ESD Association Standard

ANSI/ESD S20.20-2021

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

ESD ASSOCIATION ®rol Program for

For the Development of an Electrostatic Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices)

Electrostatic Discharge Association
218 West Court Street
Rome, NY 13440

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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)

Approved October 28, 2021
EOS/ESD Association, Inc.

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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 standard[1] 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 Terms[2]

ANSI/ESD S1.1, Wrist Straps[2]

ANSI/ESD STM2.1, Garments – Resistive Characterization[2]

ANSI/ESD STM3.1, Ionization[2]

ANSI/ESD SP3.3, Periodic Verification of Air Ionizers[2]

ANSI/ESD STM4.1, Worksurfaces – Resistance Measurements[2]

ANSI/ESD S6.1, Grounding[(2)]

ANSI/ESD STM7.1, Flooring Systems – Resistive Characterization[2]

ANSI/ESD S8.1, Symbols – ESD Awareness[2]

ANSI/ESD STM9.1, Footwear – Resistive Characterization[2]

ANSI/ESD SP9.2, Foot Grounders – Resistive Characterization[2]

ANSI/ESD STM11.11, Surface Resistance Measurement of Static Dissipative Planar Materials[2]

ANSI/ESD STM11.12, Volume Resistance Measurements of Static Dissipative Planar Materials[2]

ANSI/ESD STM11.13, Two-Point Resistance Measurement[2]

ANSI/ESD STM11.31, Bags[2]

ANSI/ESD STM12.1, Seating – Resistance Measurements[2]

ANSI/ESD S13.1, Electrical Soldering/Desoldering Hand Tools[2]

ESD TR53, Compliance Verification of ESD Protective Equipment and Materials[2]

[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 Person[2]

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

ANSI/ESD S541, Packaging Materials[2]

MIL-STD-2073-1, Department of Defense Standard Practice for Military Packaging[3]

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	< 1.0×10^9 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. The garment shall have electrical continuity from one sleeve to the other and to the garment's groundable point. It shall also meet the wrist strap system resistance requirements defined in Table 2 and the groundable static control garment system in Table 3.

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 (Section 6.11)	< 3.5×10^7 ohms	ESD TR53 Wrist Strap Section	< 3.5×10^7 ohms
Footwear/Flooring System – (Both limits shall be met)[6]	ANSI/ESD STM97.1	< 1.0×10^9 ohms	ESD TR53 Footwear Section	< 1.0×10^9 ohms[7]
	ANSI/ESD STM97.2	< 100 volts peak	ESD TR53 Flooring Section	< 1.0×10^9 ohms[7]

[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.

[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.

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, the reading shall be less than 125 volts when measured at the meter's stipulated measuring distance.
- For any process essential insulators located more than 25 mm, but less than 300 mm from an unprotected ESDS item, the voltage on the surface of the insulator shall be less than 2000 volts when measured with a non-contact electrostatic voltmeter. When using an electrostatic field meter, the reading shall be less than 2000 volts when measured at the meter's stipulated measuring distance.

NOTE: Insulators should be measured after normal handling that could occur during the processing of ESDS items with materials in use in the EPA. The insulators should not be artificially charged. See ESD TR20.20 for more information.

NOTE: See ESD TR20.20 for more information on insulators and charge mitigation techniques.

NOTE: The accurate measurement of electrostatic fields requires that the person making the measurement is familiar with the operation of the measuring equipment. An electrostatic field meter responds to the electrostatic field emanating from a charged surface and converts the field into a voltage when the meter is positioned at the meter's stipulated distance. When measuring relatively large conductors, the electrostatic field meter reading is the actual voltage on the conductor when measured at the meter's stipulated measuring distance. However, for non-uniformly charged insulators, the voltage indicated by the field meter (when measured at the meter's stipulated measuring distance) is an average of the electrostatic field strengths of the charged insulator.

