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Electrostatics –
Part 5-6: Protection of electronic devices from electrostatic phenomena – Process assessment techniques

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colour inside

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ELECTROSTATICS –

Part 5-6: Protection of electronic devices from electrostatic phenomena – Process assessment techniques

FOREWORD

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IEC PAS 61340-5-6 has been processed by IEC technical committee 101: Electrostatics.

It is based on ANSI/ESD SP17.1-2020. The structure and editorial rules used in this publication reflect the practice of the organization which submitted it.

The text of this PAS is based on the following document:	This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document
Draft PAS	**Report on voting**
101/654/DPAS	101/663/RVDPAS

Following publication of this PAS, the technical committee or subcommittee concerned may transform it into an International Standard.

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

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ESD Association Standard Practice for the Protection of Electrostatic Discharge Susceptible Items –

Process Assessment Techniques

Approved November 17, 2020
EOS/ESD Association, Inc.

(This foreword is not part of EOS/ESD Association, Inc. Standard Practice ANSI/ESD SP17.1-2020)

FOREWORD

This standard practice[1] describes a set of methodologies, techniques, and tools that can be used to characterize a process where ESD sensitive (ESDS) items are handled. This document's procedures are meant to be used by those possessing knowledge and experience with electrostatic measurements.

This document provides methods to determine the level of ESD risk that remains in the process after ESD protective equipment and materials are implemented.

These test methods' objective is to identify if potentially damaging ESD events are occurring or if significant electrostatic charges are generated on people, equipment, materials, components, or printed circuit board assemblies (PCBA) even though there are static control measures in place.

Sensitivities of items are characterized by industry-standard ESD testing and rated by their withstand voltages. This document is intended to provide methods to determine whether items of a given withstand voltage are at risk in the process.

The wide variety of ESD protective equipment and materials and the environment in which these items are used may require test setups different from those described in this document. Users of this standard practice may need to adapt the test procedure and setups described in Annex A to produce meaningful data for the user's application.

Organizations performing these tests will need to determine if on-going process characterization is necessary, and if so, the time interval between observations. It may also be important to make these observations when new products are introduced or when process changes occur. Examples of process changes may include tools, fixtures, equipment, new items/products, and additional manufacturing steps.

The topics below are not addressed in this document:

- Program Management: see ANSI/ESD S20.20 Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
- Compliance Verification: see ESD TR53-01 Compliance Verification of ESD Protective Equipment and Materials
- Troubleshooting: ESD TR53-01
- ESD Program Certification: see ANSI/ESD S20.20 Certification Program at www.esda.org

This document was designated ANSI/ESD SP17.1-2020 and approved on November 17, 2020.

[1] **ESD Association Standard Practice:** A procedure for performing one or more operations or functions that may or may not yield a test result. Note, if a test result is obtained it may not be reproducible.

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ESD Association Standard Practice for the Protection of Electrostatic Discharge Susceptible Items – Process Assessment Techniques

1.0 PURPOSE, SCOPE, LIMITATION, AND EXPERIENCE LEVEL REQUIRED

1.1 Purpose

The purpose of this document is to describe a set of methodologies, techniques, and tools that can be used to characterize a process where ESD sensitive (ESDS) items are handled. The process assessment covers risks by charged personnel, ungrounded conductors, charged ESDS items, and ESDS items in an electrostatic field.

1.2 Scope

This document 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. This document does not apply to electrically initiated explosive items, flammable liquids, or powders. The document does not address program management, compliance verification, troubleshooting, or program manager/coordinator certification. In this version of the document, risks due to electromagnetic sources that produce AC fields are not considered.

1.3 Limitation

No detailed description of the processes and measurement techniques is given. An example of a simple risk assessment of a discharge from a charged human body is described in Annex D.

Due to the sampling nature in this document's procedures, deficiencies may exist that are not detected at the time the measurements are made. The measurements described are valid only at the time the measurements are made and may or may not change with time.

NOTE: Environmental parameters such as temperature and relative humidity (RH) may significantly impact the measurement results.

1.4 Experience Level Required

The procedures in this document are for use by personnel possessing advanced knowledge and experience with electrostatic measurements. The interpretation of the results from the measurements described in this document requires significant experience and knowledge of the physics of ESD and the process.

