

ESD Association Standard

ANSI/ESD S20.20-2014
Revision of ANSI/ESD S20.20-2007

*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
7900 Turin Road, Bldg. 3
Rome, NY 13440*

*An American National Standard
Approved July 31, 2014*

***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 June 11, 2014
EOS/ESD Association, Inc.



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(This foreword is not part of ESD Association Standard ANSI/ESD S20.20-2014)

FOREWORD

This standard covers the requirements necessary to design, establish, implement and maintain an Electrostatic Discharge (ESD) Control Program for activities that manufacture, process, assemble, install, package, label, service, test, inspect 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 as 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.

The ESD robustness of devices is fully characterized by HBM and CDM. The CDM model describes the metal-to-metal contact that was formerly associated with MM. Therefore, MM testing is no longer required for qualification of devices and test data may not be available.

This document covers the ESD Control Program requirements for setting up a program to handle ESD sensitive (ESDS) items based on the historical experience of both military and commercial organizations. References include 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 on 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 as long as all items in the system are at the same potential.
- B. Necessary non-conductors (i.e. process-required insulators) in the environment cannot lose their electrostatic charge by attachment to ground. Ionization systems provide neutralization of charge on these necessary non-conductive items (circuit board materials and some device packages are examples of necessary non-conductors). Assessment of the ESD hazard created by electrostatic charge on the necessary non-conductors in the work place is required to ensure that appropriate actions are implemented, commensurate with risk to ESDS items.
- C. Transportation of ESDS items outside an ESD Protected Area (hereafter referred to as "EPA") requires enclosure in static protective materials, although the type of material depends on the situation and destination. Inside an EPA, low charging and static dissipative materials may provide adequate protection. Outside an EPA, low charging and static discharge shielding materials are recommended. While these materials are not discussed in the document, it is important to recognize the differences in their application. 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 electrostatic charge. Common sources of ESD include personnel, items made from common polymeric materials, and processing equipment. ESD damage can occur in a number of ways, including:

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

Examples of ESDS items are microcircuits, discrete semiconductors, thick and thin film resistors, hybrid devices, printed circuit boards and piezoelectric crystals. It is possible to determine device and item susceptibility by exposing the device to simulated ESD events. The level of sensitivity, determined by testing using simulated ESD events, may not necessarily relate to the level of sensitivity in a real life situation. However, the levels of sensitivity are used to establish a baseline

of susceptibility data for comparison of devices with equivalent part numbers from different manufacturers. Two different models are used for characterization of electronic components: HBM and CDM.

Compliance to this standard can be demonstrated through third party certification. The certification process is similar to any quality management system certification such as ISO 9001. Information on the certification process can be obtained by contacting an ESD Association approved Certification Body. For a list of ESD Association 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 June 11, 2014.

At the time the ANSI/ESD S20.20-2014 was prepared, the 20.20 ESD Control Program Subcommittee had the following members:

Brent Beamer 3M	Steve Gerken USAF	Ron Gibson Advanced Static Control Consulting
Gene Monroe NASA – LARC	Dale Parkin Seagate Technology	David E. Swenson, TAS Rep Affinity Static Control Consulting, LLC
Sam Theabo Plexus		Craig Zander Transforming Technologies

The following individuals made significant contributions to ANSI/ESD S20.20-2014:

Kevin Duncan Seagate Technology	Tim Jarrett Boston Scientific	Carl Newberg MicroStat Laboratories
Brian Retzlaff Plexus	Reinhold Gaertner Infineon Technologies	Scott Ward Texas Instruments

At the time the ANSI/ESD S20.20-2007 was prepared, the S20.20 Writing Team had the following members:

Ron Gibson Celestica	Steve Gerken USAF	John T. Kinnear, Jr. IBM
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The following individuals made significant contributions to ANSI/ESD S20.20-2007:

Jeremy Smallwood Electrostatic Solutions Ltd.	Reinhold Gaertner Infineon Technologies
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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.