NOTE: If a non-contact electrostatic voltmeter is used, care must be taken to ensure the non-contact electrostatic voltmeter's spot resolution (the smallest measurement area that the meter can resolve) is smaller than the insulator being measured. For a non-contact electrostatic voltmeter, this is a combination of aperture size and distance to the object. It is recommended to measure the item at the smallest distance stated by the manufacturer.

8.3.2 Isolated Conductors

If a conductor that cannot be grounded or equipotentially bonded comes into contact with an ESDS item, the process shall ensure that the potential between the isolated conductor and ground is between -35 volts and +35 volts.

For an isolated conductor that does not come into contact with an ESDS item, the requirements for insulators in Section 8.3.1 shall be met.

NOTE: For accurate measurements, it is recommended to use a high impedance contact voltmeter. If a non-contact electrostatic voltmeter or electrostatic field meter is used, care must be taken to ensure the spot resolution (the smallest measurement area that the meter can resolve) is smaller than the isolated conductor being measured. For a non-contact electrostatic voltmeter, this is a combination of aperture size and distance to the object. It is recommended to measure the item at the smallest distance stated by the manufacturer.

Table 3. EPA ESD Control Items

Technical Requirement	ESD Control Item	Product Qualification		Compliance Verification	
		Test Method	Required Limit(s)[8]	Test Method	Required Limit(s)
EPA	Worksurface[9]	ANSI/ESD STM4.1	Point to Point < 1.0 x 10^9 ohms Point to Groundable Point < 1.0 x 10^9 ohms	ESD TR53 Worksurface Section	Point to Ground < 1.0 x 10^9 ohms
	Wrist Strap	ANSI/ESD S1.1	0.8 x 10^6 to 1.2 x 10^6 ohms	For compliance verification of a Wrist Strap System, see Table 2.	
	Wristband	ANSI/ESD S1.1	Interior < 1.0 x 10^5 ohms Exterior > 1.0 x 10^7 ohms		
	Personnel Ground Wrist Strap Connection (non-monitored)	ANSI/ESD S6.1	Point to Ground[10] < 2 ohms	ESD TR53 Grounding/ Equipotential Bonding Systems Section	Point to Ground[10] < 2 ohms
	Continuous Monitors	User-defined	User-defined	ESD TR53 Continuous Monitors Section	Manufacturer defined
	Footwear	ANSI/ESD STM9.1	Point to Groundable Point < 1.0 x 10^9 ohms	For compliance verification of the Footwear/Flooring System, see Table 2.	
	Foot Grounders	ANSI/ESD SP9.2	Point to Groundable Point < 1.0 x 10^9 ohms		
	Flooring	ANSI/ESD STM7.1	Point to Point < 1.0 x 10^9 ohms Point to Groundable Point < 1.0 x 10^9 ohms		
	Seating	ANSI/ESD STM12.1	Point to Groundable Point < 1.0 x 10^9 ohms	ESD TR53 Seating Section	Point to Ground < 1.0 x 10^9 ohms

Table 3 continued next page.

[8] For standards that have multiple resistance test methods, these limits apply to all methods.

[9] Due to a wide variety of applications for worksurfaces, specific requirements that could be broadly applied are difficult to determine. If there is a concern for CDM failures, then a lower limit of 1.0 x 10^6 ohms for point to point and point to groundable point should be considered.

[10] If there is a resistor in line, then the limit must be adjusted to less than 5.0 x 10^6 ohms.