2.0 REFERENCED PUBLICATIONS

Unless otherwise specified, the following documents of the latest issue, revision, or amendment form a part of this standard to the extent specified herein:

ESD ADV1.0, ESD Association Glossary of Terms[2]

ANSI/ESD S20.20, For the Development of an Electrostatic Discharge Control Program for –Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)[2]

IEC61340-5-1, Electrostatics–Part 5-1: Protection of Electronic Devices from Electrostatic Phenomena – General Requirements[3]

[2] EOS/ESD Association, Inc. 7900 Turin Road, Bldg. 3, Rome, NY 13440, Ph: 315-339-6937; www.esda.org

[3] IEC – International Electrotechnical Commission, www.iec.ch

3.0 DEFINITIONS

The terms used in the body of this document are in accordance with the definitions found in ESD ADV1.0, ESD Association's Glossary of Terms available for complimentary download at www.esda.org.

process. A unique combination of tools, materials, methods, and people engaged in producing a measurable output.

NOTE: The term "process" can refer to a complete assembly process or a minor step, such as a pick-and-place process.

process assessment. A methodological framework to evaluate the process capabilities regarding defined parameters.

process capability. Parameters for different ESD risks that allow safe handling of items with a given ESD withstand voltage.

4.0 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. USERS ARE CAUTIONED THAT THIS DOCUMENT CANNOT REPLACE OR SUPERSEDE ANY REQUIREMENTS FOR PERSONNEL SAFETY.

GROUND FAULT CIRCUIT INTERRUPTERS (GFCI) AND OTHER SAFETY PROTECTION SHOULD BE CONSIDERED WHEREVER PERSONNEL MIGHT COME INTO CONTACT WITH ELECTRICAL SOURCES.

ELECTRICAL HAZARD REDUCTION PRACTICES SHOULD BE EXERCISED, AND PROPER GROUNDING INSTRUCTIONS FOR EQUIPMENT MUST BE FOLLOWED.

THE RESISTANCE MEASUREMENTS OBTAINED THROUGH THE USE OF THIS TEST METHOD SHALL NOT BE USED TO DETERMINE THE RELATIVE SAFETY OF PERSONNEL EXPOSED TO HIGH AC OR DC VOLTAGES.

5.0 MEASUREMENT TECHNIQUES FOR ESD RISK ASSESSMENT

Specific test equipment is needed for specific measurement techniques to perform a proper risk assessment. The appropriate instruments are required to measure if a material fulfills given requirements. Additionally, the charging status of an object or even the discharge current waveform of this object must be measured. Each process step might need a different technique and tool to measure whether there is a risk to the ESDS items being processed. This chapter describes the basic measurement techniques that can be used to assess various risks in different scenarios.

Table 1 lists tools that can measure parameters to assess whether there is a risk for the items handled in a process. Measurement of the object's actual discharge under consideration is desirable but difficult to accomplish in a production environment. The discharge waveform then could be compared with the qualification waveform, and the risk could easily be assessed. However, this is often difficult to achieve, especially in a production environment. Therefore, indirect parameters must be assessed, such as charging of the object, although this parameter does not tell the user whether a catastrophic discharge is happening. If it is not possible to measure charging, measurements such as resistance to ground may need to be used (see Figure 1). A detailed description of all the test methods is given in Annex A.

NOTE: All measurements should be performed with verified test equipment to ensure that the measurements are not influenced by defective equipment.

Table 1 – Overview of Possible Measurement Equipment Used for Different Scenarios to Assess ESD Risk

Parameter (Document)	Personnel	Conductors	Insulators	Devices/PCBs
Grounding (Annex A.2)	Resistance measurement apparatus	Multimeter	–	–
Electrostatic fields (Annex A.3)	Field meter	Field meter	Field meter	Field meter
Charge (Annex A.4)	Electrometer Current probe	Faraday cup Electrometer Current probe	Faraday cup	Faraday cup Electrometer Current probe
Electrostatic voltage (Annex A.5)	Charged Plate Monitor Walking Test Kit ESVM[a] HIDVM[b] Field meter[c]	ESVM[a] HIDVM[b] Field meter[c]	ESVM[a] Field meter[c]	ESVM[a] HIDVM[b] Field meter[c]
Resistance of material contacting ESDS item (Annex A.6)	Resistance measurement apparatus	Resistance measurement apparatus, Multimeter	–	Resistance measurement apparatus
Discharge events (Annex A.7)	Antenna with oscilloscope ESD event detector	Antenna with oscilloscope ESD event detector	–	Antenna with oscilloscope ESD event detector
Discharge currents (Annex A.8)	Current probe Pellegrini target	Current probe Pellegrini target CDM test head	–	Current probe CDM test head

