ANSI/ESD S20.20-2007
Revision of ANSI/ESD S20.20-1999

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)

ANSI/ESD S20.20-2007

Electrostatic Discharge Association
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An American National Standard
Approved March 1, 2007

ESD Association Standards Committee
Standards Interpretation Bulletin

June 19, 2008

The ESD Association Standards Committee is issuing this interpretation bulletin regarding ANSI/ESD S20.20-2007. This bulletin modifies the requirements specified in Table 3 EPA Control Items (Garments). Table 3 should now be modified to disregard the two garment types; "Groundable Static Control Garment" and "Groundable Static Control Garment System", along with their Test Methods and Requirements.

Additionally, the "Static Control Garment" Required Limit should be: 1 x 10^5 ohms to 1 x 10^{11} ohms, per ANSI/ESD STM2.1-1997.

These changes are necessary because the referenced document, ANSI/ESD STM2.1, has been brought back to a Work in Progress (WIP) status and therefore these two garment types (mentioned above) are also brought back to WIP status.

Reference Information

Table 3. EPA ESD Control Items

Technical Requirement	ESD Control Item	Product Qualification[1]		Compliance Verification	
		Test Method	Required Limit(s)[2]	Test Method	Required Limit(s)
	Garments	Static Control Garment (ANSI/ESD STM2.1)	< 1 x 10^{11} ohms	ESD TR53 Garments Section	< 1 x 10^{11} ohms
		Groundable Static Control Garment (ANSI/ESD STM2.1)	< 1 x 10^9 ohms	ESD TR53 Garments Section	< 1 x 10^9 ohms
		Groundable Static Control Garment System (ANSI/ESD STM2.1)	< 3.5 x 10^7 ohms	ESD TR53 Garments Section	< 3.5 x 10^7 ohms

John Kinnear
Working Group Chairman

Tim Jarrett
Standards Chairman

ESD Association Standards Committee
Standards Change Notification

June 14, 2007

This notification reports on two typos in ANSI/ESD S20.20-2007, Table 2 Personnel Grounding Requirement. These corrections have been made to the Standard and are highlighted below for your reference.

Previous Information

Table 2. Personnel Grounding Requirement

Personnel Grounding Technical Requirement	Product Qualification[1]		Compliance Verification	
	Test Method	Required Limit(s)	Test Method	Required Limit(s)
Wrist Strap System[2]	ANSI/ESD S1.1 (Section 5.10)	0.8×10^6 to 1.2×10^6 ohms	ESD TR53 Wrist Strap Section	$< 3.5 \times 10^7$ ohms

Current Information

Table 2. Personnel Grounding Requirement

Personnel Grounding Technical Requirement	Product Qualification[1]		Compliance Verification	
	Test Method	Required Limit(s)	Test Method	Required Limit(s)
Wrist Strap System[2]	ANSI/ESD S1.1 (Section 5.11)	$< 3.5 \times 10^7$ ohms	ESD TR53 Wrist Strap Section	$< 3.5 \times 10^7$ ohms

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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 February 11, 2007
ESD Association

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(This foreword is not part of ANSI/ESD S20.20-2007)

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). This document covers the ESD Control Program requirements and offers guidance 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 in the environment cannot lose their electrostatic charge by attachment to ground. Ionization systems provide neutralization of charges 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 charges 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 charges. Common sources of ESD include personnel, items made from common polymeric materials, and processing equipment. ESD damage can occur when:

i. A charged object comes into contact with an ESDS device, or
ii. An ESDS device is grounded while exposed to an electrostatic field.

Examples of ESDS parts 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, they are used to establish a baseline of susceptibility data for comparison of devices with equivalent part numbers from different manufacturers. Three different models are used for characterization of electronic components: HBM, Machine Model (MM), and Charged Device Model (CDM).

This document was originally designated ANSI/ESD S20.20-1999 and approved on August 4, 1999. ANSI/ESD S20.20-1999 was prepared by the 20.20 Mil-Std 1686 Conversion Committee. ANSI/ESD S20.20-2007 is a revision of ANSI/ESD S20.20-1999 and was prepared by the S20.20 Writing Team, which consists of the following members:

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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 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. Activities that handle items that are susceptible to less than 100 volts HBM may require additional control elements or adjusted limits. Processes designed to handle items that have an ESD sensitivity less than 100 volts HBM can still claim compliance to this standard. This document does not apply to electrically initiated explosive devices, flammable liquids or powders.

