the most difficult area in which to carry out full precautions are clean room areas in wafer fabrication assemblies.

IEC 61340-5-1 is based mainly on earlier work which resulted in the publication of European standard EN 100015 [1]¹⁾ In general, the text of EN 100015 has been used; however, some changes have been made in the light of more recent knowledge. Some EPA, originally in compliance with the European standard or other standards, may not conform to the requirements of IEC 61340-5-1. In these cases, the ESD co-ordinator should make every effort to improve the EPA in the shortest possible time in order that it complies with IEC 61340-5-1.

Compliance with IEC 61340-5-1 concerns the installation of new equipment only; existing equipment not in compliance should be replaced as soon as practical. For the duration of the changeover period, extra precautions should be taken.

The decision to produce a user guide to complement IEC 61340-5-1 was taken to help the user implement IEC 61340-5-1 without having to employ an array of specialists and consultants. It does not attempt to act as a comprehensive text book on the theory of electrostatics. There are many books and magazines already on the market which cover this area more than adequately.

The production of this user guide, which contains guidance as well as the reasons behind specific requirements, has permitted to produce a slimmer and clearer requirement document.

1) Figures in square brackets refer to the bibliography given in annex FF.

ELECTROSTATICS –

Part 5-2: Protection of electronic devices from electrostatic phenomena – User guide

1 Scope

1.1 This technical specification is intended to cover the protection from ESD damage of all electronic devices with voltage sensitivity of not lower than 100 V through their entire life. This is from the commencement of manufacture, through product assembly, product use and possible repair until the end of the product life.

This technical specification is intended to cater for electronic components, assemblies and subassemblies with a sensitivity of 100 V or greater (human body model (HBM)), and as such covers most items available. There are on the market a few items which may suffer damage at lower levels. Where these are used, additional or alternative methods should be used. These are not covered by either IEC 61340-5-1 or this user guide, as it would not be reasonable or economic to equip the general EPA to cater for these. Additional information on these may be found in many of the references in the bibliography.

The HBM has been chosen as the major criteria, as damage from human contact is still the most common source even in today's automated society. There are several values given in different sources for HBM, but the chosen one is 100 pF and 1 500 Ω .

1.2 Low humidity

At low relative humidities the dissipation of static charges often becomes more difficult, and some materials may not work efficiently. Above about 20 % relative humidity most materials maintain most of their efficiency. Where relative humidity may go lower the user should pay particular attention that the materials selected will perform effectively at the minimum expected relative humidity. This is of particular importance in very cold and non-oceanic climates.

1.3 Clean rooms

For clean rooms, the specialist areas are considered to be class 100 or tighter. Many of the techniques in current use for ESD protection will not satisfy the clean room constraints, for example, carbon breaking down, ionics from spray or particles from ionizer needles. Some alternative materials are available, with improved ones still being developed, that will cope with both conditions and these should be used. This area is particularly important as clean operation is an essential part of semiconductor manufacture. Damage occurring at this stage may result in undetected "walking wounded" devices which can have very expensive results. The clean room application is currently the most difficult to control, particularly in class 10 and class 1 rooms. IEC 61340-5-1 embodies current technology. As new and improved materials and techniques become available this area will be improved, with benefits in reliability.

1.4 High voltages

The term “high voltage” in this context is used to mean any voltage in excess of 250 V a.c. or 500 V d.c. This terminology differs from the definition used in some areas, such as some European standards where the reference is to higher voltages.

Accessible high voltages are not normally available in most assembly areas. There are areas which require accessible voltages in excess of the mains supply. Examples are areas for high-voltage safety tests and areas such as CRT test and repair. Means of preventing ESD damage while maintaining personnel safety are specified. For these purposes, high voltage is considered to be all voltages in excess of the standard electrical mains, including three-phase supplies. This is currently 230 V or 117 V nominal in most world areas, and to cater for tolerance 250 V a.c. is permitted, which equates in most safety areas to 500 V d.c.

1.5 Relative humidity (r.h.)

In areas where relative humidity is controlled for both ESD control and other reasons, 50 % r.h. suits most processes. Changes both in r.h. and rate of change of r.h. should be minimized.