Technical Requirement	ESD Control Item	Product Qualification		Compliance Verification	
		Test Method	Required Limit(s)[8]	Test Method	Required Limit(s)
EPA	Ionization	ANSI/ESD STM3.1	Discharge Time User-defined Offset Voltage (Peak) -35 volts < Voffset < 35 volts	ESD TR53[11] Ionization Section	Discharge Time User-defined Offset Voltage (Peak) -35 volts< Voffset < 35 volts
	Shelving[9] (When used to store unprotected ESDS items)	ANSI/ESD STM4.1	Point to Point < 1.0×10^9 ohms Point to Groundable Point < 1.0×10^9 ohms	ESD TR53 Worksurface Section	Point to Ground < 1.0×10^9 ohms
	Mobile Equipment[9](Working Surfaces)	ANSI/ESD STM4.1	Point to Point < 1.0×10^9 ohms Point to Groundable Point < 1.0×10^9 ohms	ESD TR53 Worksurface Section	Point to Ground < 1.0×10^9 ohms
	Electrical Soldering/ Desoldering Hand Tools	ANSI/ESD S13.1	Tip to Ground or Groundable Point < 2.0 ohms Tip Voltage < 20 millivolts Tip Leakage < 10 milliamps	ESD TR53 Electrical Soldering/ Desoldering Hand Tools Section	Tip to Ground or Groundable Point < 10 ohms
	Static Control Garment	ANSI/ESD STM2.1	Point to Point < 1.0×10^{11} ohms	ESD TR53 Static Control Garment Section	Point to Point < 1.0×10^{11} ohms
	Groundable Static Control Garment	ANSI/ESD STM2.1	Point to Point and Point to Groundable Point < 1.0×10^9 ohms	ESD TR53 Groundable Static Control Garment Section	Point to Groundable Point < 1.0×10^9 ohms
	Groundable Static Control Garment System	ANSI/ESD STM2.1	Point to Point and Point to Groundable Point < 1.0×10^9 ohms	ESD TR53 Groundable Static Control Garment System Section	Point to Groundable Point < 1.0×10^9 ohms

[11] For additional information on periodic testing of Ionizers, see ANSI/ESD SP3.3.

8.4 Packaging

A packaging plan shall be established to define packaging requirements, both inside and outside the EPA, per ANSI/ESD S541 or the contract, purchase order, drawing, or other documentation necessary to meet customer requirements. Test methods and test limits required for the various types of ESD protective packaging used by the Organization per ANSI/ESD S541 are summarized in Table 4.

Packaging considered 'single use' shall be subjected to the same product qualification and compliance verification requirements outlined in Sections 7.3 and 7.4 and shall meet the corresponding test method and test limit requirements of Table 4.

Table 4. Packaging Requirements

Technical Requirement	ESD Control Item	Product Qualification		Compliance Verification	
		Test Method	Required Limit(s)[8]	Test Method	Required Limit(s)
Packaging	Conductive Packaging	ANSI/ESD STM11.11 or ANSI/ESD STM11.12 or ANSI/ESD STM11.13	< 1.0×10^4 ohms	ESD TR53 Packaging Section	< 1.0×10^4 ohms
	Dissipative Packaging	ANSI/ESD STM11.11 or ANSI/ESD STM11.12 or ANSI/ESD STM11.13	≥1.0×10^4 to <1.0×10^{11} ohms	ESD TR53 Packaging Section	≥ 1.0×10^4 to < 1.0×10^{11} ohms
	Discharge Shielding (Bags Only)	ANSI/ESD STM11.31	< 20 nJ	ESD TR53 Packaging Section	≥1.0×10^4 to <1.0×10^{11} ohms

When ESDS items are placed on packaging materials, and the ESDS items have work being performed on them, then the packaging materials become worksurfaces. The worksurface requirements for resistance to ground shall apply.

8.4.1 United States Department of Defense (DoD) Packaging Requirements

Department of Defense (DoD) organizations or those performing work under DoD contracts shall comply with MIL-STD-2073-1 for packaging requirements unless other contractual requirements apply or are exempt from this requirement based upon application-specific requirements.

8.5 Marking

ESDS items, system, or packaging marking shall be per customer contracts, purchase orders, drawings, or other documentation. When the contract, purchase order, drawing, or other documentation does not define ESDS items, system, or packaging marking, the Organization developing the ESD control program plan should consider the need for marking. If it is determined that marking is required, it shall be documented as part of the ESD control program plan. If it is determined that marking is not required, it does not have to be documented as part of the ESD control program plan.

NOTE: See ANSI/ESD S8.1 for symbols that can be used.