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[1]

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

ANSI/ESD STM2.1, Garments[1]

ANSI/ESD STM3.1, Ionization[1]

ANSI/ESD SP3.3, Periodic Verification of Air Ionizers[1]

ANSI/ESD S4.1, Worksurfaces – Resistance Measurements[1]

ANSI/ESD STM4.2, ESD Protective Worksurfaces – Charge Dissipation Characteristics[1]

ANSI/ESD S6.1, Grounding[1]

ANSI/ESD S7.1, Floor Materials – Characterization of Materials[1]

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

ESD SP9.2, Footwear – Foot Grounders Resistive Characterization[1]

ANSI/ESD STM97.1, Floor Materials and Footwear – Resistance Measurement in Combination with a Person[1]

ANSI/ESD STM97.2, Floor Materials and Footwear – Voltage Measurement in Combination with a Person[1]

ESD TR53, Compliance Verification of ESD Protective Equipment and Materials[1]

ANSI/ESD STM12.1, Seating – Resistive Measurement[1]

ANSI/ESD S541, Packaging Materials for ESD Sensitive Items[1]

[1] 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.

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.

6.0 ESD CONTROL PROGRAM

6.1 ESD Control Program Requirements

The Program shall include both administrative and technical requirements as described herein. The most sensitive level of the items to be handled, in accordance with the Program, shall be documented. 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 added, modified or deleted. 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
- Compliance Verification
- Grounding / Equipotential Bonding Systems
- Personnel Grounding
- 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 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 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. Process monitoring (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 shall occur. The Compliance Verification Plan shall document the test methods and equipment used for process monitoring and 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

The following sections, 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 (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	< 1.0×10^9 ohms[1]

[1] The maximum resistance between any ESD technical element and the common connection point.

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.

NOTE: Use of a garment to achieve personnel grounding shall be documented in the ESD Control Program Plan. The garment shall be electrically conductive from one sleeve to the next and must also meet the system resistance requirements defined in Note 2 in Table 2.

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

For standing operations, personnel shall be grounded via a wrist strap system or by a flooring-footwear system. When a flooring-footwear system is used, one of the two following conditions shall be met:

A. When the total resistance of the system (from the person, through the footwear and flooring to the grounding / equipotential bonding system) is less than 3.5×10^7 ohms, Method 1 shall be followed (see Table 2).

B. When the total resistance of the system (from the person, through the footwear and flooring to the grounding / equipotential bonding system) is greater than 3.5×10^7 ohms and less than 1×10^9 ohms, Method 2 shall be followed (see Table 2).

Table 2. Personnel Grounding Requirement

Personnel Grounding Technical Requirement	Product Qualification[1]		Compliance Verification	
	Test Method	Required Limit(s)	Test Method	Required Limit(s)
Wrist Strap System[2]	ANSI/ESD S1.1 (Section 5.11)	< 3.5×10^7 ohms	ESD TR53 Wrist Strap Section	< 3.5×10^7 ohms
Flooring / Footwear System – Method 1	ANSI/ESD STM97.1	< 3.5×10^7 ohms	ESD TR53 Flooring Section	< 3.5×10^7 ohms
			ESD TR53 Footwear Section	< 3.5×10^7 ohms
Flooring / Footwear System – Method 2 (both required)	ANSI/ESD STM97.1	< 10^9 ohms	ESD TR53 Flooring Section	< 1.0×10^9 ohms
	ANSI/ESD STM97.2	< 100 volts	ESD TR53 Footwear Section	< 1.0×10^9 ohms

[1] 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.

[2] For situations where an ESD garment is used as part of the wrist strap grounding path, the total system resistance including the person, garment and grounding cord shall be less than 3.5×10^7 ohms.

8.3 ESD Protected Areas (EPAs)

Handling of ESDS parts, assemblies and equipment without ESD protective covering or packaging shall be performed in an EPA. Caution signs indicating the existence of the EPA shall be posted and clearly visible to personnel prior to entry to the EPA.

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

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.

