

INTERNATIONAL STANDARD



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

Withhold

<https://standards.iteh.ai/standards/iec/ea6b16b7-9f3d-4adb-9d9d-da56eb7890ab/iec-61340-5-1-2016>





THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2016 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

IEC 61340-5-1:2016

<https://standards.iteh.ai/standards/iec/ea8b16b7-9f3d-4adb-9d9d-da56eb7890ab/iec-61340-5-1-2016>



IEC 61340-5-1

Edition 2.0 2016-05
REDLINE VERSION

INTERNATIONAL STANDARD



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

<https://standards.iteh.ai/standards/iec/ea6b16b7-9f3d-4adb-9d9d-da56eb7890ab/iec-61340-5-1-2016>

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 17.220.99; 29.020

ISBN 978-2-8322-3443-3

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	3
INTRODUCTION.....	5
1 Scope.....	7
2 Normative references.....	7
3 Terms and definitions	8
4 Personnel safety.....	10
5 ESD control program	10
5.1 General.....	10
5.1.1 ESD control program requirements.....	10
5.1.2 ESD coordinator.....	10
5.1.3 Tailoring	10
5.2 ESD control program administrative requirements.....	11
5.2.1 ESD control program plan	11
5.2.2 Training plan.....	11
5.2.3 Product qualification.....	11
5.2.4 Compliance verification plan.....	12
5.3 ESD control program plan technical requirements.....	12
5.3.1 General	12
5.3.2 Grounding/equipotential bonding systems.....	12
5.3.3 Personnel grounding.....	14
5.3.4 ESD protected areas (EPA).....	16
5.3.5 Packaging.....	19
5.3.6 Marking.....	19
Annex A (normative) Test methods.....	20
Bibliography	22
Figure 1 – Schematic of an EPA with a ground reference.....	13
Figure 2 – Schematic of an equipotential bonding system	14
Figure A.1 – Wrist strap testing.....	21
Figure A.1 – Footwear functional testing (example).....	21
Table 1 – Grounding/bonding requirements	14
Table 2 – Personnel grounding requirements.....	15
Table 3 – EPA requirements	18
Table 4 – Packaging.....	18

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTROSTATICS –

Part 5-1: Protection of electronic devices from electrostatic phenomena – General requirements

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of 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, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). 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. 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 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 IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 61340-5-1 has been prepared by IEC technical committee 101: Electrostatics.

This second edition cancels and replaces the first edition published in 2007. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) Technical requirements were changed to align IEC 61340-5-1 with other industry ESD standards;
- b) Reference documents were updated to reflect newly released IEC standards;
- c) A section on product qualification was added;
- d) Table 4 was deleted and detailed packaging requirements were deferred to IEC 61340-5-3;
- e) Clause A.1 was removed and is now included in IEC 61340-4-6.

The text of this standard is based on the following documents:

FDIS	Report on voting
101/505/FDIS	101/508/RVD

Full information on the voting for the approval of this standard 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 2.

A list of all parts in the IEC 61340 series, published under the general title *Electrostatics*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

The contents of the corrigendum of May 2017 have been included in this copy.

IMPORTANT – The “colour inside” logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

INTRODUCTION

This part of IEC 61340 covers the requirements necessary to design, establish, implement and maintain an electrostatic discharge (ESD) control program for activities that: manufacture, process, assemble, install, package, label, service, test, inspect, transport or otherwise handle electrical or electronic parts, assemblies and equipment susceptible to damage by electrostatic discharges greater than or equal to 100 V human body model (HBM), 200 V charged device model (CDM) and 35 V on isolated conductors. Isolated conductors were historically represented by machine model (MM). The 35 V limit is related to the level achievable using ionizers specified in this standard. The MM test is no longer required for qualification of devices, only the HBM and CDM tests are. The MM test is retained in this standard for process control of isolated conductors only.