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

ANNEX A (INFORMATIVE) – ADDITIONAL PROCESS CONSIDERATIONS

The following sections provide guidance and outline documents available to help the users evaluate additional control products and equipment. Users need to develop their acceptance and compliance verification criteria as the industry has not yet defined the required limits for these items.

1. Automated Handlers (ANSI/ESD SP10.1, Automated Handling Equipment [AHE]). To demonstrate ESD control in automated handling equipment, it may be necessary to measure resistance to ground of machine components and monitor or verify electrostatic charge on a product as it passes through the equipment. This can provide both continuous verification of ESD countermeasures and a method for locating sources of charge generation. This standard practice covers resistance-to-ground of machine components and sources of charge in automated handling equipment. For more information on assessing equipment and processes, see ANSI/ESD SP17.1, Process Assessment Techniques.
2. Gloves (ANSI/ESD STM15.1, Standard Test Method for In-Use Resistance Testing of Gloves and Finger Cots). This standard test method is intended to provide test procedures for measuring the intrinsic electrical resistance of gloves and finger cots and electrical resistance of gloves or finger cots and personnel together as a system. This standard test method applies to all gloves and finger cots used to control ESD. This standard test method provides data that is relevant to the user's specific environment and application.
3. Conveyor systems often move unprotected ESD-sensitive items from station to station or through various process stages such as surface mount technology (SMT) lines, wave solder machines, and reflow ovens. Currently, no standard exists that addresses the various types of conveyor systems. Some of the more common systems are flat belt systems, narrow belt systems (often seen on SMT equipment), roller systems, and brush driven systems. While the single flat belt systems can often use the same test methods as worksurfaces, the other systems require different evaluation techniques.
4. ESD Handbook (ESD TR20.20). The ESD Association Standards Committee produced the ESD Handbook for individuals and organizations faced with controlling ESD. It provides guidance that can be used for developing, implementing, and monitoring an electrostatic discharge control program per ANSI/ESD S20.20. This Handbook 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 volts human body model (HBM). Charged device model (CDM) and machine model (MM) factory issues are also addressed.

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

ANNEX B (INFORMATIVE) – ESD SENSITIVITY TESTING

Assessing the ESD sensitivity of parts, assemblies, and equipment and the required protection levels is an important element of an ESD control program. A common method for establishing ESD sensitivity limits is to use HBM and CDM to characterize electronic items. The selection of specific ESD control procedures or materials is at the discretion of the ESD control program plan preparer. It should be based on risk assessment and the established ESD sensitivities of parts, assemblies, and equipment. All devices should be considered sensitive to HBM and CDM.

Technical literature and failure analysis data exist that indicate ESD failures are due to a complex series of interrelated effects. Some of the factors that influence ESD sensitivity include the ESD current and energy envelope, the rise time of the ESD event, device design, fabrication technology, and device package style. Energy sensitive devices are typically damaged by currents across a circuit element or a protection element causing thermal damage. Voltage sensitive devices are typically damaged when the breakdown voltage across a dielectric, for example, the gate oxide, is exceeded. ESD sensitivity testing of devices, whether performed using HBM or CDM, provides ESD sensitivity levels for comparing one device to another using defined parameters. The ESD sensitivity of the device (defined in volts), as determined by using any of the defined models, may not be the actual failure voltage level in the manufacturing process or user environment. Table 5 provides a reference for various standards and test methods for ESD sensitivity testing.

1. Human Body Model Sensitivity

A source of ESD damage is the charged human body, as modeled by HBM standards. This testing model represents the discharge from the fingertip of a standing individual delivered to the conductive contact of the device, for example, a conductive lead or a ball that is on a different potential on at least one other conductive contact. It is modeled by a 100-pF capacitor discharged through a switching component and 1500-ohm series resistor into the device under test (DUT). HBM ESD sensitivity of devices may be determined by testing the device using one of the referenced test methods.

