IEC TR 61340-5-2

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TECHNICAL REPORT

colour inside

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

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FOREWORD

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IEC TR 61340-5-2, which is a Technical Report, 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:

This second edition of IEC TR 61340-5-2 has been modified to provide guidance for users of IEC 61340-5-1:2016. The text has been arranged to follow the requirements of

IEC 61340-5-1:2016 as closely as possible as well as providing specific guidance on each of the requirements of IEC 61340-5-1:2016.

The text of this Technical Report is based on the following documents:

Enquiry draft	Report on voting
101/532/DTR	101/543/RVDTR

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

This document 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 document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,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

A bilingual version of this publication may be issued at a later date.

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 document using a colour printer.

INTRODUCTION

This user guide has been produced for individuals and organizations that are faced with controlling electrostatic discharge (ESD). It provides guidance that can be used for developing, implementing and monitoring an electrostatic discharge control program in accordance with IEC 61340-5-1.

This user guide applies to activities that manufacture, process, assemble, install, package, label, service, test, inspect or otherwise handle electrical or electronic parts, assemblies and equipment susceptible to damage by electrostatic discharges greater than or equal to 100 V using the human body model (HBM), 200 V charged device model (CDM) or 35 V on isolated conductors. Isolated conductors were historically represented by the machine model (MM). The MM test is no longer used for qualification of devices, only HBM and CDM. The MM is retained in this document for process control of isolated conductors. These three levels were selected for IEC 61340-5-1 as the baseline susceptibility threshold, since a large majority of the ESD products on the market have a sensitivity of greater than 100 V HBM, 200 V CDM and 35 V for isolated conductors. If ESD sensitive devices (ESDS) of less than these values are being handled, additional controls can be implemented or some of the technical control item requirements can be adjusted.

The requirements established for each of the ESD control items are specified for an ESD control program designed for 100 V HBM, 200 V CDM and 35 V for isolated conductors. The 100 V HBM value is predicated on maximum voltage levels attainable on an individual when they are grounded via techniques accepted throughout the electronics industry as outlined in IEC 61340-5-1.

For organizations concerned with charged device model damage, IEC 61340-5-1 establishes requirements concerning the use of insulators in the ESD protected area (EPA) based on maximum electrostatic field limits.

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, 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.

The general principles described in IEC 61340-5-1 are not limited in their applicability to ESDS with ESD sensitivities defined in IEC 61340-5-1 (e.g. 100 V HBM). For organizations that handle ESDS with withstand voltages higher or lower than those defined in IEC 61340-5-1, the general principles of IEC 61340-5-1 can still be used. The organization can modify some of the required limits specified in Tables 2 to 3 of IEC 61340-5-1:2016. The program documentation identifies the lowest ESDS withstand voltage(s) that can be handled,

and if different to those defined in IEC 61340-5-1, appropriate changes to the limits specified in IEC 61340-5-1 can be made in the program documentation.

The fundamental ESD control principles that form the basis of IEC 61340-5-1 are as follows:

a) Avoid a discharge from any charged, conductive object (personnel, equipment) into the sensitive device:

   It is preferred that all conductors that may come into contact with ESDS including personnel, are bonded or electrically connected to a known ground or contrived ground (as on shipboard or on aircraft). This attachment creates an equipotential balance between all items and personnel. Electrostatic protection can be maintained at a potential different from “zero” voltage ground potential, as long as all items in the system are at the same potential. If a conductor that cannot be grounded (e.g. isolated conductor) comes into contact with an ESDS, the ESD risk should be evaluated and if necessary mitigated.

b) Avoid a discharge from any charged ESD sensitive device (the charging process that can lead to a discharge can result from direct contact and separation or can be field induced):

   Insulators cannot lose their electrostatic charge by grounding. It is preferred that insulators should be removed from the vicinity of ESDS. Some insulators are essential to the process or product and cannot be removed from the vicinity of the ESDS. Ionization or other mitigating techniques can provide neutralization of charges on these essential insulators (circuit board materials and some device packages are examples of essential insulators). Assessment of the ESD hazard created by electrostatic charges on the essential insulators in the work place is done to ensure that appropriate actions are implemented, according to the risk.

c) Once outside of an electrostatic discharge protected area (hereafter referred to as an EPA) it is generally not possible to control the above items, therefore, ESD protective packaging can be used. 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, low charging and static discharge shielding materials are recommended. While all of these materials are not discussed in this document, it is important to recognize the differences in their application. Requirements and associated test methods for ESD protective packaging are specified in IEC 61340-5-3.