Any contact and physical separation of materials or flow of solids, liquids, or particle-laden gases can generate electrostatic charges. Common sources of ESD include charged: personnel, conductors, common polymeric materials, and processing equipment. ESD damage can occur when:

- a charged person or object comes into contact with an ESD sensitive device (ESDS);
- an ESDS comes into direct contact with a highly conductive surface while exposed to an electrostatic field;
- a charged ESDS comes into contact with another conductive surface which is at a different electrical potential. This surface may or may not be grounded.

Examples of ESDS are microcircuits, discrete semiconductors, thick and thin film resistors, hybrid devices, printed circuit boards and piezoelectric crystals. It is possible to determine device and item susceptibility by exposing the device to simulated ESD events. The ESD withstand voltage determined by sensitivity tests using simulated ESD events does not necessarily represent the ability of the device to withstand ESD from real sources at that voltage level. However, the levels of sensitivity are used to establish a baseline of susceptibility data for comparison of devices with equivalent part numbers from different manufacturers. Three different models have been used for qualification of electronic components – human body model (HBM), machine model (MM), and charged device model (CDM). In current practice devices are qualified only using HBM and CDM susceptibility tests.

This standard covers the ESD control program requirements necessary for setting up a program to handle ESDS, based on the historical experience of both military and commercial organizations. The fundamental ESD control principles that form the basis of this standard are as follows.

- Avoid a discharge from any charged, conductive object (personnel and especially automated handling equipment) into the ESDS. This can be accomplished by bonding or electrically connecting all conductors in the environment, including personnel, to a known ground or contrived ground (as on board ship or on aircraft). This attachment creates an equipotential balance between all conducting objects and personnel. Electrostatic protection can be maintained at a potential different from a “zero” voltage ground potential as long as all conductive objects in the system are at the same potential.
- Avoid a discharge from any charged ESD sensitive device. Charging can result from direct contact and separation or it can be induced by an electric field. Necessary insulators in the environment cannot lose their electrostatic charge by attachment to ground. Ionization systems provide neutralization of charges on these necessary insulators (circuit board materials and some device packages are examples of necessary insulators). ~~Assessment of~~ The ESD hazard created by electrostatic charges on the necessary insulators in the work place is ~~required~~ ~~assessed~~ to ensure that appropriate actions are implemented, according to the risk.
- Once outside of an electrostatic discharge protected area (hereinafter referred to as an EPA) it is ~~often~~ ~~generally~~ not possible to control the above items, therefore, ESD protective packaging may be required. ESD protection can be achieved by enclosing ESD sensitive products in static protective materials, although the type of material depends on

the situation and destination. Inside an EPA, static dissipative materials may provide adequate protection. Outside an EPA, static discharge shielding materials are recommended. Whilst all of these materials are not discussed in this standard, it is important to recognize the differences in their application. For more information see IEC 61340-5-3.

Each company has different processes, and so will require a different blend of ESD prevention measures for an optimum ESD control program. ~~It is vital that these~~ Measures ~~are~~ **should be** selected, based on technical necessity and carefully documented in an ESD control program plan, so that all concerned can be sure of the program requirements.

Training is an essential part of an ESD control program in order to ensure that the personnel involved understand the equipment and procedures they are to use in order to be in compliance with the ESD control program plan. Training is also essential in raising awareness and understanding of ESD issues. Without training, personnel are often a major source of ESD risk. With training, they become an effective first line of defence against ESD damage.

Regular compliance verification checks and tests are essential to ensure that equipment remains effective and that the ESD control program is correctly implemented in compliance with the ESD control program plan.

~~Any contact and physical separation of materials or flow of solids, liquids, or particle laden gases can generate electrostatic charges. Common sources of ESD include charged: personnel, conductors, common polymeric materials, and processing equipment. ESD damage can occur when:~~

- ~~— a charged person or object comes into contact with an ESDS;~~
- ~~— an ESDS comes into direct contact with a highly conductive surface while exposed to an electrostatic field;~~
- ~~— a charged ESDS comes into contact with another conductive surface which is at a different electrical potential. This surface may or may not be grounded.~~