In order to mitigate field-induced CDM damage, the ESD program shall include a plan for the handling of process-required insulators. If the field exceeds 2,000 volts/inch, steps shall be taken to either:

A) Separate the insulator from the ESD-sensitive device by a distance of 30 cm (12 inches);

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 get an accurate reading.

All nonessential insulators such as coffee cups, food wrappers and personal items shall be removed from the workstation or any operation where unprotected ESDS items are handled.

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

Table 3. EPA ESD Control Items

Technical Requirement	ESD Control Item	Product Qualification[1]		Compliance Verification	
		Test Method	Required Limit(s)[2]	Test Method	Required Limit(s)
EPA	Worksurface	ANSI/ESD S 4.1 and/or ANSI/ESD STM 4.2	< 1 x 10^9 ohms and/or < 200 volts	ESD TR53 Worksurface Section	< 1 x 10^9 ohms resistance to ground
	Wrist Strap Cord	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.	
	Wrist Strap Cuff	ANSI/ESD S1.1	Interior < 1 x 10^5 ohms		
			Exterior > 1 x 10^7 ohms		
	Wrist Strap Cord Bending Life	ANSI/ESD S1.1	> 16,000 cycles		
	Footwear	ANSI/ESD STM9.1	< 1 x 10^9 ohms	See Table 2	See Table 2
	Foot Grounders	ESD SP9.2	< 1 x 10^9 ohms	See Table 2	See Table 2
	Flooring	ANSI/ESD S7.1	< 1 x 10^9 ohms	See Table 2	See Table 2
	Seating	ANSI/ESD STM 12.1	< 1 x 10^9 ohms	ESD TR53 Seating Section	< 1 x 10^9 ohms resistance to ground
	Ionization other than Room Systems	ANSI/ESD STM 3.1 - Discharge time	User defined	ESD TR53[3] - Discharge time	User defined
		- Offset voltage	< ± 50 volts	- Offset voltage	< ± 50 volts
	Ionization (Room Systems)	ANSI/ESD STM3.1 - Discharge time	User defined	ESD TR53[3] - Discharge time	User defined
		- Offset voltage	< ± 150 volts	- Offset voltage	< ± 150 volts
	Shelving	ANSI/ESD S4.1	< 1 x 10^9 ohms	ESD TR53 Worksurface Section	< 1 x 10^9 ohms resistance to ground
	Mobile Equipment (Working Surfaces)	ANSI/ESD S4.1	< 1 x 10^9 ohms	ESD TR53 Mobile Equipment Section	< 1 x 10^9 ohms resistance to ground
	Continuous Monitors	User defined	User defined	ESD TR53 Continuous Monitors Section	Manufacturer defined
	Garments	Static Control Garment (ANSI/ESD STM2.1)	< 1 x 10^{11} ohms	ESD TR53 Garments Section	< 1 x 10^{11} ohms
		Groundable Static Control Garment (ANSI/ESD STM2.1)	< 1 x 10^9 ohms	ESD TR53 Garments Section	< 1 x 10^9 ohms
		Groundable Static Control Garment System (ANSI/ESD STM2.1)	< 3.5 x 10^7 ohms	ESD TR53 Garments Section	< 3.5 x 10^7 ohms

[1] 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.

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

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

8.4 Packaging

ESD protective packaging shall be in accordance with the contract, purchase order, drawing or other documentation. When not specified by the above documentation, the organization shall define ESD protective packaging requirements, both inside and outside the EPA per ANSI/ESD S541.

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 ANSI/ESD S20.20-2007)

ANNEX A – 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 (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 are relevant in the user's specific environment and application.

3. Hand Tools (ESD STM13.1, Electrical Soldering/Desoldering Hand Tools). This standard test method provides electric soldering/desoldering hand tool test methods for measuring electrical leakage and tip to ground reference point resistance. The standard test method provides parameters for electrical overstress (EOS) safe soldering operation. Even though not specifically discussed in STM13.1, battery powered, pneumatic and other hand tools may also need to be evaluated.

4. ESD Handbook (TR20.20). The ESD Association Standards Committee produced this ESD Handbook for individuals and organizations that are faced with controlling electrostatic discharge (ESD). It provides guidance that can be used for developing, implementing and monitoring an electrostatic discharge control program in accordance with 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.