The characteristics of material during changes in r.h. vary widely according to the materials. In very general terms, material with a high conductivity ($<10^7 \Omega$ surface resistance) will change very little, whereas materials with a higher resistance will undergo a substantial resistance increase as r.h. decreases. This is not a linear effect, and resistance changes above 40 % r.h. are normally minimal, but from 20 % to 30 % changes can be as much as two orders of magnitude, a factor of 100, with further increases below 20 %. Some natural materials such as cotton can undergo a very large change in resistivity over a narrow band of r.h. The use of a charge decay characteristic is technically the correct measurement and where problems are likely, charge decay measurement should be also used in addition to resistance measurements.

When measurements are being carried out for high-resistance materials at high r.h. levels, care may be needed to ensure that the resistance measured is that of the material and not that of its affected surface or surrounds. Use of high r.h. environments is not considered to be a prime method of controlling ESD, and high humidity environments may cause additional unwanted effects such as corrosion.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 61340. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 61340 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60479-1:1994, *Effects of current on human beings and livestock – Part 1: General aspects*

IEC/TR2 60479-2:1987, *Effects of current passing through the human body – Part 2: Special aspects*

IEC 61010-1:1990, *Safety requirements for electrical equipment for measurement, control and laboratory use – General requirements*

IEC 61340-4-1:1995, *Electrostatics – Part 4: Standard test methods for specific applications – Section 1: Electrostatic behaviour of floor coverings and installed floors*

IEC 61340-5-1:1998, *Electrostatics – Part 5-1: Protection of electronic devices from electrostatic phenomena – General requirements*

3 Definitions

For the purpose of this technical specification, the definitions of IEC 61340-5-1 apply, with the following clarifications.

3.2

electrostatic discharge sensitive device (ESDS)

according to IEC 61340-5-1 "A discrete device, integrated circuit or assembly that may be damaged by electrostatic fields or electrostatic discharge encountered in routine handling, testing or transit."

Damage referred to includes any degradation, parameter change or malfunction of the device performance

3.18

packaging characteristics

covers the terms of low charging and electrostatic shielding in addition to the resistive and static dissipation characteristics.

It should also be noted that although the terms antistatic and astatic have gained common usage in industry and in some documents, the term low charging has been used as both anti-static and astatic have been used with other meanings and could be ambiguous.

The term low charging has often been defined as "packaging containing properties which minimize charge generation when rubbed against or separated from the same or other materials". According to clause 6, low charging packaging by itself may be used as complete packaging, so a quantitative structure is required.

3.101

Abbreviations and symbols

a.c.	alternating current
C	capacitance (farads)
°C	Celsius (temperature)
CDM	charge device model
d.c.	direct current
E	energy (joules)
EMI	electro magnetic interference
FIFO	first in, first out
HBM	human body model
I	current (ampere)
IC	integrated circuit (chip)

JIT	just in time
MM	machine model
MTBF	mean time between failure
r.h.	relative humidity
QA	quality assurance
QE	quality engineering
PCB	printed circuit board
PWB	printed wiring board
SMT	surface mount technology
SPC	statistical process control
TQM	total quality management
VDU	video display unit.
σ	surface charge density (pC/cm ²)

4 Signs and markings – General

Markings and signs are essential for the recognition and identification of ESDS and protection materials. These signs will in part be written in the local language or languages such as ESD Protected Area, but the use of internationally recognized symbols, such as the hand symbol, and figures 1, 2 and 3 in IEC 61340-5-1 is recommended as far as possible, particularly as many products are intended for international use.

4.1 Markings

Markings are defined and available for ESDS, ESD packaging material and EPA compatible materials. It is important that these are used wherever possible.

Markings on ESDS, ESD packaging material and EPA compatible materials exist to inform users that the devices, the devices within the packages, or devices in the area are electrostatic sensitive and precautions need to be taken to avoid damage. Such markings need to be seen and where size permits, such as on all PCBs, assemblies and larger ICs and component products, these should be marked or labelled. It is appreciated that on some small ESDS this is inappropriate and markings need to be on the packaging. An internationally recognized and approved sign, that of a hand with a bar through it, is normally used for this purpose. It has the advantage over writing of being language independent. If writing is used, then it should be in the language of the major user. Part of this recognition is based on colour, and a yellow hand on a black background is the preferred colour.

