

ANSI/ESD S20.20-2021

ESD Association Standard

ANSI/ESD S20.20-2021
Revision of ANSI/ESD S20.20-2014



*For the Development of an Electrostatic
Discharge Control Program for*

*Protection of Electrical and Electronic
Parts, Assemblies, and Equipment
(Excluding Electrically Initiated
Explosive Devices)*

*Electrostatic Discharge Association
218 West Court Street
Rome, NY 13440*

An American National Standard
Approved December 14, 2021

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***ESD Association Standard
for the Development of an Electrostatic Discharge
Control Program for
Protection of Electrical and Electronic
Parts, Assemblies and Equipment
(Excluding Electrically Initiated Explosive
Devices)***

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(This foreword is not part of ESD Association Standard ANSI/ESD S20.20-2021)

FOREWORD

This standard covers the requirements necessary to establish, implement, and maintain an electrostatic discharge (ESD) control program for activities that manufacture, process, assemble, install, transport, 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 volts human body model (HBM) and 200 volts charged device model (CDM). The CDM voltage level used in this document is based on managing process essential insulators to mitigate field-induced voltages on devices that could lead to damage.

This standard also defines the requirements for isolated conductors. The reference to machine model (MM) is retained in this standard for the historical association to the MM robustness of devices to isolated conductors.

HBM and CDM fully characterize the ESD robustness of devices. Therefore, MM testing is no longer required to qualify devices, and test data may not be available.

This document covers the ESD control program requirements for establishing a program to handle ESD sensitive (ESDS) items based on the historical experience of both military and commercial organizations. References include EOS/ESD Association, U.S. Military, and ANSI approved standards for material properties and test methods. The fundamental ESD control principles that form the basis of this document are:

- A. All conductors in the environment, including personnel, shall be bonded or electrically connected and attached to a known ground or contrived ground (as on shipboard or aircraft). This attachment creates an equipotential balance between all items and personnel. Electrostatic protection can be maintained at a potential above a "zero" voltage ground potential if all items in the system are at the same potential.
- B. Process essential insulators in the environment cannot lose their electrostatic charge by attachment to ground. Ionization systems provide neutralization of charge on these process essential insulators (circuit board materials and some device packages are examples of necessary insulators). Assessment of the ESD hazard created by electrostatic charge on the process essential insulators in the workplace is required to ensure that appropriate actions are implemented, commensurate with the risk to ESDS items.
- C. Transportation of ESDS items necessitates enclosures in protective materials, although the type of material depends on the situation and destination. While these materials are not discussed in the document, it is important to recognize the differences in applications. For more clarification, see ANSI/ESD S541.

Any relative motion and physical separation of materials or flow of solids, liquids, or particle-laden gases can generate an electrostatic charge. Common sources of electrostatic charge include personnel, items made from common polymeric materials, and processing equipment. ESD damage can occur in several ways, including:

- i. A charged object (including a person) coming into contact with an ESDS item.
- ii. A charged ESDS item making contact with ground or another conductive object at a different potential.
- iii. An ESDS item making contact with ground or another conductive object while exposed to an electrostatic field.

Examples of ESDS items include, but are not limited to, 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 item to simulated ESD events. The level of sensitivity, determined by testing using simulated ESD events, may not necessarily relate to the level of sensitivity in a real-life situation. However, the sensitivity levels are used to establish a baseline of susceptibility data to compare devices with equivalent part numbers from different manufacturers. Two different models are used for the characterization of electronic items: HBM and CDM.

For more information on the requirements in this standard, there is a technical report, ESD TR20.20 – ESD Association Technical Report – Handbook for the Development of an Electrostatic Discharge Control Program for the Protection of Electronic Parts, Assemblies, and Equipment.

Compliance with this standard can be demonstrated through third-party certification. The certification process is like any quality management system certification such as ISO 9001. Information on the certification process can be obtained by contacting an EOS/ESD Association, Inc. approved certification body. For a list of EOS/ESD Association, Inc. approved certification bodies, see www.esda.org.

This standard¹ was originally designated ANSI/ESD S20.20-1999 and was approved on August 4, 1999. ANSI/ESD S20.20-2007 was a revision of ANSI/ESD S20.20-1999 and was approved on February 11, 2007. ANSI/ESD S20.20-2014 is a revision of ANSI/ESD S20.20-2007 and was approved on March 25, 2016. ANSI/ESD S20.20-2021 is a revision of ANSI/ESD S20.20-2014 and was approved on October 28, 2021.