[a] ESVM = non-contact electrostatic voltmeter

[b] HIDVM = contact-based high-impedance digital voltmeter

[c] used as non-contact electrostatic voltmeter

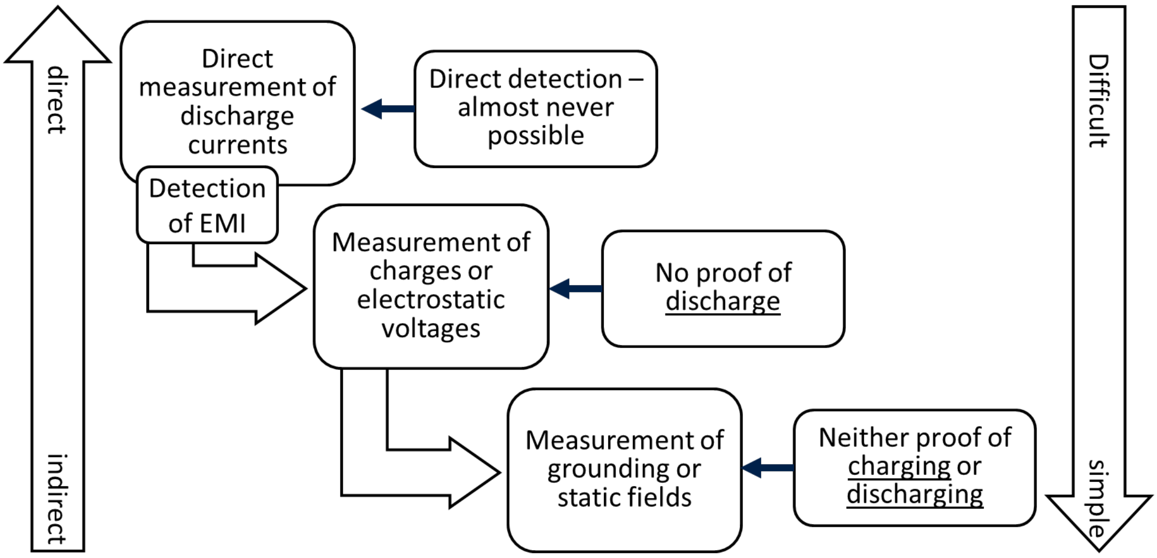

Figure 1 – Direct (Best Correlation) and Indirect (Least Correlation) Measurements to Assess an ESD Risk

6.0 ESD ROBUSTNESS OF ESDS ITEMS USED IN PROCESSES

For a successful process assessment, one or more of the electrical/physical parameters listed in Table 1 and the process assessment flows in Section 7.0 must be measured and compared against set limits. However, the parameters' limits depend on the process, measurement methodologies and techniques, and ESD robustness of the ESDS items. Therefore, it is not possible to define one limit for the parameters of all ESDS items and processes. It is particularly important to distinguish between handling a single integrated circuit (IC) and electronic assemblies. For example, a single device with relatively high robustness against a charged device model (CDM) discharge may be more susceptible to damage once installed on a PCBA. The PCBA has a larger capacitance than the single device, which may result in more severe stress (higher peak current, higher charge).

Defining limits requires some knowledge about the ESD robustness of the ESDS item that is being handled in the process and knowledge about the process itself. As the ESD robustness of the ESDS item in this process is better known, and the process is analyzed in greater detail, more accurate limits can be determined. Otherwise, reasonable assumptions must be made.