Where these colours are clearly impractical, for instance on non-colour printers, or direct single-colour stamping onto neither black nor yellow cases, or on PCB copper artwork or other items, then other colours may be allowed, provided these do not cause any ambiguity. Note that under no circumstances may the black and yellow colour be reversed as this combination is taken as hazard instructions to the fire service.

4.1.1 ESDS marking

ESDS should contain the symbol shown in IEC 61340-5-1, figures 1 to 3, where practical, both on components and assemblies (see C.2 of IEC 61340-5-1).

4.1.2 Packaging marking

In previous standards and reports, the hand symbol was used both for ESDS, ESD packaging materials and EPA compatible materials, but it was realised that this could cause confusion by non-technical personnel assuming that protective packaging was ESDS, so the protective arc or umbrella has been added. The style of packaging should read electrostatic discharge shielding, electrostatic conductive, electrostatic dissipative, or low charging, according to the major intended function of the packaging, and EPA compatible materials should read EPA. These symbols are shown in figures 4 and 5 of IEC 61340-5-1.

The ESDS protective symbol (figure 4 of IEC 61340-5-1) should, ideally, be present on all packaging materials, although in the few cases where this may be impractical, for example some electrostatic conductive foam, the symbol should be on the outer box for recognition purposes.

The additional information required is described in 4.1.2 of IEC 61340-5-1. The prime function will normally be included on the symbol. Additional information on the label can be in the form of a unique batch number or can be in the form of date or date code. It should provide traceability to the manufacturer's batch so that, in the event of process problems being found, a recall or other appropriate action can take place. It also allows that in the event of the properties not being permanent, a "use-by" date can be established, for example in the case of bags or tubes with surface-coated treatments. The manufacturer's logo is not there solely for advertisement purposes but to allow the manufacturer to be traced in the event of problems. If some or all of this information cannot be put on the actual packaging, due to lack of space or other limitations, then the manufacturer's mark has higher priority than the batch identification. When all of the information is not marked on the individual item, then a certificate of conformance should accompany each batch giving the missing details required. This information is required for traceability purposes. Some manufacturers or users may require additional information such as date codes to assist first in, first out (FIFO) through stores.

4.1.3 Equipment marking

It is particularly important that equipment which may be moved into and out of EPA should contain the symbol with the letters EPA, particularly if they are similar in appearance to similar non-compatible equipment. This is both to reduce the risk of damage to ESDS and to assist in auditing.

4.3 Signs for ESD protected areas (EPA)

In large EPA the user may also consider an "ATTENTION YOU ARE LEAVING THE EPA" sign as defined in figure 10. Additional packaging for ESDS protection from ESD may need to be applied.

These signs are vital, as, in large manufacturing areas, taking EPA precautions becomes a natural process, and an exit to a non-EPA environment which may have uncontrolled conditions needs a memory "jog".

5 ESD protected area (EPA) – General

Within clause 5, the individual items and materials, construction and use of the EPA are split up. The specification of most basic materials, items, tools and machinery needed is described in 5.2, as is the application of surface resistance. Application of these items in construction is

described in 5.3, and working practices, such as telling users to wear wrist straps are described in 5.5. As long sections of text are difficult to read, the numeric specifications for all parts are described in tabular form in table 1 of IEC 61340-5-1 and explained in additional paragraphs ("Table 1 – ...") of this guide.

Throughout clause 5, point-to-point resistance has been discussed, rather than the surface and volume resistivity which was found in previous standards and reports. This change has been made to cater for non-homogenous materials, which are becoming increasingly common in these applications, as well as ease of measurement. Charge decay times have been specified in addition where surface-to-ground resistance values have been called up $>10^{10} \Omega$ (10 000 M Ω). The reason for the use of resistance as the major parameter is the practicality of measurement, as inexpensive resistance measurement can be used and will successfully correlate to charge decay at these low resistance values.