2. Charged Device Model Sensitivity

A source of damage for CDM is the rapid discharge from a charged device to a conductive object. The ESD event is device-dependent, but its location relative to ground can influence the failure level in the real world. This test model assumes the device itself has become charged, and rapid discharge occurs when the charged device's conductive leads contact a conductive surface, which is at a lower potential. The entire CDM event can take place in less than 2.0 ns. Although very short in duration, current levels can reach several tens of amperes during discharge. CDM ESD sensitivity of devices may be determined by testing the device using the referenced test method.

3. Machine Model (Historical Information Only)

The MM was originally thought to describe a rapid transfer of energy to the conductive leads of the device from an isolated charged conductor with at least one lead of the device grounded. The equipment designed did not simulate the intended discharge event. Isolated charged conductor discharges to devices that are not grounded can also be characterized by the CDM event. MM is no longer required for device qualification as it does not give any additional information to the HBM and CDM data. Nevertheless, the control of discharges from charged conductors in the manufacturing environment is still a key element in the ESD control program. For more information on MM, see JEDEC JEP172A: Discontinuing Use of the Machine Model for Device ESD Qualification.

Table 5. ESD Susceptibility Test References for Devices

ESD Model	ESD Standards and Methods for Susceptibility Testing of Devices
HBM	ANSI/ESDA/JEDEC JS-001 MIL-STD-883-3 Method 3015 MIL-STD-750 Method 1020 MIL-PRF-19500 MIL-PRF-38534 MIL-PRF-38535
CDM	ANSI/ESDA/JEDEC JS-002
MM (For Information Only)	ESD SP5.2

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

ANNEX C (INFORMATIVE) – TAILORING

Tailoring allows users of ANSI/ESD S20.20 to deviate from or exclude a requirement of the standard if the user can provide justification and technical rationale for the deviation or exclusion. Tailoring statements must be documented but are typically added to an organization's ESD control program plan and include the requirement(s) of ANSI/ESD S20.20 that are excluded or modified as well as the technical justification or rationale for the change.

The use of tailoring statements by an organization to deviate from or exclude a requirement from ANSI/ESD S20.20 in an ESD control program plan is often misunderstood by both the organization and those trying to determine compliance with the standard. This most often evolves from a misunderstanding of what is or is not a requirement within the standard. In the tailoring examples provided below, the affected requirement within ANSI/ESD S20.20 includes the word 'shall' or 'mandatory". Tailoring statements derived by the organization to address where and how the program deviates from ANSI/ESD S20.20 requirements (see Section 6.3) must include the requirement within the standard that is affected and the technical rationale for the exclusion or deviation from the requirement.

Examples of Acceptable Tailoring Statements and Rationale

Example 1

Tailoring Statement: This ESD control program plan does not include personnel grounding.

ANSI/ESD S20.20 Requirement Affected: Section 8.2, first sentence: "All personnel shall be bonded or electrically connected to the selected grounding/equipotential bonding system when handling ESDS items."

Technical Rationale for Exclusion: The organization utilizes a fully automated manufacturing process with no human interaction or handling of ESDS items.

Example 2

Tailoring Statement: The upper point to ground limit for worksurfaces used within cleanroom EPAs is less than 1.0 x 10^{10} ohms instead of 1.0 x 10^{9} ohms as required for product qualification and compliance verification.

ANSI/ESD S20.20 Requirement Affected: Table 3, product qualification and compliance verification 'point to groundable point' and 'point to ground' maximum resistance limit of 1.0 x 10^{9} ohms as tested using ANSI/ESD STM4.1 and ESD TR53, respectively. Also, in Sections 7.3 (product qualification plan) and 7.4 (compliance verification plan), the required test limits provided in Tables 2, 3, and 4 shall be met.

Technical Rationale for Deviation: The organization has a cleanliness requirement for multiple cleanrooms where ESDS items are handled. The worksurface materials meeting cleanliness requirements within these cleanrooms have resistance (point to ground) values that exceed 1.0 x 10^{9} ohms but are less than 1.0 x 10^{10} ohms. By ensuring these worksurfaces and personnel are properly grounded, the organization believes all ESDS items and personnel are at the same electrical potential. The manufacturing process in the cleanrooms where these worksurfaces are used is controlled, and yield rates for the end products produced have been acceptable since the initial installation.