Each organization has different processes, and so there will be a different blend of ESD prevention measures for an optimum ESD control program. It is vital that these measures are 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 5-2: Protection of electronic devices from electrostatic phenomena – User guide

1 Scope

This part of IEC 61340, which has been developed to support IEC 61340-5-1, 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. Additional control elements or adjusted limits can be applicable for ESDS with lower withstand voltages.

NOTE Isolated conductors were historically represented by MM.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61340-5-1:2016, *Electrostatics – Part 5-1: Protection of electronic devices from electrostatic phenomena – General requirements*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61340-5-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.2 Abbreviated terms

AHE automated handling equipment
CDM charged device model
CPM charged plate monitor
DUT device under test
EPA ESD protected area
ESD electrostatic discharge
ESDS ESD sensitive device
HBM human body model
MM machine model
MVTR moisture vapour transmission rate

PPE personal protective equipment

RC resistor-capacitor

4 Personnel safety

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

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

5 ESD control program

5.1 General

5.1.1 ESD control program requirements

The program includes both administrative and technical requirements as described in IEC 61340-5-1, which requires the organization to establish, document, implement, maintain and verify the compliance of the program.

5.1.2 ESD coordinator

An ESD coordinator is a person appointed by the organization to be responsible for organizing and maintaining the ESD control program. In order to have a well thought out and implemented ESD control program, IEC 61340-5-1 requires that an ESD coordinator be assigned. The ESD coordinator is responsible for all aspects of ESD in the facility. In order to be effective the ESD coordinator needs:

a) the full support of management;

b) a good understanding of electrostatics and how ESD sensitive devices can be damaged; the ESD coordinator will often need to attend educational classes or seminars related to ESD in order to maintain or update knowledge;

c) a thorough understanding of IEC 61340-5-1 and all of the organization’s processes related to the handling of ESD sensitive devices.

d) access to measuring equipment for the purposes of performing compliance verification measurements as well as testing new ESD products and materials for use in the ESD control program;

e) depending on the size of the facility, the ESD coordinator might also need to have auditors assigned to conduct the ESD audits.

Finally, management should provide the ESD coordinator with the authority and funding necessary to ensure that the ESD control program is maintained and enforced.

5.1.3 Tailoring

It is possible that portions of IEC 61340-5-1 may not apply to all areas within an organization. In these situations it is acceptable for the organization to document an exception to one or more of the required elements of IEC 61340-5-1 as long as there is a valid, substantiated and documented justification for the exception. An example of an acceptable exception to IEC 61340-5-1 can be found in the sample ESD control program plan at the end of this document (Annex A).

5.2 ESD control program administrative requirements

5.2.1 ESD control program plan

5.2.1.1 General

This clause outlines a step-by-step approach that can be used to establish an ESD control program.

5.2.1.2 Determination of ESD withstand voltage

One step in developing an ESD control program plan is to determine the part, assembly or equipment sensitivity level under which the plan is to be developed. Although the requirements outlined in IEC 61340-5-1 are effective for handling parts sensitive to 100 V HBM or 200 V CDM or higher, the organization may choose to develop an ESD control program based on ESD sensitivities that are greater or less than these limits. In this situation, the organization should develop an ESD control program plan that clearly states the ESD sensitivity that the program is based on.

The organization can use various methods to determine the ESD sensitivity of the products that are to be handled. Any of the following methods may be used:

- assumption that all ESDS products have an HBM withstand voltage of 100 V and 200 V CDM;
- actual testing of ESD sensitive devices to establish the ESD withstand voltage using IEC standards (see Bibliography);
- referencing ESD withstand voltage data in published documents such as manufacturer's published data sheets.

For more information see the Industry Council on ESD target levels white papers (www.esdindustrycouncil.org).

5.2.1.3 Initial process and organizational assessment

Before the ESD control program plan can be developed, an initial assessment of the processes and organizations impacted by an ESD control program should be conducted. Organizations and processes that might be affected include (this list represents examples of areas involved):

- purchasing (purchasing the qualified ESD control items);
- design engineering (selecting components/materials with consideration of ESD issues);
- receiving and inspection (taking care of handling ESD susceptible components as well as secondary packaging);
- quality assurance;
- manufacturing (design and operation of manufacturing lines);
- testing;
- maintenance (production/grounding);
- packaging and shipping;
- field service (implement ESD control during field service operations);
- failure analysis;
- repair services;
- spare parts storage;
- material handling and parts conveyance;
- facility management (e.g. cleaning/grounding).

An assessment of each area where ESDS parts are handled should be conducted in order to determine ESD hazards and the appropriate ESD control process procedures. The information accumulated throughout these steps forms the basis for developing the ESD control program plan.