~~Examples of ESDS are microcircuits, discrete semiconductors, thick and thin film resistors, hybrid devices, printed circuit boards and piezoelectric crystals. It is possible to determine device and item susceptibility by exposing the device to simulated ESD events. The level of sensitivity, determined by test using simulated ESD events, may not necessarily relate to the level of sensitivity in a real life situation. However, they are used to establish a baseline of susceptibility data for comparison of devices with equivalent part numbers from different manufacturers. Three different models are used for characterization of electronic components — human body model (HBM), machine model (MM), and charged device model (CDM).~~

ELECTROSTATICS –

Part 5-1: Protection of electronic devices from electrostatic phenomena – General requirements

1 Scope

This part of IEC 61340 applies to activities that: manufacture, process, assemble, install, package, label, service, test, inspect, transport or otherwise handle electrical or electronic parts, assemblies and equipment ~~susceptible to damage by electrostatic discharges greater than or equal to 100 V human body model (HBM)~~ with withstand voltages greater than or equal to 100 V HBM, 200 V CDM and 35 V for isolated conductors. ESDS with lower withstand voltages may require additional control elements or adjusted limits. Processes designed to handle items that have lower ESD withstand voltage(s) can still claim compliance to this standard.

This standard provides the requirements for an ESD control program. ~~The user should refer to IEC TR 61340-5-2 [9]¹ for~~ provides guidance on the implementation of this standard.

This standard does not apply to electrically initiated explosive devices, flammable liquids, gases and powders.

The purpose of this standard is to provide the administrative and technical requirements for establishing, implementing and maintaining an ESD control program (hereinafter referred to as the “program”).

NOTE Isolated conductors were historically represented by MM.

2 Normative references

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

~~IEC 60364 (all parts), Low-voltage electrical installations~~

~~IEC/TS 60479-1, Effects of current on human beings and livestock – Part 1: General aspects~~

~~IEC/TS 60479-2, Effects of current on human beings and livestock – Part 2: Special aspects~~

~~IEC 60749-26, Semiconductor devices – Mechanical and climatic test methods – Part 26: Electrostatic discharge (ESD) sensitivity testing – Human body model (HBM)~~

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

~~IEC 61140, Protection against electric shock – Common aspects for installation and equipment~~

¹ Numbers in square brackets refer to the bibliography.

IEC 61340-2-3, *Electrostatics – Part 2-3: Methods of test for determining the resistance and resistivity of solid planar materials used to avoid electrostatic charge accumulation*

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

IEC 61340-4-3, *Electrostatics – Part 4-3: Standard test methods for specific applications – Footwear*

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

IEC 61340-4-6, *Electrostatics – Part 4-6: Standard test methods for specific applications – Wrist straps*

IEC 61340-4-7, *Electrostatics – Part 4-7: Standard test methods for specific applications – Ionization*

IEC 61340-4-9, *Electrostatics – Part 4-9: Standard test methods for specific applications – Garments*

~~IEC/TR 61340-5-2, *Electrostatics – Part 5-2: Protection of electronic devices from electrostatic phenomena – User guide*~~

IEC 61340-5-3, *Electrostatics – Part 5-3: Protection of electronic devices from electrostatic phenomena – Properties and requirements classification for packaging intended for electrostatic discharge sensitive devices*

~~ANSI/ESD S1.1, *Standard Test Method for the protection of electrostatic charge susceptible items – Wrist Straps*~~

~~ANSI/ESD STM2.1, *Standard Test Method for the protection of electrostatic discharge susceptible items – Garments*~~

~~ANSI/ESD STM3.1, *Standard Test Method for the electrostatic discharge susceptible items – Ionization*~~

~~ANSI/ESD STM4.31, *Standard Test Method for evaluating the performance of electrostatic discharge shielding materials – Bags*~~

3 Terms and definitions

For the purposes of this document, the following terms and definitions ~~in the future IEC 61340-1-2 as well as the following~~, apply.

NOTE For the purposes of this document “earth” and “ground” have the same meaning.

3.1

charged device model

CDM

ESD stress model that approximates the discharge event that occurs when a charged component is quickly discharged to another object at a different electrostatic potential

Note 1 to entry: Charged device model is described in ANSI/ESDA/JEDEC JS-002-2014 [1].

Note 2 to entry: This note only applies to the French language.