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¹ **ESD Association Standard (S):** A precise statement of a set of requirements to be satisfied by a material, product, system, or process that also specifies the procedures for determining whether each of the requirements is satisfied.

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ESD Association Standard for the Development of an Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices)

1.0 PURPOSE

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

2.0 SCOPE

This document applies to organizations 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 volts human body model (HBM) and 200 volts charged device model (CDM). Also, protection from isolated conductors is handled by limiting the voltage on isolated conductors to less than 35 volts. Processes that include items susceptible to lower withstand voltages may require additional control elements or adjusted limits. Processes designed to handle items with a lower ESD withstand voltage can still claim compliance to this standard. This document does not apply to electrically initiated explosive devices, flammable liquids, or powders.

NOTE: The CDM voltage level used in this document is based on industry experience when managing process essential insulators to mitigate induced voltages on devices that could lead to damage.

3.0 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's Glossary of Terms²
- ANSI/ESD S1.1, Wrist Straps²
- ANSI/ESD STM2.1, Garments – Resistive Characterization²
- ANSI/ESD STM3.1, Ionization²
- ANSI/ESD SP3.3, Periodic Verification of Air Ionizers²
- ANSI/ESD STM4.1, Worksurfaces – Resistance Measurements²
- ANSI/ESD S6.1, Grounding⁽²⁾
- ANSI/ESD STM7.1, Flooring Systems – Resistive Characterization²
- ANSI/ESD S8.1, Symbols – ESD Awareness²
- ANSI/ESD STM9.1, Footwear – Resistive Characterization²
- ANSI/ESD SP9.2, Foot Grounders – Resistive Characterization²
- ANSI/ESD STM11.11, Surface Resistance Measurement of Static Dissipative Planar Materials²
- ANSI/ESD STM11.12, Volume Resistance Measurements of Static Dissipative Planar Materials²
- ANSI/ESD STM11.13, Two-Point Resistance Measurement²
- ANSI/ESD STM11.31, Bags²
- ANSI/ESD STM12.1, Seating – Resistance Measurements²
- ANSI/ESD S13.1, Electrical Soldering/Desoldering Hand Tools²
- ESD TR53, Compliance Verification of ESD Protective Equipment and Materials²

² EOS/ESD Association, Inc. 218 West Court Street, Rome, NY 13440, Ph: 315-339-6937; www.esda.org

ANSI/ESD STM97.1, Footwear/Flooring System – Resistance Measurement in Combination with a Person²

ANSI/ESD STM97.2, Footwear/Flooring System – Voltage Measurement in Combination with a Person²

ANSI/ESD S541, Packaging Materials²

MIL-STD-2073-1, Department of Defense Standard Practice for Military Packaging³

4.0 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. For the purposes of this standard, the following definitions apply:

conductor. A material that measures less than 1.0×10^4 ohms point to point.

ESD control items. All the items, materials, devices, tools, and equipment used within an EPA for the control of static electricity. (See also ESD technical elements).

insulator. Any material that measures greater than or equal to 1.0×10^{11} ohms by ANSI/ESD STM11.11, ANSI/ESD STM11.12, or ANSI/ESD STM11.13.

isolated conductor. A conductor that measures greater than or equal to 1.0×10^9 ohms from the contact point (where the ESDS item will be contacted) to ground.

unprotected ESDS item. Any ESDS item without ESD protective packaging or coverings.

worksurface. Any surface where any type of work or processing is performed on an unprotected ESDS item.

5.0 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 SHALL BE FOLLOWED.

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

6.0 ESD CONTROL PROGRAM

6.1 ESD Control Program Requirements

The Program shall include both administrative and technical requirements as described herein. The Program shall document the lowest level(s) of device ESD sensitivity that can be handled. The Organization shall establish, document, implement, maintain, and verify the compliance of the Program per the requirements of this document.

³ <https://quicksearch.dla.mil/>

6.2 ESD Control Program Manager or Coordinator

The Organization shall assign an ESD control program manager or coordinator to verify the compliance of the Program per the requirements of this document.