5.1 Configuration

5.1.1 General

The range of configurations is such that an EPA may be of any size from a single bench up to a full industrial site of several thousand square metres. In cases where a new site or major renovation of a site is involved, it is recommended that most of the site is made into a large single EPA, as at this stage very few extra resources will be involved. It is appreciated that for existing sites, extensive rework may not be practical or economically viable. In these cases, a small EPA, or several separate EPA which may not include the floor, is also permitted. In this case it should be remembered that if in the manufacturing or other processes the product needs to go through more than one EPA, additional packaging and precautions may be needed when the product is transferred between EPA.

A nominal 1 M Ω resistor is commonly used in wrist straps and to ground work surfaces. In the event of an operator touching an energized conductor, for the normal mains electricity supplies (including three-phase) this resistor will limit the current flowing through the person to less than 0,5 mA. This is considered to be a safe value by IEC 60479 and IEC 61010-1 (see 5.3.2 of this user guide). In cases where, under normal operations, there is a possibility of touching such live conductors, additional current limiting or cut-off devices should also be considered and in some areas may be demanded by legislation. Where exposed voltages in excess of normal mains are present in the area, then the additional precautions described elsewhere in IEC 61340-5-1 and this user guide need to be implemented.

The boundaries of the EPA need defining and will vary between different types of EPA, but will typically have coloured (but not electrostatic generative) markings on the floor.

5.1.3 High-voltage EPA

In some EPA, high exposed potentials, in excess of nominal 230 V mains, may be present; for instance extra high tension (EHT) to drive display tubes and for high-voltage safety certification testing. Where these may be present, additional safeguards will need to be taken to protect both the product and the personnel. These safeguards are defined elsewhere in IEC 61340-5-1 and this guide, but warning notices that comply with national legal requirements are needed.

5.2 Requirements for specific ESD protective items

5.2.1 General

Items should be tested at the lower and higher expected or defined relative humidity value and normally at $23\text{ °C} \pm 2\text{ °C}$. Prior to testing, the item should have been at this relative humidity sufficiently for stability to have been reached. For many thin materials, 16 h is a suitable time. In many cases this will be a qualification testing rather than a test of all equipment. It will also be impractical in most *in situ* testing and auditing to reduce the area to this value, and the normal value of r.h. at the time of testing should be recorded.

A guide to material testing can be found in [2].

As has been stated in clause 1, relative humidity will have little effect on materials in the lower range of resistance. On some materials with a higher resistance, the resistance may decrease by up to two orders (a factor of 100) or more but, as this will not affect its characteristics in table 1, there is no need to repeat tests at a high relative humidity.

Any equivalent alternative method to the test methods called up in annex A may be used, although in a case of conflict the method called up in the annex will be considered as the reference method.

This subclause defines items rather than construction.

5.2.2 Working surfaces and storage racks

All working surfaces need to be capable of being grounded through resistance and to have a point-to-point resistance as defined in IEC 61340-5-1, table 1. In some cases this surface-to-ground resistance need not be a discrete resistor, but can be through the material which is directly grounded. This may well apply in practice if the working surface is a floor, as there is no essential difference between a bench and a floor used as a working surface in the material requirements. EPA grounding of instruments or surfaces by chaining, or by placing items in series should not be used, since in the event of a broken connection the risk of floating items and ESD damage will be unnecessarily increased.

5.2.3 Floors

Where the floor is used as the means of grounding personnel through suitable footwear, then the floor should also conform to the same aspects as a wrist strap as shown in table 1 of IEC 61340-5-1. In some circumstances, the charge generated while walking may be less than when sitting and higher values of the resistance to ground can be considered but should be treated with caution. Under no circumstances should these ever be in excess of $1 \times 10^9\ \Omega$. EPA which do not include the floor may be used, provided adequate packaging is used when moving ESDS between EPA, although the use of a suitable floor is strongly recommended.

Where new buildings are built, or major renovations are carried out and EPA are required, then it is usually a comparatively easy and cost-effective job to fit compliant flooring. In an existing building, it may be more cost-efficient to use floor mats. However, unless these adjoin each other, then a large single EPA cannot be made and additional protection is needed to carry the product between separate EPA.