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Edition 2.0 2016-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Électrostatique – Partie 5-1: Protection des dispositifs électroniques contre les phénomènes électrostatiques – Exigences générales

IEC 61340-5-1:2016-05(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ELECTROSTATICS –

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

FOREWORD

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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- withdrawn,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.

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). The ESD hazard created by electrostatic charges on the necessary insulators in the work place is 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 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. Measures 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.

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 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. IEC TR 61340-5-2 [9][1] 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 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*

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1 Numbers in square brackets refer to the bibliography.

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 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*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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 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 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 shall be exercised and proper grounding instructions for equipment shall be followed.

5 ESD control program

5.1 General

5.1.1 ESD control program requirements

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 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. 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 shall occur. The compliance verification plan shall document the test methods used for process monitoring and measurements. If the organization uses different test methods to replace those of this standard, the organization 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 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 and other conductors that ESDS might come into contact with such as personnel, automated handling equipment, fixtures and mobile equipment. 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).

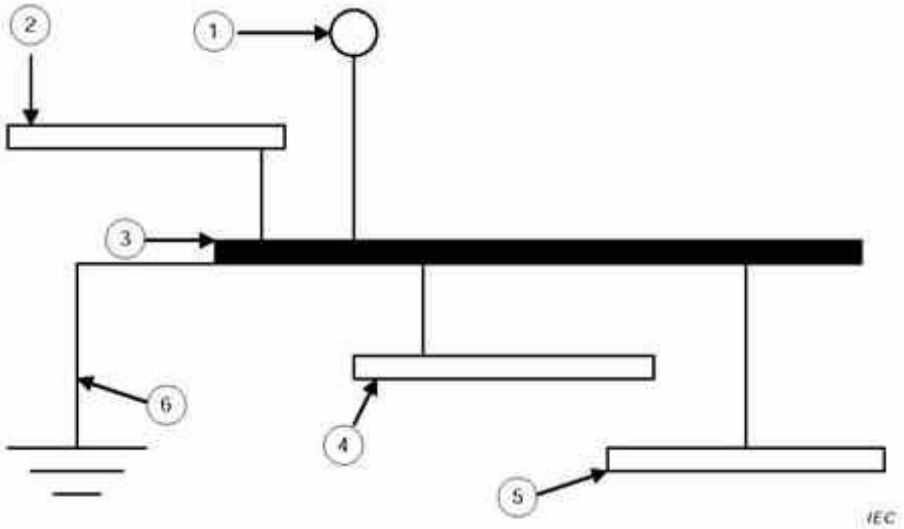
- Grounding using functional ground

  The second acceptable ESD ground is achieved through the use of a functional ground. This conductor can be a ground rod, stake or a separate wiring system that is bonded to the AC ground at the main service panel (see Figure 1); in order to eliminate differences in potential between protective earth and the functional ground system, the two systems shall be electrically bonded together where possible.

- Equipotential bonding

  In the event that a ground facility is not available, ESD protection can be achieved by connecting all of the ESD control items together at a common connection point (see Figure 2). The maximum resistance between any protective item and the common connection point shall comply with the limits established for the protective items as per Tables 2 and 3.

Whichever grounding/bonding system is selected, it shall be referred to as "ground" in the remainder of this standard.



Key

1 Wrist strap (band and ground cord)

2 Work surface

3 Common ground point

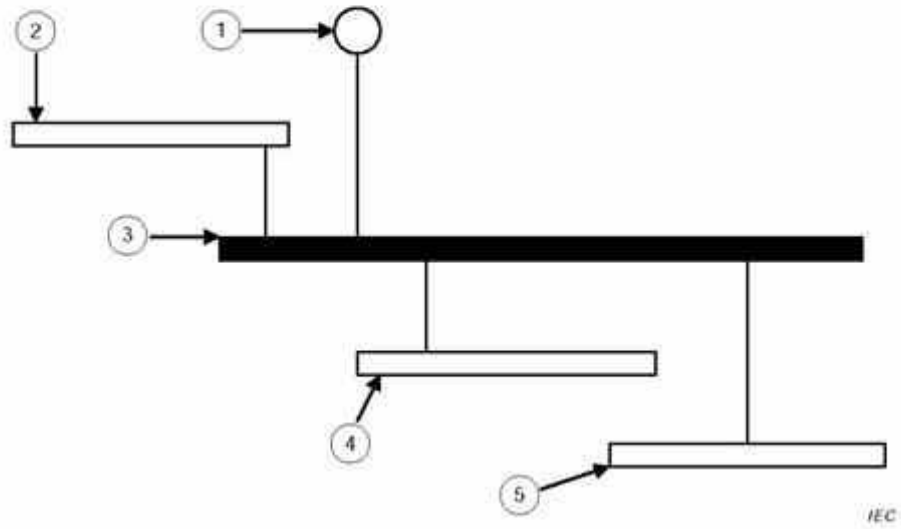
4 Floor mat

5 Floor

6 Protective earth or functional ground (functional ground, if used, shall be bonded to protective earth)

Figure 1 – Schematic of an EPA with a ground reference

CAUTION: Users are advised to consult local and national electrical codes and regulations before making any connections to facility electrical wiring systems.



Key

1 Wrist strap and cord
2 Work surface
3 Common connection point
4 Floor mat
5 Floor

Figure 2 – Schematic of an equipotential bonding system

Table 1 – Grounding/bonding requirements

Technical requirement	Grounding method	Test method/standard	Required limit(s)
Grounding/bonding system	Protective earth	National electrical system standard	National electrical code limits
	Functional ground	National electrical system standard	National electrical code limits If the national electrical code does not specify a requirement, then the resistance between functional ground and protective earth shall not exceed 25 Ω
	Equipotential bonding	See applicable implementing process from Tables 2 and 3	See limits for each ESD control item from Tables 2 and 3

5.3.3 Personnel grounding

All personnel shall be grounded or equipotentially bonded according to the requirements below when handling ESDS. When personnel are seated at ESD protective workstations, they shall be connected to ground via a wrist strap system.

For standing operations, personnel can be grounded via a wrist strap system or by a footwear-flooring system. When a footwear-flooring system is used, personnel shall wear ESD footwear on both feet and the two following conditions shall be met:

- the total resistance of the system (from the person, through the footwear and flooring to ground) shall be less than $1,0 \times 10^9$ Ω;
- the maximum body voltage generation shall be less than 100 V.

Table 2 – Personnel grounding requirements

Technical requirement	ESD control item	Product qualification		Compliance verification	
		Test method	Limits[b]	Test method	Limits[b]
Personnel grounding	Wrist straps (bands and ground cords)	IEC 61340-4-6	$R < 5 \times 10^6$ Ω or user defined value	See wrist strap system	
	Wrist band resistance	IEC 61340-4-6			
		– interior	$\leq 1 \times 10^5$ Ω	Not applicable	
		– exterior	$> 1 \times 10^7$ Ω	Not applicable	
	Wrist strap system[a]	Not applicable		IEC 61340-4-6 Wrist strap continuity test	$R < 3,5 \times 10^7$ Ω
	Footwear	IEC 61340-4-3[c]	$R \leq 1 \times 10^9$ Ω	See person/footwear system	
	Person/footwear /flooring system	IEC 61340-4-5	$R_g < 1,0 \times 10^9$ Ω and absolute value of body voltage < 100 V (average of 5 highest peaks)	IEC 61340-4-5	$R_g < 1,0 \times 10^9$ Ω[d,f]
	Person/footwear system	Not applicable		See Annex A[e]	$R_{gp} < 1,0 \times 10^9$ Ω

[a] For situations where an ESD garment is used as part of the wrist strap grounding path, the total system resistance including the person, garment and grounding cord should be less than $3,5 \times 10^7$ Ω.

[b] Symbols used in this table: R_g refers to resistance to ground, R_{gp} refers to resistance to groundable point

[c] For the product qualification of footwear, the environmental conditions for testing, using IEC 61340-4-3 should be (12 ± 3) % RH and 23 °C ± 2 °C.

[d] A periodic body voltage generation test should be done to verify the voltage is less than 100 V

[e] The resistance limit applies to measuring each foot one by one, not two in parallel.

[f] The required limit of $< 1,0 \times 10^9$ Ω is the maximum allowed value. The user should establish an upper limit from the resistance values that were measured for product qualification for the footwear and the floor to comply with the < 100 V body voltage generation and use these resistances for compliance verification.

5.3.4 ESD protected areas (EPA)

5.3.4.1 Handling ESDS and access to EPA

Handling of ESDS without ESD protective covering or packaging shall be performed in an EPA. The boundaries of the EPA shall be clearly identified as EPA boundaries (e.g. Caution signs indicating the existence of the EPA can be posted and conspicuous to personnel prior to entry to the EPA.)

NOTE An EPA can, for example, consist of a building, an entire room or a single workstation.