Example 3

Tailoring Statement: The pulsed DC ceiling-mounted room ionization system utilized in this EPA will have Offset Voltage (Peak): -250 volts < Voffset < 250 volts.

ANSI/ESD S20.20 Requirement Affected: Table 3, Product Qualification and Compliance Verification Ionization Offset Voltage(Peak): -35 volts < Voffset < 35 volts.

Technical Rationale for Deviation: The ESD sensitivity of wafers in front-end manufacturing operations is significantly lower than after the die are separated. A ceiling-based room ionization system is used in the EPA's covered in this ESD Control Plan. The purpose of this system is primarily for contamination control. It will be utilized for reducing the charge on the many process essential insulators typically present in any wafer fabrication facility. A wide-coverage (versus point-of-use) ionization system is critical in any wafer fabrication facility to reduce electric fields on the many process essential insulators. In limited critical operations where a tighter offset is deemed required by engineering or the ESD program manager, peak ionizer offset voltage maximum specification is ± 35 Volts.

Examples of Unacceptable or Unnecessary Tailoring Statements and Rationale

Example 1

Tailoring Statement: Seating as an ESD control item is not required because all personnel must wear a grounded wrist strap when seated inside an EPA.

ANSI/ESD S20.20 Requirement Affected: Section 8.2 (personnel grounding), second paragraph: "When personnel are seated at ESD protective workstations, they shall be connected to the selected grounding / equipotential bonding system via a wrist strap system."

Why is this Tailoring Statement Unnecessary? The standard does not require ESD protective seating. ESD protective seating is one of many 'optional' ESD control items for EPAs provided in Table 3 of the standard. The actual requirement is for seated personnel to be connected to a grounded wrist strap, and this is independent of whether ESD protective seating is used.

Example 2

Tailoring Statement: Nonessential insulators are not allowed inside the organization's EPAs in designated areas.

ANSI/ESD S20.20 Requirement Affected: Section 8.3.1 (insulators), first paragraph, second sentence: "All nonessential insulators shall be separated from any ESDS item by at least 300 mm".

Why is this Tailoring Statement Unnecessary? By not allowing nonessential insulators inside EPAs, the ANSI/ESD S20.20 requirement to ensure all nonessential insulators are separated from ESDS items by 300 mm is met. As a result, no tailoring statement is required.

Example 3

Tailoring Statement: The lower point to ground limit for worksurfaces used within the EPAs is greater than 1.0×10^5 ohms instead of 0 ohms as required.

ANSI/ESD S20.20 Requirement Affected: Table 3, product qualification and compliance verification 'point to groundable point' and 'point to ground' minimum resistance limit of 0 ohms as tested using ANSI/ESD STM4.1 and ESD TR53, respectively. Also, in Sections 7.3 (product qualification plan) and 7.4 (compliance verification plan), the required test limits provided in Table 3 shall be met.

Why is this Tailoring Statement Unnecessary? The lower limit established is within the limits of ANSI/ESD S20.20. Since it is within the limits, tailoring is not required. This lower limit will be the requirement of this facility.

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

ANNEX D (INFORMATIVE) – RELATED DOCUMENTS

The following documents are listed for further reference. Some documents may be canceled. However, this listing provides a reference of documents reviewed during the preparation of this standard.

Military / U.S. Government

MIL-STD-3010, Federal Test Method Standard

MIL-PRF-81705, Barrier Materials, Flexible, Electrostatic Discharge Protective, Heat-Sealable

MIL-PRF-38534, Performance Specification: Hybrid Microcircuits, General Specification

MIL-PRF-38535, Performance Specification: Integrated Circuits (Microcircuits) Manufacturing, General Specification

MIL-STD-883-3 Method 3015, Test method standard for microcircuits

MIL-STD-750-1 Method 1020, Test methods for semiconductor devices

MIL-PRF-19500, Semiconductor Devices, General Specification

MIL-STD-1686, Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices) – **This standard has been canceled.**

MIL-HDBK-263, Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically-Initiated Explosive Devices) – **This handbook has been canceled.**

MIL-M-38510, General Specification for Military Microcircuits - **This standard is inactive**.