At the time the ANSI/ESD S20.20-1999 was prepared, the 20.20 Mil-Std 1686 Conversion Committee had the following members:

Steve Gerken, Co-Chairman
USAF

Dave Leeson, Co-Chairman
Motorola SSTG

Ron Gibson
Celestica

Anthony Klinowski
Boeing

Garry McGuire
NASA
(Hernandez Engineering)

Thomas Mohler
Raytheon Systems
Corporation

David E. Swenson
3M

The following individuals made significant contributions to ANSI/ESD S20.20-1999:

Donald E. Cross
USN

Robert Cummings
NASA

Ronald L. Johnson
Intel

John T. Kinnear Jr.
IBM

Ralph Myers
ASC

Robert Parr
Consultant

Jeffrey Scanlon
ASC

Joel Weidendorf
River's Edge Technical
Service

Sheryl Zayic
Boeing

TABLE OF CONTENTS

1.0 PURPOSE	1
2.0 SCOPE	1
3.0 REFERENCED PUBLICATIONS.....	1
4.0 DEFINITIONS.....	2
5.0 PERSONNEL SAFETY	2
6.0 ESD CONTROL PROGRAM.....	2
6.1 ESD CONTROL PROGRAM REQUIREMENTS.....	2
6.2 ESD CONTROL PROGRAM MANAGER OR COORDINATOR	2
6.3 TAILORING.....	2
7.0 ESD CONTROL PROGRAM ADMINISTRATIVE REQUIREMENTS.....	2
7.1 ESD CONTROL PROGRAM PLAN.....	2
7.2 TRAINING PLAN.....	3
7.3 PRODUCT QUALIFICATION PLAN.....	3
7.4 COMPLIANCE VERIFICATION PLAN.....	3
8.0 ESD CONTROL PROGRAM PLAN TECHNICAL REQUIREMENTS.....	3
8.1 GROUNDING / EQUIPOTENTIAL BONDING SYSTEMS	3
8.2 PERSONNEL GROUNDING	4
8.3 ESD PROTECTED AREAS (EPAs).....	4
8.4 PACKAGING	7
8.5 MARKING.....	8

ANNEXES

Annex A (Informative): Additional Process Considerations.....	9
Annex B (Informative): ESD Sensitivity Testing	10
Annex C (Informative): Related Documents	12
Annex D (Informative): ANSI/ESD S20.20-2014 Revision History.....	13

TABLES

Table 1. Grounding / Equipotential Bonding Requirements	4
Table 2. Personnel Grounding Requirement.....	4
Table 3. EPA ESD Control Items.....	6
Table 4. ESD Susceptibility Test References for Devices	11

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 activities that manufacture, process, assemble, install, package, label, service, test, inspect, transport or otherwise handle electrical or electronic parts, assemblies and equipment susceptible to damage by electrostatic discharges greater than or equal to 100 volts HBM, 200 volts CDM, and 35 volts on isolated conductors. Activities that handle items that are susceptible to lower withstand voltages may require additional control elements or adjusted limits. Processes designed to handle items that have an ESD sensitivity to lower withstand voltages 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 as used in this document is based on managing process essential insulators to mitigate induced voltages on devices that could lead to damage.

NOTE: Isolated conductors were historically represented by MM.

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⁽²⁾

ANSI/ESD STM3.1, Ionization⁽²⁾

ANSI/ESD SP3.3, Periodic Verification of Air Ionizers⁽²⁾

ANSI/ESD S4.1, Worksurfaces – Resistance Measurements⁽²⁾

ANSI/ESD STM4.2, ESD Protective Worksurfaces – Charge Dissipation Characteristics⁽²⁾

ANSI/ESD S6.1, Grounding⁽²⁾

ANSI/ESD S7.1, Floor Materials – Characterization of Materials⁽²⁾

ANSI/ESD STM9.1, Footwear – Resistive Characterization⁽²⁾

ESD SP9.2, Footwear – Foot Grounders Resistive Characterization⁽²⁾

ANSI/ESD STM12.1, Seating – Resistive Measurement⁽²⁾

ANSI/ESD S13.1, Electrical Soldering/Desoldering Hand Tools⁽²⁾

ESD TR53, Compliance Verification of ESD Protective Equipment and Materials⁽²⁾

ANSI/ESD STM97.1, Floor Materials and Footwear – Resistance Measurement in Combination with a Person⁽²⁾

ANSI/ESD STM97.2, Floor Materials and Footwear – Voltage Measurement in Combination with a Person⁽²⁾

ANSI/ESD S541, Packaging Materials for ESD Sensitive Items⁽²⁾

² ESD Association, 7900 Turin Road, Bldg. 3, Ste. 2, Rome, NY 13440-2069, 315-339-6937

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.

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 in accordance with the requirements of this document.

6.2 ESD Control Program Manager or Coordinator

An ESD Control Program Manager or Coordinator shall be assigned by the Organization to verify the compliance of the Program in accordance with the requirements of this document.

6.3 Tailoring

This document, or portions thereof, may not apply to all applications. Tailoring is accomplished by evaluating the applicability of each requirement for the specific application. Upon completion of the evaluation, requirements may be deleted or modified outside the limits of this standard. Tailoring decisions, including rationale and technical justifications, shall be documented in the ESD Control Program Plan.