6.3 Tailoring

This document, or portions thereof, may not apply to all ESD control programs. Any deviation from, or exclusion of, a requirement of this document is considered tailoring. Tailored requirements shall be summarized in the ESD control program plan and include the justification and technical rationale for the deviation or exclusion of the requirement from the plan. See Annex C for more information.

7.0 ESD CONTROL PROGRAM ADMINISTRATIVE REQUIREMENTS

7.1 ESD Control Program Plan

The Organization shall prepare an ESD control program plan that addresses each of the requirements of the Program. Those requirements include:

- Training
- Product qualification
- Compliance verification
- Grounding/equipotential bonding systems
- Personnel grounding
- ESD protected area (EPA) requirements
- Packaging
- Marking

The ESD control program 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 ESD control program plan shall identify the areas within the Organization that are a part of the overall ESD control program.

7.2 Training Plan

A training plan shall be established to ensure all personnel who handle or otherwise come in contact with any ESDS items are provided with initial and recurrent ESD awareness and prevention training. Initial training shall be provided before personnel handle ESDS items. The type and frequency of ESD training for personnel shall be defined in the training plan. The training plan shall include maintaining personnel 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 the methods used by the Organization to verify trainee comprehension and training adequacy.

7.3 Product Qualification Plan

A product qualification plan shall be established to ensure the ESD control items selected by the Organization meet the requirements identified in Tables 2, 3, and 4 of this standard. This includes the use of the test methods and test limits identified in these tables.

Product qualification shall occur during the initial selection of the ESD control item and before initial use. It may use any of the following qualification methods:

- (1) product specification review,
- (2) independent laboratory evaluation, or
- (3) internal laboratory evaluation.

Independent of the organization's qualification method, qualification records shall include the test method used, the test results obtained from that method, and the test limits. Also, the qualification

data shall include the environmental conditioning used during the testing as defined within the test method. The product qualification plan shall also include the location of the qualification records.

Organizations with facilities where the annual minimum relative humidity (RH) is above the environmental conditioning levels identified within the product qualification test method for each ESD control item can use this minimum value to qualify each item used within that facility. However, any ESD control items that leave these facilities (for example, packaging) shall be qualified using environmental test requirements within the product qualification test methods identified in Tables 2, 3, and 4 of this standard.

Organizations that can verify the use of ESD control items before adopting this standard to certify their ESD control program can use compliance verification records to meet product qualification requirements. These records shall cover a minimum of one year and reflect a timeframe immediately before using as product qualification records. These records shall reflect test results that meet the compliance verification test limits identified in Tables 2, 3, and 4 of this standard.

The use of compliance verification records for product qualification does not apply when the organization selects a footwear/flooring system as the personnel grounding method. When a flooring/footwear system is selected, it shall be qualified using the environmental test conditioning specified in the test methods identified in Table 2 or by the lowest RH at the facility as described above. Product qualification shall be completed for each footwear and flooring type combination used by the Organization.

7.4 Compliance Verification Plan

A compliance verification plan shall be established to ensure the ESD control items used by the organization meet the requirements identified in Tables 2, 3, and 4 of this standard. This includes the use of the test methods and test limits identified in these tables. The compliance verification plan shall identify the ESD control items to be tested periodically and the frequency with which the items are tested.

The compliance verification plan shall document the test methods and equipment used for making the measurements. If the test methods or test limits used by the Organization differ from any of the test methods referenced in Tables 2, 3, or 4 of this standard, a tailoring statement shall be developed and documented as part of the ESD control program plan. This shall include the technical rationale for the deviation from the test method or test limit requirement.

Compliance verification records shall be established and maintained to provide evidence of conformity to the technical requirements. The location of the compliance verification records shall be defined.

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

NOTE: Calibration certificates do not ensure test equipment is capable of making the required compliance verification measurements.

8.0 ESD CONTROL PROGRAM PLAN TECHNICAL REQUIREMENTS

The following sections provide information regarding the technical requirements used in the development of an ESD control program. For ESD control items selected for use or come into direct contact with ESDS items, the required limits and test methods for those items become mandatory.

The required limits are based on the test methods or standards listed in each table. The compliance verification plan shall document the methods used to verify the limits.

8.1 Grounding/Equipotential Bonding Systems

Grounding/equipotential bonding systems shall be used to ensure that ESDS items, personnel, and any other conductors that come into contact with ESDS items (for example, mobile equipment) are at the same electrical potential. An implementing process shall be selected from Table 1.