MIL-DTL-82646, Plastic Film, Conductive, Heat Sealable, Flexible

MIL-PRF-87893, Workstations, Electrostatic Discharge (ESD) Control

MIL-STD-129, Marking for Shipment and Storage

MIL-STD-1285, Marking of Electrical and Electronic Parts

KSC-MMA-1985-79, Standard Test Method for Evaluating Triboelectric Charge Generation and Decay

MIL-HDBK-103, List of Standard Microcircuit Drawings

Supplemental Information Sheet for Electronic QML-19500

Industry Standards

ANSI/IEEE-STD-142, IEEE Green Book (IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems)

ANSI/ESD SP5.0, ESD Association Standard Practice for Electrostatic Discharge Sensitivity Testing – Reporting ESD Withstand Levels on Datasheets

ANSI/ESDA/JEDEC JS-001, ESDA/JEDEC Joint Standard for Electrostatic Discharge Sensitivity Testing – Human Body Model (HBM) – Component Level

ANSI/ESDA/JEDEC JS-002, ESDA/JEDEC Joint Standard for Electrostatic Discharge Sensitivity Testing – Charged Device Model (CDM) – Device Level

ESD SP5.2, ESD Association Standard Practice for Electrostatic Discharge Sensitivity Testing - Machine Model (MM) – Component Level

ANSI/ESD SP10.1, ESD Association Standard Practice for the Protection of Electrostatic Discharge Susceptible Items – Automated Handling Equipment (AHE)

ANSI/ESD STM15.1, ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items – Methods for Resistance Measurement of Gloves and Finger Cots

ANSI/ESD SP17.1, ESD Standard Practice for the Protection of Electrostatic Discharge Susceptible Items – Process Assessment Techniques

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

JESD625, Requirements for Handling Electrostatic-Discharge-Sensitive (ESDS) Devices

IPC/JEDEC J-STD-033, Handling, Packing, Shipping and Use of Moisture Reflow, and Process Sensitive Devices

TR3.0-02-05, Selection and Acceptance of Air Ionizers

ESDSIL, Reliability Analysis Center (RAC) ESD Sensitive Items List

JESD471, Symbol and Label for Electrostatic Sensitive Devices

IEC 61340-5-1, Protection of Electronic Devices from Electrostatic Phenomena – General Requirements

VZAP, Electrostatic Discharge Susceptibility Data

ISO 9001, Quality Management Systems – Requirements

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

ANNEX E (INFORMATIVE) – STATEMENT OF DIRECTION

These sections may be included in future revisions of ANSI/ESD S20.20. The sections are placed here for information only and do not have to be implemented.

E.1 Component Threshold Plan

It is important to know what the human body model and charged device model classifications are for any ESDS item that will come into the process. A plan should be established to determine, before initial use, that ESDS item thresholds are within the scope of this standard.

The recommended test methods for establishing the HBM and CDM levels are ANSI/ESDA/JEDEC JS-001 and ANSI/ESDA/JEDEC JS-002, respectively. Ideally, HBM and CDM thresholds would be available and reported in component datasheets. For example, ANSI/ESD SP5.0 contains a template for reporting ESD data.

NOTE: The following would be acceptable objective evidence by including the following question in contractual agreements: "Are any components in this contract outside the scope of ANSI/ESD S20.20 (< 100 volts HBM; < 200 volts CDM)?". Alternatively, a similar question could be included in manufacturing readiness reviews, design reviews, component datasheet reviews, or any other documented process for obtaining component information

E.2 Process Assessments

The current version of the standard does not require any data to support claims of handling devices with 100 volts HBM and 200 volts CDM sensitivities. In a future release of this standard, it is the goal to require data to support the HBM and CDM claims. There currently are no standards or standard test methods that can provide data to support the claims. A working group within the ESD Association is working to provide test methods to "measure" the process. When these test methods become available, there may be a requirement added to future revisions of this standard to provide data related to the process capability of the installed ESD process.