(This annex is not part of ANSI/ESD S20.20-2007)

ANNEX B – ESD SENSITIVITY TESTING

Assessing the ESD sensitivity of parts, assemblies and equipment and their required protection levels can be an important element of an ESD Control Program. A common method for establishing ESD sensitivity limits is to use one or more of the three ESD models (HBM, MM and CDM) for characterization of electronic items. The selection of specific ESD control procedures or materials is at the option of the ESD Control Program Plan preparer and should be based on risk assessment and the established electrostatic discharge 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, MM or the 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. The discharge itself is a double exponential waveform with a rise time of 2-10 nanoseconds and a pulse duration of approximately 150 nanoseconds. The use of a 1,500 ohm series resistor means this model approximates a current source. 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. HBM sensitivities can be found in RAC VZAP, Qualified Manufacturers List of Products (QML-19500) or Qualified Manufacturer List (QML-38535).

2. *Machine Model Sensitivity*

A source of damage for the MM is a rapid transfer of energy from a charged conductor to the conductive leads of the device. This ESD model is a 200 pF capacitor discharged through a 500 nH inductor directly into the device with no series resistor. Due to the lack of a series current limiting resistor, this model approximates a voltage source. In the real world this model represents a rapid discharge from items such as charged board assembly, charged cables or the conduction arm of an automatic tester. The discharge itself is a sinusoidal decaying waveform with a rise time of 5 to 8 nanoseconds and a period of approximately 80 nanoseconds.

3. *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. An issue with the preparation of a CDM test standard is the availability of suitable instrumentation to measure the discharge event. The waveform rise time is often less than 200 picoseconds. The entire 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.

Table 4. ESD Susceptibility Test References for Devices

ESD Model	ESD Standards and Methods for Susceptibility Testing of Devices
HBM	ANSI/ESD STM5.1 MIL-STD-883 Method 3015 MIL-STD-750 Method 1020 MIL-PRF-19500 MIL-PRF-38535
MM	ANSI/ESD STM5.2
CDM	ANSI/ESD STM5.3.1

Assembly, Equipment and Design Hardening

1. Assembly, Equipment and Design Hardening Guidance

Assemblies and equipment should have protective circuitry or techniques to meet the desired design goals. Determining the ESD susceptibility of assemblies and equipment may be based on simulation modeling, or actual testing. Table 5 provides a quick reference for various test methods associated with assembly and equipment susceptibility testing.

2. Direct Contact, Non-Operating Assembly, Body/Finger or Hand/Metal Tests

This model can be used to verify that assemblies will not be damaged during non-operating conditions by direct contact to input, output and interface connections. This threat applies to all types of assemblies (see Table 5).

3. Direct Contact Operating Equipment Hand/Metal Test

This model can be used to verify that operating equipment will not be damaged (or non-recoverable faults will not be injected) by direct contact to operator accessible points and exposed surface areas during the normal maintenance process. This threat is limited to equipment subject to operator adjustments or maintenance activities during operation (see Table 5).

4. Indirect Contact, Operating Equipment Furniture Model Test

This model can be used to verify that operating equipment in a home or office environment will not be damaged (or non-recoverable faults will not be injected) by indirect contact during normal activities performed within the proximity of the equipment. This threat applies to all electronic equipment in a home or office environment (see Table 5).

Table 5. ESD Susceptibility Test References for Assemblies and Equipment

ESD Assembly / Equipment Model	ESD Test Standard or Method
Body / Finger HBM	IEEE STD C62.38 (Sub-Assembly)
Hand / Metal HBM	IEC 61000-4-2 ANSI C63.16 (Equipment)
Furniture Model	ANSI C63.16 (Equipment)

(This annex is not part of ANSI/ESD S20.20-2007)

ANNEX C – 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-DTL-117, "Bags, Sleeves and Tubing – Interior Packaging"

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 625A, "Requirements for Handling Electrostatic-Discharge-Sensitive (ESDS) Devices"

EIA-583, "Packaging Material Standards for Moisture Sensitive Items"

ESD-ADV3.2, "Selection and Acceptance of Air Ionizers"

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

EIA-471, "Symbol and Label for Electrostatic Sensitive Devices"

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

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

VZAP, "Electrostatic Discharge Susceptibility Data"