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 Systems
- 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 apply to all applicable facets of the Organization's work.

7.2 Training Plan

Initial and recurrent ESD awareness and prevention training shall be provided to all personnel who handle or otherwise come into contact with any ESD sensitive (ESDS) items. 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 a requirement for maintaining employee training records and shall document where the records are stored. Training methods and the use of specific techniques are at the Organization's discretion. The training plan shall include 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 that the ESD control items that have been selected meet the requirements in the plan. The test methods and required limits are located in the product qualification columns in Tables 2 and 3. Product qualification is normally conducted during the initial selection of ESD control items. Any of the following methods can be used: product specification review, independent laboratory evaluation or internal laboratory evaluation. For ESD control items that were installed by the Organization before the adoption of this standard, on-going compliance verification records can be used as evidence of product qualification.

7.4 Compliance Verification Plan

A Compliance Verification Plan shall be established to ensure the Organization's fulfillment of the technical requirements of the ESD Control Program Plan. Measurements shall be conducted in accordance with a Compliance Verification Plan that identifies the technical requirements to be verified, the measurement limits and the frequency at which those verifications occur. The Compliance Verification Plan shall document the test methods and equipment used for making the measurements. If the test methods used by the Organization differ from any of the standards referenced in this document, then there must be a tailoring statement that is documented as part of the ESD Control Program Plan. Compliance verification records shall be established and maintained to provide evidence of conformity to the technical requirements.

The test equipment selected shall be capable of making the measurements defined in the Compliance Verification Plan.

8.0 ESD CONTROL PROGRAM PLAN TECHNICAL REQUIREMENTS

Sections 8.1 to 8.5 describe the key technical requirements used in the development of an ESD Control Program.

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 (e.g., mobile equipment) are at the same electrical potential. An implementing process shall be selected from Table 1.

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
	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 ⁽³⁾

8.2 Personnel Grounding

All personnel shall be bonded or electrically connected to the 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 grounding / equipotential bonding system via a wrist strap.

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 must also meet the wrist strap 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 ⁽⁴⁾		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 x 10 ⁷ ohms	ESD TR53 Wrist Strap Section	< 3.5 x 10 ⁷ ohms
Footwear / Flooring System ⁽⁵⁾ – (Both limits must be met)	ANSI/ESD STM97.1	< 1.0 x 10 ⁹ ohms	ESD TR53 Footwear Section	< 1.0 x 10 ⁹ ohms ⁽⁶⁾
	ANSI/ESD STM97.2	< 100 volts Peak	ESD TR53 Flooring Section	< 1.0 x 10 ⁹ ohms ⁽⁶⁾

8.3 ESD Protected Areas (EPAs)

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

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

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

An EPA shall be established wherever ESDS items are handled. However, there are many different ways to establish ESD controls within an EPA. Table 3 lists some optional ESD control

³ The maximum resistance between any ESD control items and the common connection point.

⁴ Product qualification is normally conducted during the initial selection of ESD control products and materials. Any of the following methods can be used: product specification review, independent laboratory evaluation or internal laboratory evaluation.

⁵ For ESD control footwear/flooring systems that were installed before the adoption of this standard, on-going compliance verification records can be used as evidence of product qualification.

⁶ The required limit of < 1.0 x 10⁹ ohm is the "maximum" allowed value. The user should document the resistance values that were measured for product qualification for the footwear and the floor to comply with the < 100 volts body voltage generation and use these resistances for compliance verification.

items which can be used to control static electricity. For those ESD control items that are selected for use in the ESD Control Program, the required limits and test methods for those items become mandatory.

8.3.1 Insulators

All nonessential insulators such as coffee cups, food wrappers and personal items shall be removed from the EPA.

The ESD program shall include a plan for handling process-required insulators in order to mitigate field-induced CDM damage.

If the field measured on the process required insulator is greater than 2000 volts/inch and the process required insulator is less than 30 cm (12 inches) from the ESDS item, steps shall be taken to either:

- A) Separate the required insulator from the ESDS item by a distance of greater than 30 cm (12 inches); or
- B) Use ionization or other charge mitigating techniques to neutralize the charge.

If the field measured on the process required insulator is greater than 125 volts/inch and the process required insulator is less than 2.5 cm (1 inch) from the ESDS item, steps shall be taken to either:

- A) Separate the required insulator from the ESDS item by a distance of greater than 2.5 cm (1 inch); or
- B) Use ionization or other charge mitigating techniques to neutralize the charge.