There are no requirements for a compliance verification plan for testing the grounding system; only initial verification is required. If ground fault circuit interrupters (GFCI) are installed at the user's facility, this measurement is not required.

NOTE: Verification of the grounding system should be considered after electrical system maintenance or service additions.

Table 1. Grounding/Equipotential Bonding Requirements

Technical Requirement	Implementing Process	Test Method	Required Limit(s)
Grounding/Bonding System	Equipment Grounding Conductor	ANSI/ESD S6.1	< 1.0 ohm impedance ⁽⁴⁾
	Auxiliary Ground	ANSI/ESD S6.1	< 25 ohms to the Equipment Grounding Conductor
	Equipotential Bonding	ANSI/ESD S6.1	< 1.0 x 10 ⁹ ohms ⁽⁵⁾

8.2 Personnel Grounding

All personnel shall be bonded or electrically connected to the selected grounding/equipotential bonding system when handling ESDS items. The personnel grounding method(s) shall be selected from Table 2.

When personnel are seated at ESD protective workstations, they shall be connected to the selected grounding/equipotential bonding system via a wrist strap system.

For standing operations, personnel shall be grounded via a wrist strap or by a footwear/flooring system meeting the requirements of Table 2.

When garments are used to achieve personnel grounding, it shall be documented in the ESD control program plan. It shall also meet the groundable static control garment system resistance requirements defined in Table 2 and the groundable static control garment in Table 3.

⁴ If there is a GFCI, this measurement is not required and may cause the GFCI to activate.

⁵ The maximum resistance between any ESD control items and the common connection point.

Table 2. Personnel Grounding Requirement

Technical Requirement	Product Qualification		Compliance Verification	
	Test Method(s)	Required Limit(s)	Test Method(s)	Required Limit(s)
Wrist Strap System	ANSI/ESD S1.1	System Resistance < 3.5×10^7 ohms	ESD TR53 Wrist Strap Section	System Resistance < 3.5×10^7 ohms
Groundable Static Control Garment System	ANSI/ESD STM2.1	System Resistance < 3.5×10^7 ohms	ESD TR53 Garment Section	System Resistance < 3.5×10^7 ohms
Footwear/Flooring System – (Both limits shall be met) ⁶	ANSI/ESD STM97.1	System Resistance < 1.0×10^9 ohms	ESD TR53 Footwear Section	System Resistance < 1.0×10^9 ohms ⁽⁷⁾
	ANSI/ESD STM97.2	Peak Voltage < 100 volts	ESD TR53 Flooring Section	Point to Ground Resistance < 1.0×10^9 ohms ⁽⁷⁾

8.3 ESD Protected Areas (EPAs)

Handling of ESDS items, parts, assemblies, and equipment without ESD protective coverings or packaging shall be performed in an EPA. The EPA shall have clearly identified boundaries.

An EPA can consist of a single workstation, entire room, building, or other designated areas.

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

An EPA shall be established wherever ESDS items are handled. However, there are many ways to establish ESD controls within an EPA. Table 3 lists optional ESD control items which can be used to control static electricity. The required limits and test methods for ESD control items selected for use in the ESD control program become mandatory.

8.3.1 Insulators

The Organization's ESD control program shall include a plan for handling insulators to mitigate field induced CDM damage. All nonessential insulators shall be separated from any ESDS item by at least 300 mm. Areas can be designated within the EPA to store static generating items provided the areas do not cause any of the requirements below to be exceeded. When qualifying a process to be deployed in an EPA, process essential insulators shall be evaluated in accordance with how the insulators will be used.

For initial process qualification and ongoing compliance verification measurements, one of the following criteria shall be met:

- Measure the field at the location where the ESDS item is handled. The electrostatic field shall be less than 5000 volts/meter (125 volts/inch).

or

- For any process essential insulators located less than or equal to 25 mm from an unprotected ESDS item, the voltage on the surface of the insulator shall be less than 125 volts when measured with a non-contact electrostatic voltmeter. When using an electrostatic field meter,

⁶ A periodic body voltage generation test should be done to verify the voltage is less than 100 volts.

⁷ The required limit of < 1.0×10^9 ohm is the "maximum" allowed value. The user should document the resistance values that were measured for product qualification for the footwear and the flooring system to comply with the < 100 volts body voltage generation and use these resistances for compliance verification.

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