3.2**common ground point**

grounded device or location where the conductors of two or more ESD control items are bonded

3.3**common connection point**

device or location where the conductors of two or more ESD control items are connected in order to bring the ESD protective items to the same electrical potential through equipotential bonding

3.4**equipotential bond**

electrical connection of ~~exposed~~ conductive parts (or items used to control ESD) so that they are at substantially the same voltage under normal and fault conditions

3.5**electrostatic discharge****ESD**

rapid transfer of charge between bodies that are at different electrostatic potentials

Note 1 to entry: This note only applies to the French language.

3.6**ESD control items**

materials or products designed to prevent the generation of static charge and/or dissipate static charges that have been generated so as to prevent damage to ESD sensitive devices

3.7**ESD protected area****EPA**

area in which an ESDS can be handled with accepted risk of damage as a result of electrostatic discharge or fields

Note 1 to entry: This note only applies to the French language.

3.8**ESD sensitive device****ESDS**

sensitive device, integrated circuit or assembly that may be damaged by electrostatic fields or electrostatic discharge

3.9**ESD withstand voltage**

highest voltage level that does not cause device failure

Note 1 to entry: The device passes all tested lower voltages.

3.10**functional ground**

terminal used to connect parts to ~~earth~~ ground for reasons other than safety

3.11**human body model****HBM**

ESD stress model that approximates the discharge from the fingertip of a typical human being onto a pin of a device with another pin grounded

Note 1 to entry: Human body model is described in IEC 60749-26 [2].

Note 2 to entry: This note only applies to the French language.

3.12 machine model

MM

ESD stress model that approximates the discharge to a device pin due to contact of equipment or tools such as those found in the manufacturing line

Note 1 to entry: Machine model is described in IEC 60749-27 [3].

Note 2 to entry: This note only applies to the French language.

3.13 organization

company, group or body that handles ESDS

3.14 protective earth

terminal used to connect parts to earth for safety reasons

4 Personnel safety

The procedures and equipment described in this standard may expose personnel to hazardous electrical conditions. Users of this standard are responsible for selecting equipment that complies with applicable laws, regulatory codes and both external and internal policy. Users are cautioned that this standard cannot replace or supersede any requirements for personnel safety.

Electrical hazard reduction practices ~~should~~ shall be exercised and proper grounding instructions for equipment ~~must~~ shall be followed.

5 ESD control program

5.1 General

5.1.1 ESD control program requirements

~~An ESD control program, that has been established using the technical limits required by this standard, will minimize ESD related damage to devices that have an ESD sensitivity greater than or equal to 100 V HBM as determined through testing using IEC 60749-26.~~ The ESD control program shall include all the administrative and technical requirements of this standard. **The ESD control program shall document the lowest ESD withstand voltage(s) that can be handled.** The organization shall establish, document, implement, maintain and verify the compliance of the program in accordance with the requirements of this standard.

5.1.2 ESD coordinator

A person shall be assigned by the organization with the responsibility for implementing the requirements of this standard including establishing, documenting, maintaining and verifying the compliance of the program.

5.1.3 Tailoring

This standard, or portions of it, may not apply to all applications. Tailoring is accomplished by evaluating the applicability of each requirement for the specific application. Upon completion of the evaluation, requirements may be added, modified or deleted. Tailoring decisions, including rationale and technical justification, shall be documented.

5.2 ESD control program administrative requirements

5.2.1 ESD control program plan

The organization shall prepare an ESD control program plan that addresses each of the requirements of the program. Those requirements ~~concern~~ are:

- training,
- product qualification,
- compliance verification,
- grounding/bonding systems,
- personnel grounding,
- EPA requirements,
- packaging systems,
- marking.

The plan is the principal document for implementing and verifying the program. The goal is a fully implemented and integrated program that conforms to internal quality system requirements. The plan shall apply to all applicable facets of the organization's work.