The discharge event is the most critical point of a process or application, and determining the discharge current is the most direct parameter for the risk assessment. Comparing the discharge current as measured in the process with the withstand current obtained during ESD qualification tests is theoretically the best approach. However, discharge currents from qualification data are often unknown and not easily obtainable directly in process measurements. Hence, more indirect parameters must be used for ESD risk assessment. In most cases, the charging and the ESD robustness voltage of the ESDS item are used for the assessment. Each uncertainty in the ESD robustness of the ESDS item or the knowledge about the process reduces the accuracy and, consequently, results in a higher effort combined with a possible larger margin that has to be taken to exclude any risk.

Section 6.1 discusses how the withstand current of the different discharge scenarios can be either derived from qualification data or from limits defined in ANSI/ESD S20.20 or IEC 61340-5-1. A similar discussion of withstand currents of electronic assemblies is outlined in Section 6.2. These withstand currents are the basis for assessing the limits of the measurement parameters listed in Table 1 and the process assessment flows in Section 7.0.

6.1 ESD Withstand Currents of Single Devices (Components)

6.1.1 Human Body Model

Component manufacturers use the human body model (HBM) test to determine ESDS items' sensitivity to discharge from a simulated charged person. Current HBM qualification procedure is described in the standard ANSI/ESDA/JEDEC JS-001 [1]. Typically, in HBM qualification, the HBM discharge voltage V_{HBM} is reported, not the HBM discharge current I_{HBM}, which is the real damaging parameter. However, the HBM withstand current I_{HBM} can be derived from the HBM withstand voltage rather accurately by $I_{HBM} = V_{HBM}/R_{HBM}$ with R_{HBM} = 1500 ohms being the serial resistance in the HBM discharge network.

- If the HBM robustness in terms of withstand voltage VHBM of the component is known, the withstand current can be calculated by $I_{HBM} = V_{HBM}/R_{HBM}$. For example, a component with an HBM robustness of 1000 volts has an HBM withstand current of I_{HBM} = 1000 volts/1500 ohms ≈ 670 milliamperes.

  NOTE: If the HBM robustness of the component is unknown, but similar products with the same power supply concept and set of I/O cells have been qualified according to HBM, this qualification value can be used as HBM robustness.

- If the HBM robustness of the component is not known, 100 volts HBM robustness can be used as a reasonable lower limit of ESDS items that can be handled in an EPA according to ANSI/ESD S20.20. For most of the components, this value might be quite conservative, but still can be achieved rather easily in a process. The maximum HBM withstand current I_{HBM} is then 67 milliamperes.
- If the component's HBM robustness is unknown, and the application does not tolerate any ESD-related failures, the assumed HBM robustness could be lowered; however, a lower HBM robustness might require additional ESD control measures.

6.1.2 Discharge of Charged Conductors

The risk of a component being damaged by the contact to a charged conductor while at least one pin of the component is on a different potential (typically grounded) was previously thought to correlate to the "machine model" (MM) test. However, MM is no longer used for component ESD qualification due to severe deficiencies in repeatability and reproducibility. Therefore, MM qualification results are typically not available.

NOTE: A discharge of a charged conductor to a floating device is modeled by CDM because it is the closest approximation.

- If HBM qualification is available, HBM thresholds divided by ten could act as a reasonable approach to correlate with a charged conductor's discharge into a component on a different potential. According to [2], the correlation between V_{HBM} and V_{MM} is in the range of 3:1 to 30:1. According to [3], the MM withstand current is 1.75 amperes per 100 volts. As an example, if the HBM robustness of a component is 500 volts, the corresponding MM withstand voltage can be estimated to be $V_{MM} = V_{HBM}/10$ = 50 volts, and the MM withstand current to be I_{MM} = 1.75 amperes x (V_{MM}/100 volts) = 880 milliamperes.
- If the HBM robustness of the component is not known, 35 volts MM robustness against a discharge of a charged conductor can be used as a reasonable lower limit of ESDS items that can be handled in an EPA according to ANSI/ESD S20.20. For most of the components, this value might be quite conservative, but still can be achieved rather easily in a process. A withstand voltage of 35 volts corresponds to approximately 600 milliamperes MM withstand current.
- If the component's HBM robustness is unknown, and the application does not tolerate any ESD-related failures, the assumed MM robustness could be lowered; however, a lower MM robustness might require additional ESD control measures.