Access to the EPA shall be limited to personnel who have completed appropriate ESD training. Untrained individuals shall be escorted by trained personnel while in an EPA.

5.3.4.2 Insulators

All non-essential insulators and items (plastics and paper), such as coffee cups, food wrappers and personal items shall be removed from the workstation or any operation where unprotected ESDS are handled.

The ESD threat associated with process essential insulators or electrostatic field sources shall be evaluated to ensure that:

- the electrostatic field at the position where the ESDS are handled shall not exceed 5 000 V/m;

or

- if the electrostatic potential measured at the surface of the process required insulator exceeds 2 000 V, the item shall be kept a minimum of 30 cm from the ESDS; and
- if the electrostatic potential measured at the surface of the process required insulator exceeds 125 V, the item shall be kept a minimum of 2,5 cm from the ESDS.

If the measured electrostatic field or surface potential exceeds the stated limits, ionization or other charge mitigating techniques shall be used.

Some of the measurements should be taken at the lowest expected relative humidity experienced by the facility.

NOTE 1 These measurements are made based on the frequency defined in the compliance verification plan.

NOTE 2 An ESD threat is considered a metal to metal contact while the ESDS is in the presence of the field

NOTE 3 The accurate measurement of electrostatic fields requires that the person making the measurement is familiar with the operation of the measuring equipment. Most hand held meters require that the reading be taken at a fixed distance from the object. They also normally specify that the object has a minimum dimension of fixed size in order to obtain an accurate reading.

5.3.4.3 Isolated conductors

When establishing an ESD control plan, if a conductor that comes into contact with an ESDS item cannot be grounded or equipotentially bonded together, then the process shall ensure that the difference in potential between the conductor and the contact of the ESDS item is less than 35 V.

This can be accomplished by measuring the ESDS item and the conductor by using: a non-contact electrostatic voltmeter or a high impedance contact electrostatic voltmeter.

NOTE The 35 V limit is related to the level achievable using ionizers specified in this standard.

5.3.4.4 ESD control items

An EPA shall be established wherever ESD sensitive products are handled without ESD protective covering or packaging. However, there are many different ways to establish an ESD control program. Table 3 lists some optional ESD control items which can be used to control static electricity. For those ESD control items that are selected for use in the ESD control program, the required range for that item becomes mandatory.

If the limits in Table 3 are exceeded, the ESD control program shall include a tailoring statement as required by 5.1.3.

Table 3 – EPA requirements

EPA requirements	ESD control item	Product qualification[a]		Compliance verification[b]	
		Test method	Limits[c]	Based on test method	Limits[c]
	Working surfaces, storage racks and trolley[g]	IEC 61340-2-3	$R_{gp} < 1 \times 10^9\ \Omega$ $R_{p-p} < 1 \times 10^9\ \Omega$[f]	IEC 61340-2-3	$R_g < 1 \times 10^9\ \Omega$
	Wrist strap bonding point				$R_g < 5 \times 10^8\ \Omega$
	Flooring	IEC 61340-4-1[d,e]	$R_{gp} < 1 \times 10^9\ \Omega$	IEC 61340-4-1	$R_g < 1 \times 10^9\ \Omega$
	Ionization	IEC 61340-4-7	Decay (1 000 V to 100 V and −1 000 V to −100 V) < 20 s Offset voltage < ± 35 V	IEC 61340-4-7	Decay (1 000 V to 100 V and −1 000 V to −100 V) < 20 s or user defined Offset voltage < ± 35 V
	Seating	IEC 61340-2-3 (resistance to groundable point measurements)	$R_{gp} < 1 \times 10^9\ \Omega$	IEC 61340-2-3 (resistance to ground measurements)	$R_g < 1 \times 10^9\ \Omega$
	Static control garments	IEC 61340-4-9 or user defined method	$R_{p-p} < 1 \times 10^{11}\ \Omega$ or user defined limit	IEC 61340-4-9 or user defined method	$R_{p-p} < 1 \times 10^{11}\ \Omega$ or user defined limit
	Groundable static control garments	IEC 61340-4-9	$R_{gp} < 1 \times 10^9\ \Omega$	IEC 61340-4-9	$R_{gp} < 1 \times 10^9\ \Omega$

[a] For product qualification, the environmental conditions for testing should be (12 ± 3) % RH and 23 °C ± 2 °C. When not specified in the referenced IEC standard, the minimum environmental conditioning time for product qualification should be 48 hours.

[b] The test methods in the compliance verification column refer to the basic test procedure only. It is not expected that the test method will be followed in its entirety.