5.2.2 Training plan

The training plan shall define all personnel that are required to have ESD awareness and prevention training. At a minimum, initial and recurrent ESD awareness and prevention training shall be provided to all personnel who handle or otherwise come into contact with any ESDS items. Initial training shall be provided before personnel handle ESD sensitive devices. The type and frequency of ESD training for personnel shall be defined in the training plan. The training plan shall include a requirement for maintaining employee training records and shall document where the records are stored. Training methods and the use of specific techniques are at the organization's discretion. The training plan shall include methods used by the organization to ensure trainee comprehension and training adequacy.

5.2.3 Product qualification

The organization shall qualify all ESD control items that are selected for use as part of the ESD control program. Tables 2 and 3 list the required product qualification test methods, associated limits for each ESD control item and other requirements as stated in this standard.

Acceptable evidence of product qualification includes:

- a) Product data sheets published by the manufacturer of the ESD control item:
 - 1) The data sheet shall reference the required IEC test method for that item.
 - 2) The data sheet limits shall, at a minimum, comply with the limits for that ESD control item
- b) Test reports from an independent laboratory: the test report shall reference the applicable IEC test method and the limits shall comply with the limits for that item as specified in this standard.
- c) Test reports generated internally by the organization for its own use: the test report shall reference the applicable IEC test method and the limits shall comply with the limits for that item.
- d) For ESD control items that were installed by the organization before the adoption of this standard, on-going compliance verification records can be used as evidence of product qualification.

For ESD control items that are not listed in Tables 2 and 3, but are considered to be a part of the ESD control program, the organization using such items shall qualify these products prior

to use. The test method used for product qualification and the user defined acceptance limits for each item shall be documented in the ESD control program plan.

NOTE IEC TR 61340-5-2 contains guidance for items not listed in Tables 2 and 3 of this document.

5.2.4 Compliance verification plan

A compliance verification plan shall be established to ensure the organization's fulfilment of the requirements of the plan. Process monitoring (measurements) shall be conducted in accordance with a compliance verification plan that identifies the technical requirements to be verified, the measurement limits and the frequency at which those verifications ~~must shall~~ occur. The compliance verification plan ~~must shall~~ document the test methods used for process monitoring and measurements. If the organization uses ~~different test methods that differ from the standards referenced in~~ to replace those of this standard, the organization ~~must shall~~ be able to show that the results achieved correlate with the referenced standards. ~~Where test methods are devised for testing items not covered in this standard, these shall be adequately documented including corresponding test limits.~~ Compliance verification records shall be established and maintained to provide evidence of conformity to the technical requirements.

The test equipment selected shall be capable of making the measurements defined in the compliance verification plan.

Consideration should be taken regarding the lowest relative humidity levels experienced by the organization; some of the measurements should be made under these conditions.

5.3 ESD control program plan technical requirements

5.3.1 General

The following subclauses describe the essential technical requirements used in the development of an ESD control program.

The required limits are based on the test methods or standards listed in Table 1, Table 2 and Table 3. The compliance verification plan ~~must shall~~ document the methods used to verify the limits. These procedures may or may not be based on the test methods in each table. Test methods and corresponding limits used by the organization that differ from the test methods or references in Tables 1 to 3 shall be documented with a technical justification that supports their use.

Some of the technical elements listed in Tables 1 to 3 do not have a defined lower resistance limit. However, a minimum resistance value may be required for safety reasons.

See relevant national requirements and/or IEC 60364[4] series, IEC TS 60479-1[5], IEC TS 60479-2[6], IEC 61010-1[7] and IEC 61140[8].

5.3.2 Grounding/equipotential bonding systems

In order to eliminate ESD damage, it is necessary to eliminate differences in potential between ESDS ~~items~~ and other conductors that ESDS might come into contact with such as personnel, automated handling equipment, fixtures and mobile equipment. ~~All conductive and dissipative items shall be connected to ground or to each other (equipotential bonding) in order to eliminate differences in potential.~~ All items that come into contact with ESDS and are capable of conducting electricity shall be connected to ground or electrically bonded in order to eliminate differences in potential. This can be achieved in three different ways:

- Grounding using protective earth

The first and preferred ESD ground is protective earth if available. In this case, the ESD control elements and grounded personnel are connected to protective earth (see Figure 1).