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

8.3.2 Isolated Conductors

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

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

Table 3. EPA ESD Control Items

Technical Requirement	ESD Control Item	Product Qualification ⁽⁷⁾		Compliance Verification		
		Test Method	Required Limit(s) ⁽⁸⁾	Test Method	Required Limit(s)	
EPA	Worksurface ^(9,10) (Qualification can be done by either Test Method)	ANSI/ESD S4.1	Point to Point $< 1 \times 10^9$ ohms	ESD TR53 Worksurface Section	Point to Ground $< 1 \times 10^9$ ohms	
			Point to Groundable Point $< 1 \times 10^9$ ohms			
	ANSI/ESD STM4.2		< 200 volts			
	Wrist Strap	ANSI/ESD S1.1	0.8×10^6 to 1.2×10^6 ohms	For compliance verification of a Wrist Strap System, see Table 2.		
	Wristband	ANSI/ESD S1.1	Interior $< 1 \times 10^5$ ohms			
			Exterior $> 1 \times 10^7$ ohms			
	Personnel Ground wrist strap Connection (non-monitored)	ANSI/ESD S6.1	Point to Ground < 2 ohms	ESD TR53 Grounding Bonding Systems	Point to Ground < 2 ohms	
	Footwear	ANSI/ESD STM9.1	Point to Groundable Point $< 1 \times 10^9$ ohms	For compliance verification of Footwear / Flooring System, see Table 2.		
	Foot Grounders	ESD SP9.2	Point to Groundable Point $< 1 \times 10^9$ ohms			
	Flooring	ANSI/ESD STM7.1	Point to Point $< 1 \times 10^9$ ohms			
			Point to Groundable Point $< 1 \times 10^9$ ohms			
	Seating	ANSI/ESD STM12.1	Point to Groundable Point $< 1 \times 10^9$ ohms	ESD TR53 Seating Section	Point to Ground $< 1 \times 10^9$ ohms	

Table 3 continued on next page.

⁷ Product qualification is normally conducted during the initial selection of ESD control products and materials. Any of the following methods can be used: product specification review, independent laboratory evaluation or internal laboratory evaluation.

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

⁹ Worksurfaces are defined as any surface on which an unprotected ESDS item is placed.

¹⁰ 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 1×10^6 ohms for point to point and point to groundable point should be considered.

Technical Requirement	ESD Control Item	Product Qualification ⁽⁷⁾		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 $-35 < V_{offset} < 35$	ESD TR53 ⁽¹¹⁾ Ionization Section	Discharge Time User defined Offset Voltage $-35 < V_{offset} < 35$
	Shelving (When used to store unprotected ESDS)	ANSI/ESD S4.1	Point to Point $< 1 \times 10^9$ ohms	ESD TR53 Worksurface Section	Point to Ground $< 1 \times 10^9$ ohms
	Mobile Equipment (Working Surfaces)		Point to Groundable Point $< 1 \times 10^9$ ohms		
	Electrical Soldering / Desoldering Hand Tools	ANSI/ESD S13.1	Point to Point $< 1 \times 10^9$ ohms	ESD TR53 Worksurface Section	Point to Ground $< 1 \times 10^9$ ohms
	Continuous Monitors		Point to Ground < 2.0 ohms		
	Static Control Garment		Tip < 20 millivolts		
	Groundable Static Control Garment	ANSI/ESD STM2.1	Tip Leakage < 10 millamps	ESD TR53 Soldering Iron Section Or ANSI/ESD S13.1 Section 6.1	Tip to Ground < 10 ohms
	Groundable Static Control Garment System	ANSI/ESD STM2.1	User defined	ESD TR53 Continuous Monitors Section	Manufacturer defined
			Point to Point $< 1 \times 10^{11}$ ohms	ESD TR53 Garments Section	Resistance Point to Point $< 1 \times 10^{11}$ ohms
			Point to Groundable Point $< 1 \times 10^9$ ohms	ESD TR53 Garments Section	Resistance to Groundable Point $< 1 \times 10^9$ ohms
			$< 3.5 \times 10^7$ ohms	ESD TR53 Personal Grounding with Garments Section	$< 3.5 \times 10^7$ ohms

8.4 Packaging

The organization shall define ESD protective packaging requirements, both inside and outside the EPA per ANSI/ESD S541 or in accordance with the contract, purchase order, drawing or other documentation necessary to meet customer requirements.

NOTE: 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 apply.

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

8.5 Marking

ESDS items, system or packaging marking shall be in accordance with customer contracts, purchase orders, drawing or other documentation. When the contract, purchase order, drawing or other documentation does not define ESDS items, system or packaging marking, the Organization, in developing the ESD Control Program Plan, shall consider the need for marking. If it is determined that marking is required, it shall be documented as part of the ESD Control Program Plan.