Measurements may include, but are not limited to:

- The voltage on devices in the process
- The voltage on printed circuit boards while moving through the process
- Discharge current measurements

For more information, please see ANSI/ESD SP17.1, ESD Standard Practice for the Protection of Electrostatic Discharge Susceptible Items - Process Assessment Techniques.

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

ANNEX F (INFORMATIVE) – REVISION HISTORY FOR ANSI/ESD S20.20

D.1 2014 Version

Foreword: Added CDM and MM sensitivities to the foreword and a section on Facility Certification.

2.0 Scope: Added 200 volts CDM and 35 volts on isolated charged conductors that this standard applies.

6.1 ESD Control Program Requirements: Second sentence was revised to "The Program shall document the lowest level(s) of device ESD sensitivity that can be handled" from "The most sensitive level of the items to be handled, per the Program, shall be documented."

7.1 ESD Control Program Plan: Product Qualification was added as a required element.

7.3 Product Qualification: Section was added.

7.4 Compliance Verification Plan: Renumbered from 7.3, the content remained the same.

8.2 Personnel Grounding: Note was removed, and the text was made a requirement for garments. Standing requirements were changed; Method 1 and Method 2 have been changed to one method of qualification for standing.

8.3 ESD Protected Areas (EPAs): Additional requirement for process essential insulators was added. Within 1 inch of the ESDS items, the limit for fields was reduced to 125 volts/inch.

Table 3: Wrist Strap Cord Bending Life was removed. Ionization offset voltages were updated for room systems. Soldering iron requirements were added.

8.4 Packaging: The section was reworded, but the requirements remained the same.

Annex A: Soldering Irons were moved into Table 3. Conveyor systems were added to this section.

Annex B: Updated HBM standard to ANSI/ESDA/JEDEC JS-001 in Table 4.

D.2 2021 Version

General changes to improve clarity.

3.0 References: Added reference to MIL-STD-2073-2

4.0 Definitions: Definitions for ESD control items, insulator, conductor, isolated conductor, and unprotected ESDS item were added and only apply to this document.

6.3 Tailoring: Updated wording for tailoring for clarity. A reference to a new annex with examples was added.

7.1 Clarify that marking is optional.

7.3 Product Qualification: Several changes were made to the requirements. Qualification for ESD control items that stay on-site can be done at the lowest RH on the site. This does not apply across multiple sites or materials that leave the site. Qualification records are now required to include supporting technical reports. Added explanation that the flooring/footwear system cannot use compliance verification data for qualification. Body voltage measurements must also be made.

7.4 Note added that calibration does not imply the equipment can make measurements.

8.1 Grounding/Equipotential Bonding Systems: A statement that compliance verification of the grounding system is not required was added. No change in the requirements.

8.3.1 Insulators: The section was updated with a field measurement of where the ESDS item is handled. The original measurement was retained, and either could be used.

8.3.2 Isolated Conductors: The inclusion of non-contact electrostatic voltmeters and electrostatic field meters were included with a note on measurement issues.

Table 3: Deleted ANSI/ESD STM4.2 as a qualification for worksurfaces. Added point-to-point requirements to groundable static control garments and groundable static control garment systems.

8.4 Packaging: Added Table 4 for packaging requirements, which summarizes ANSI/ESD S541 requirements.

8.4.1 United States Department of Defense (DoD) Packaging Requirements: New section was added per a request from the DoD to support the withdrawal of Mil-STD 1686.

Annex C Tailoring: New annex was added with examples of tailoring.

Annex E Statement of Direction: New annex that discusses possible additions to ANSI/ESD S20.20. These are statements at this time and may or may not become requirements in the future.