[c] Symbols used in this table: R_{p-p} refers to point to point resistance. R_g refers to resistance to ground and R_{gp} refers to resistance to groundable point.

[d] The maximum test voltage allowed for measuring ESD flooring that should be used for an ESD program complying with this standard is 100 V.

[e] If flooring is used for grounding personnel that handle ESDS refer to the system requirements in Table 2.

[f] In situations where charged device model (CDM) damage is a concern, a minimum point to point resistance limit of $1 \times 10^4\ \Omega$ is recommended.

[g] Worksurfaces are defined as any surface on which an unprotected ESD sensitive item is placed.

5.3.5 Packaging

ESD protective packaging and package marking shall be in accordance with customer contracts, purchase orders, drawing or other documentation. When the contract, purchase order, drawing or other documentation does not define ESD protective packaging, the organization shall define ESD protective packaging requirements for ESDS within the plan based on IEC 61340-5-3. Packaging, when required, shall be defined for all material movement within EPAs, between EPAs, between job sites, field service operations and to the customer.

5.3.6 Marking

ESDS, system or packaging marking shall be in accordance with customer contracts, purchase orders, drawing or other documentation. When the contract, purchase order,

drawing or other documentation does not define ESDS, system or packaging marking, the organization, in developing the ESD control program plan, shall consider the need for marking. If it is determined that marking is required, it shall be documented as part of the plan.

Annex A
(normative)

Test methods

The operator shall stand with one foot on the conductive footwear electrode. The hand contact plate shall be pressed to verify that the person/footwear system resistance is within acceptable parameters (see Figure A.1). The test shall be repeated for the other foot. The test apparatus can be an integrated, commercially available tester or other instrumentation that is capable of measuring resistance from $5{,}0 \times 10^4$ Ω to at least $1{,}0 \times 10^9$ Ω. The tester open-circuit voltage is typically between 9 V d.c. and 100 V d.c.

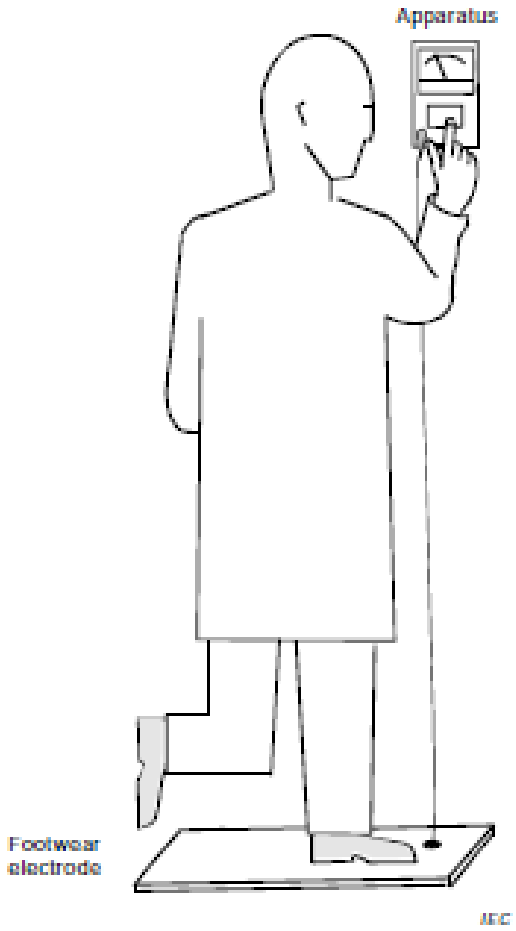


Figure A.1 – Footwear functional testing (example)

Bibliography

[1] ANSI/ESDA/JEDEC JS-002-2014, *ESDA/JEDEC Joint Standard for Electrostatic Device Sensitivity Testing – Charged Device Model (CDM) – Device Level*

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

[3] IEC 60749-27, *Semiconductor devices – Mechanical and climatic test methods – Part 27:Electrostatic discharge (ESD) sensitivity testing – Machine model (MM)*

[4] IEC 60364 (all parts), *Low-voltage electrical installations*

[5] IEC TS 60479-1, *Effects of current on human beings and livestock – Part 1: General aspects*

[6] IEC TS 60479-2, *Effects of current on human beings and livestock – Part 2: Special aspects*

[7] IEC 61010-1, *Safety requirements for electrical equipment for measurement, control and laboratory use – Part 1: General requirements*

[8] IEC 61140, *Protection against electric shock – Common aspects for installation and equipment*

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

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