(This annex is not part of ESD Association Standard ANSI/ESD S20.20-2014)

ANNEX A (INFORMATIVE) – ADDITIONAL PROCESS CONSIDERATIONS

The following sections provide guidance and outline documents that are available to help the users evaluate additional control products and equipment. Users will need to develop their own acceptance and compliance verification criteria as the industry has not yet defined 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 product as it passes through the equipment. This can provide both continuous verification of ESD counter-measures 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.
2. Gloves (ANSI/ESD SP15.1, Standard Practice for In-Use Resistance Testing of Gloves and Finger Cots). This standard practice 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 practice applies to all gloves and finger cots used to control ESD. This standard practice provides data that is relevant in the user's specific environment and application.
3. Conveyer systems often have unprotected ESD sensitive items on them for movement of the 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 conveyer 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 (TR20.20). The ESD Association Standards Committee produced the ESD Handbook for individuals and organizations that are faced with controlling ESD. It provides guidance that can be used for developing, implementing and monitoring an electrostatic discharge control program in accordance with 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. Charged Device Model (CDM) and Machine Model (MM) factory issues are also addressed.

(This annex is not part of ESD Association Standard ANSI/ESD S20.20-2014)

ANNEX B (INFORMATIVE) – ESD SENSITIVITY TESTING

Assessing the ESD sensitivity of parts, assemblies and equipment and their required protection levels is an important element of an ESD Control Program. A common method for establishing ESD sensitivity limits is to use one or both of the ESD models (HBM and CDM) for characterization of electronic items. The selection of specific ESD control procedures or materials is at the discretion of the ESD Control Program Plan preparer and should be based on risk assessment and the established ESD sensitivities of parts, assemblies, and equipment.

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 damaged by currents through the resistance of a bipolar junction, protection resistor, or protection MOS transistor. Voltage sensitive devices are damaged when the breakdown voltage across the gate oxide is exceeded. ESD sensitivity testing of devices, whether performed using the HBM or CDM, provide ESD sensitivity levels for the comparison of 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 4 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 leads of the device. It is modeled by a 100 pF capacitor discharged through a switching component and 1,500 ohm series resistor into the device under test. All devices should be considered as HBM sensitive. The 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 the CDM is the rapid discharge of energy from a charged device. The ESD event is totally device dependent, but its location relative to ground can influence the failure level in the real world. The assumption for this test model is that 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 nanoseconds. Although very short in duration, current levels can reach several tens of amperes during discharge.

3. Machine Model Sensitivity

A source of damage for the MM historically was described as a rapid transfer of energy to the conductive leads of the device. Isolated charged conductor discharges to devices are better 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 Machine Model and device targets, see White Paper 1: A Case for Lowering Component Level HBM/MM ESD Specifications and Requirements by the Industry Council.

Table 4. 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 Method 3015 MIL-STD-750 Method 1020 MIL-PRF-19500 MIL-PRF-38535
CDM	ANSI/ESD S5.3.1 JEDEC JESD22-C101
MM (For Information Only)	ANSI/ESD STM5.2 JEDEC JESD22-A115

(This annex is not part of ESD Association Standard ANSI/ESD S20.20-2014)

ANNEX C (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 Free, Heat Sealable"
MIL-E-17555, "Electronic and Electrical Equipment, Accessories, and Provisioned Items (Repair Parts): Packaging of"
MIL-STD-1686, "Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)"
MIL-HDBK-263, "Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically-Initiated Explosive Devices)"
MIL-M-38510, "General Specification for Military Microcircuits"
MIL-P-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"
MMA-1985-79, Revision 3, "Standard Test Method for Evaluating Triboelectric Charge Generation and Decay"

Industry Standards

ANSI/IEEE-STD-142, "IEEE Green Book (IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems)"
JESD 625, "Requirements for Handling Electrostatic-Discharge-Sensitive (ESDS) Devices"
EIA-583, "Packaging Material Standards for Moisture Sensitive Items"
TR3.0-02-05, "Selection and Acceptance of Air Ionizers"
ESDSIL, "Reliability Analysis Center (RAC) ESD Sensitive Items List"
EIA-471, "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 S20.20-2014)

ANNEX D (INFORMATIVE) – ANSI/ESD S20.20-2014 REVISION HISTORY

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 to.

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, in accordance with 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, content remained the same.

8.2 Personnel Grounding: Note was removed and 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 required 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: Section was reworded but the requirements remained the same.

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

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