5.2.1.4 Guidance of how to determine ESD hazards

The first step in determining ESD hazards is to identify whether ESD susceptible components, PCBs or other items (ESDS) are handled in the facility. Most semiconductors and some passive devices are ESDS. In general populated PCBs, modules and similar assemblies should be considered ESD susceptible. If their ESD withstand voltage is not known then assume the product is ESD sensitive. Even PCBs or modules that are fully contained within an enclosure may have some susceptibility to ESD that may enter via a connector or flying leads.

The second step is to identify the processes in which ESDS should be handled in an unprotected state. These processes may be manual or automated. A major contribution to ESD protection may be made by minimizing handling of ESDS in an unprotected state. Where handling is necessary, some form of ESD control is required – these are defined as ESD protected areas (EPA) in IEC 61340-5-1. All areas in which ESD controls are not applied are unprotected areas. Any ESDS in unprotected areas should be protected within ESD protective packaging of some form.

The third step is to identify the potential ESD sources in each process. The most common of these are;

- a charged person touching the ESDS;
- a charged metal or conductive object, tool or other item touching the ESDS;
- the ESDS becoming charged and touching a conductive item (e.g. metal part or equipment).

Electrostatic fields are not usually in themselves damaging (with a few exceptions). However electrostatic fields help set up the conditions in which ESD can occur because any isolated conductor (e.g. metal parts or the device itself) within the electrostatic field will attain a voltage. If two conductors touch (or become sufficiently close to each other) within an electrostatic field, and at least one is isolated, then ESD will probably occur between them.

A particularly damaging form of ESD can occur when an ESDS comes into contact with a high conductivity (low resistance, e.g. metal) item. An ESD event occurring in this circumstance can have a very short duration high discharge current. The susceptibility of the ESDS to this type of event is characterized by its charged device model (CDM) withstand voltage. This type of damage can often be avoided where the device instead makes contact with a higher resistance (> 10^4 Ω) resistance material.

5.2.1.5 How to determine appropriate ESD measures

It follows that the first step in determining the appropriate ESD control measures is to define the boundary of each EPA. These should then be marked or signed so that personnel can easily identify which areas are EPA and which are unprotected areas. Within the EPAs the ESD control measures can then be determined.

- Personnel handling ESDS are grounded so that they cannot be at a high enough voltage to damage the ESDS that they touch. This normally means that the body voltage on personnel should be reduced to less than the human body model withstand voltage of the ESDS.
- Any metal or conductive items, that make contact with ESDS, are grounded to ensure that they are not charged.

- Sources of high electrostatic fields (e.g. charged insulators or equipment that generates external electrostatic fields) are kept far enough away from ESDS not to risk inducing high voltages on the device.
- ESDS are often in an ungrounded state when they make contact with other components or process items; this can create charged device ESD risk. This risk should be managed by use of dissipative materials or reducing voltage differences.

5.2.1.6 Documentation of ESD control program plan

After gathering the above information, the organization is in a position to begin documenting the ESD control program plan. The plan should state the scope of the program which includes the tasks, activities and procedures necessary to protect the ESD sensitive items at or above the ESD sensitivity level chosen for the plan. Although the primary focus of the plan is to outline strategies for meeting the administrative and technical elements of IEC 61340-5-1, other items may be beneficial to incorporate as well. These additional items might include:

- organizational responsibilities;
- defined roles and responsibilities between the organization and subcontractors and suppliers;
- strategies for monitoring product yields and processes that might be important in determining the effectiveness of ESD control measures currently in place or in assessing whether additional measures should be taken;
- approaches for ensuring continual improvement of the ESD control program;
- a list of approved ESD control products and materials.

The administrative and technical elements of IEC 61340-5-1 that need to be addressed in the plan include:

- training plan;
- product qualification;
- compliance verification plan;
- grounding/bonding systems;
- personnel grounding;
- protected areas;
- packaging;
- marking.

5.2.2 Training plan

Training of personnel is a critical element in the implementation of an ESD control program. A sustained commitment and attitude among all personnel that ESD prevention is a valuable, continuing effort by everyone is one of the primary goals of training.

One of the first decisions that is to be made is who will be required to attend ESD training courses. IEC 61340-5-1 requires that, at a minimum, initial and recurrent ESD training be provided to all personnel that handle or otherwise come into contact with ESD sensitive items. This decision seems straight-forward but care should be taken to ensure that all people that handle ESD sensitive devices receive adequate training. One example is the finance department. Many people will immediately state that this group should be exempt from ESD training. However, in some organizations the finance department personnel are involved in the annual physical inventory where parts are counted. In these situations, the finance employees are touching ESD sensitive parts and therefore should receive ESD training in order for the organization to be in compliance with IEC 61340-5-1.

Although it is not a requirement of IEC 61340-5-1, the organization should consider providing some form of ESD training to personnel who do not handle ESD sensitive parts such as: