

JEDEC STANDARD

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

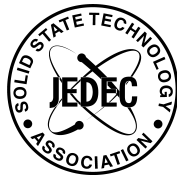
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JEDEC Solid State Technology Association



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REQUIREMENTS FOR HANDLING ELECTROSTATIC-DISCHARGE-SENSITIVE (ESDS) DEVICES

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Foreword

This standard was prepared to standardize the requirements for a comprehensive Electrostatic Discharge (ESD) control program for handling ESD-Sensitive (ESDS) devices. The requirements within this standard were derived from existing industry standards, specifications, test methods, and input from various industry reviews.

The intent of this document is for users to incorporate these minimal requirements into their ESD control program to provide a consistent ESD protection level for their products.

This standard replaces JEDEC Standard No. 42 (formerly JEDEC Publication 108-B, Distributor Requirements for Handling Electrostatic-Discharge Sensitive (ESDS) Devices).

REQUIREMENTS FOR HANDLING ELECTROSTATIC-DISCHARGE-SENSITIVE (ESDS) DEVICES

(From JEDEC Board ballot JCB-98-134, formulated under the cognizance of JEDEC JC-14.1 Committee on Reliability Test Methods for Packaged Devices and the JC-13 Committee on Government Liaison.)

1 Purpose

This standard establishes the minimum requirements for Electrostatic Discharge (ESD) control methods and materials used to protect electronic devices that are susceptible to damage or degradation from electrostatic discharge (ESD). The passage of a static charge through an electrostatic-discharge-sensitive (ESDS) device can result in catastrophic failure or performance degradation of the part.

Device sensitivity to ESD is determined by test methods such as JESD22-A114. ESDS devices with human body model sensitivities of less than ± 200 volts may need additional protective measures beyond those specified in this standard.

2 Scope

2.1 Applicable users

- a) Semiconductor Manufacturers - from wafer electrical probe through shipment of finished devices except for in-process operations when all leads are shorted together.

NOTE — The requirements of this standard are not imposed prior to probe. Prior to probe, the manufacturer should take appropriate ESD precautions to minimize damage to devices.

- b) Semiconductor Distributors - from receipt through shipment of finished devices.
- c) Semiconductor Processing/Testing Facilities - from receipt through shipment of finished devices.
- d) ESDS Device Users – from receipt to installation in a higher assembly/card

2.2 Applicable device types

The device types for which these requirements are applicable include, but are not limited to, ESD-sensitive discrete and integrated circuit semiconductors, hybrid microcircuits, and thin film passive devices.

NOTE — ESD susceptibility/sensitivity may be determined and specified by the manufacturer or user.

3 Related documents

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

3.1 Applicable documents

ANSI/ASQC-Q9001	Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation and Servicing (US version of ISO-9001)
ANSI/ASQC-Q9002	Quality Systems - Model for Quality Assurance in Production and Installation (US version of ISO-9002)
ANSI/EIA-471	Symbol and Label for Electrostatic Sensitive Devices (Formulated by JEDEC JC-10 Committee)
ANSI/EIA-541	Packaging Materials Standards for ESD sensitive Items
ANSI/EOS/ESD-S3.1	Standard for Protection of Electrostatic Discharge Susceptible Items - Ionization
ANSI/EOS/ESD-S4.1	Standard for Protection of Electrostatic Discharge Susceptible Items - Worksurfaces - Resistive Characterization
ANSI/EOS/ESD-S6.1	Standard for Protection of Electrostatic Discharge Susceptible Items - Grounding - Recommended Practice
ANSI/EOS/ESD-S7.1	Standard for Protection of Electrostatic Discharge Susceptible Items - Floor Materials - Resistive Characterization of Materials
ANSI/NCSL Z540-1	Calibration Laboratories and Measuring and Test Equipment - General Requirements
ANSI/EOS/ESD-S5.1	Human Body Model (HBM) Electrostatic Discharge (ESD) Sensitivity Testing Standard
JESD22-A114	Electrostatic Discharge (ESD) Sensitivity Testing - Human Body Model (HBM)
JESD22-A115	Electrostatic Discharge (ESD) Sensitivity Testing - Machine Model (MM)
JESD22-C101	Field Induced Charged Device Model Test Method for Electrostatic Discharge Withstand Threshold for Microelectronic Modules
IEC-101/61340-5-1	Specification for the Protection of Electronic Devices from Electrostatic Phenomena - Section 1: General Requirements.
IEC-101/61340-5-2	Specification for the Protection of Electronic Devices from Electrostatic Phenomena - Section 2: User Guide.

3 Related documents (cont'd)

MIL-HDBK-263	Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
MIL-STD-129	Marking for Shipment and Storage

4 Terms and definitions

For the purpose of this standard the following definitions apply.

air ionizer: A source of charged air molecules (ions).

antistatic material: Referring to the property of material that inhibits triboelectric charging. Antistatic materials shall not triboelectric charge to greater than $\pm 1,000$ volts under normal/ intended usage.

NOTE — A material's antistatic property is not necessarily correlatable with its resistivity or resistance.

conductive material: A material that has a surface resistivity less than 1×10^5 ohms per square or a volume resistivity less than 1×10^4 ohm centimeter.

NOTE — A conductive material is not necessarily antistatic.

electrostatic charge: see “static electricity”.

electrostatic discharge (ESD): The transfer of electrostatic charge between bodies or surfaces that are at different electrostatic potentials.

electrostatic-discharge susceptibility [sensitivity] (ESDS): The lowest level of ESD that produces changes in device characteristics such that the device fails to meet its specified characteristics.

electrostatic field: Lines of force surrounding an electrically charged object.

electrostatic shielding: A barrier or enclosure that limits the penetration of an electrostatic field so that its effects do not reach the stored or contained devices and produce damage.

equipment ground: The entire low-impedance path from a piece of electrical equipment to a hard-ground electrode (e.g., the third wire (green) terminal of a receptacle).

ESD ground: The point, electrodes, bus bar, metal strips, or other system of conductors that form a path from a statically charged person or object to ground.

ESD-protected area: A work environment with materials and equipment that limit electrostatic potential.

4 Terms and definitions (cont'd)

ESD-protected workstation: A work position with materials and equipment that limit electrostatic potential.

ESD-protective packaging: A packaging system that provides electrostatic protection and limits triboelectric charging to levels that do not result in device damage.

ESD-protective worksurface: A table top or other surface on which to work that has a resistance to ground of less than 10^9 ohms

ground: (1) A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth or some conducting body that serves in place of earth.

(2) The portion of an electrical circuit at zero potential with respect to the earth.

(3) A conducting body, such as the earth or the hull of a steel ship, used as a return path for electric currents and as an arbitrary zero reference point.

groundable point: A designated connection, location, or assembly used on an ESD protective material or device that is intended to accommodate electrical connection from the device to ESD ground.

insulative material: A material having a surface resistivity of at least 1×10^{12} ohms per square or volume resistivity of at least 1×10^{11} ohm centimeter.

static: A short form of electrostatic.

static dissipative material: A material having a surface resistance between 1×10^5 ohms and 1×10^{11} ohms or a volume resistivity between 1×10^5 ohm centimeters and 1×10^{11} ohm centimeters.

static electricity: Electrical charge at rest.

NOTE — The electrical charge is due to the transfer of electrons within a body (polarization) or from one body to another.

surface resistance: The dc voltage divided by the current passing between two electrodes of specified configuration that contact the same side of a insulative material or item.

NOTE — Surface resistance is expressed in ohms.

triboelectric charging: The generation of electrostatic charges when two pieces of material in intimate contact are separated (where one or both is an insulator).

NOTE — Substantial generation of static electricity can be caused by contact and separation of two materials or by rubbing two substances together.

unprotected ESDS device: An ESDS device that is not in an ESD protective package.

NOTE — See “ESD-protective packaging”

4 Terms and definitions (cont'd)

volume resistivity (ρ_v): The dc voltage per unit thickness, applied across two electrodes in contact with a specimen, divided by the current per unit area passing through the system.

NOTE

1 Volume resistivity is generally expressed in ohm centimeters.

2 When concentric ring electrodes are used as described in ASTM-D991, volume resistivity is calculated from the following equation:

$$\text{volume resistivity } (\rho_v) = \frac{\pi \times (D_1)^2 \times R}{4T}$$

where

D_1 = diameter of inner electrode or disk

R = measured resistance in ohms

T = thickness of specimen

5 Inspection, measuring and test equipment

5.1 Calibration system

The calibration system for all inspection, measuring and test equipment used to perform required ESD Item Checks listed in table 2 shall be compliant with the requirements of ANSI/NCSL Z540-1 and ANSI/ASQC-Q9001/Q9002.

5.2 Recommended inspection, measuring and test equipment types

The recommended test equipment types and capabilities are listed below:

- a) A Go/No-go tester, a meter, an in-line monitor, or equivalent resistance path measuring equipment shall be capable of measuring the resistance of each connection path (e.g., wrist strap, heel strap or ESD protective footwear) (see 6.4.1 and 6.4.2) within the table 2 limits.
- b) When wrist strap monitoring equipment is used, it shall alarm (audio and/or visual) when a wrist strap exceeds the limits specified in table 2 and when there is a broken or missing connection to the user or to ground.

5 Inspection, measuring and test equipment (cont'd)

5.2 Recommended inspection, measuring and test equipment types (cont'd)

- c) Electrostatic fieldmeters shall be capable of verifying the presence of electrostatic fields in the work environment.

NOTES

- 1 Electrostatic fieldmeters used in ionized air streams shall be constructed (e.g., chopper-stabilized) to operate in that environment.
 - 2 In this standard, items with measured potential greater than +/- 1000 volts are to be kept at least 12 inches from unprotected ESDS devices. This refers to Measurements of +/- 1000 volts using a fieldmeter per the manufacturer's instructions, typically +/-1000 volts at one inch.
- d) Meters used to verify ESD ground continuity shall be capable of verifying resistance values less than one ohm.
 - e) Meters use to measure resistance to ground and resistance point to point shall be capable of verifying resistance values within the table 2 limits.
 - f) Electrostatic charged plate monitors shall be capable of measuring the charge neutralization properties of ionization equipment within the table 2 limits.

6 Facilities for ESD protected areas and workstations

6.1 Minimum requirements

The minimum requirements for ESD protected areas and workstations are listed in table 1 and illustrated in figure 1. The required and recommended ESD item checks are listed in table 2.

6 Facilities for ESD protected areas and workstations (cont'd)

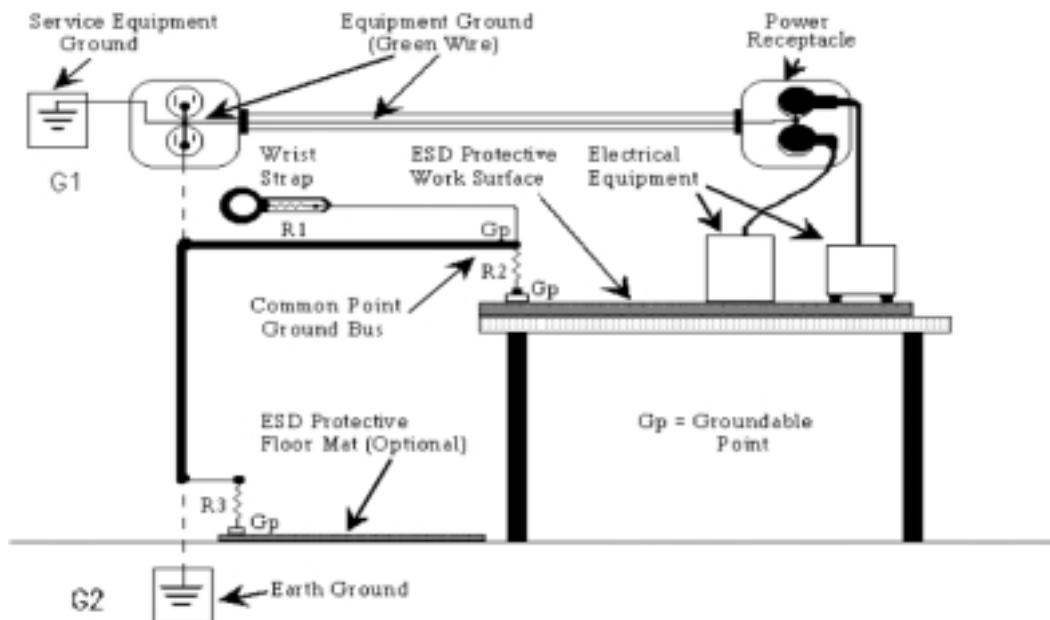
6.1 Minimum requirements (cont'd)

Table 1 — Minimum requirements for ESD protected areas, workstations, and tools

ITEM	MINIMUM REQUIREMENTS
1. ESD Protective Worksurface	Where unprotected ESDS devices are handled, a grounded static protective worksurface with a resistance to ground of less than $10^9 \Omega$ shall be used.
2. ESD Protective Flooring or Floor Mats	Grounded flooring or floor mats are only required when personnel or mobile ESD protective workstations utilize floor grounding methods.
3. Personnel Grounding	<p>Each person handling or within twelve (12) inches of unprotected ESDS devices shall be grounded using <u>EITHER</u>:</p> <p>a) Wrist straps that shall:</p> <ol style="list-style-type: none"> 1) Provide a continuous electrical path from the user directly to ESD ground. 2) Have an integral resistance at the wrist band end of the grounding wire that will limit current to less than 0.5 mA through that specific path to ground at the highest power supply voltage that may be encountered. 3) Be worn by operators handling unprotected ESDS devices when seated. <p>b) ESD protective footwear (heel straps, toe straps or shoes) that shall:</p> <ol style="list-style-type: none"> 1) Provide a continuous electrical path from the user directly to the ESD protective flooring or floor mat. 2) Be worn on both feet. 3) Limit current to less than 0.5 mA through that specific path to ground at the highest power supply voltage that may be encountered. 4) <u>NOT</u> be relied upon for grounding of seated personnel.
4. Static Generating Sources and Charged Surfaces	<ol style="list-style-type: none"> a) Nonessential and personal items shall not be placed on ESD protective worksurfaces that are in use. b) No item with an electrostatic potential greater than +/- 1000 volts (as measured with a fieldmeter) shall be closer than 12 inches from unprotected ESDS devices. c) Operations, equipment or clothing generating electrostatic potential greater than $\pm 1,000$ volts within twelve (12) inches of unprotected ESDS devices shall be neutralized or reduced to less than $\pm 1,000$ volts. d) Charged items must not contact ESDS devices.
5. ESD Protective Smocks	When ESD protective smocks are worn, they shall cover all personal garments above the waist except at the neck area.
6. Air Ionizers	Air ionizers may be used to reduce electrostatic potentials to less than $\pm 1,000$ volts within twelve (12) inches of unprotected ESDS devices if those voltages are not controlled by other means.
7. ESD Protected Area and Workstation Identification	ESD caution signs shall be posted at each ESD protected workstation or at the entrances of defined ESD protected areas.

6 Facilities for ESD protected areas and workstations (cont'd)

6.1 Minimum requirements (cont'd)



NOTES

- 1 G1 (equipment ground) or G2 (earth ground) is acceptable for ESD ground. Where both grounds are used, they shall be connected (bonded) together.
- 2 R1 is mandatory for all wrist straps. Its value shall be within the limits specified in table 2, 1.a.
- 3 R2 (for static dissipative worksurfaces) and R3 (for ESD protective floor mats) are optional. When R2 or R3 are used, the resistor values shall be as recommended by the ESD protective equipment manufacturer. ESD protective flooring shall be connected directly to the ESD ground without R3.
- 4 See paragraph 7 of this standard for grounding details (Reference EOS/ESD-S6.1).

Figure 1 — ESD protected workstation (Side View)

6 Facilities for ESD protected areas and workstations (cont'd)

6.1 Minimum requirements (cont'd)

Table 2 — ESD protective item checks

FREQUENCY (see Notes 1&2)	ITEMS	ACCEPTANCE LIMITS	REF. PARA.
1. Required Daily	a) Wrist straps (see Note 3).	$\geq 500 \text{ k}\Omega$ to $\leq 10 \text{ M}\Omega$	6.4/6.4.1
	b) ESD protective footwear (see Note 4).	$\geq 500 \text{ k}\Omega$ to $\leq 10^9 \Omega$	6.4/6.4.2
	c) Personnel ESD protective smock (e.g., buttoned smocks) on personnel required to wear them.	Visual check	11.4
	d) Wrist straps or ESD protective footwear on personnel required to wear them.	Visual check	6.3
2. Recommended Weekly	a) ESD protected workstation. (e.g., ground connections)	Visual check	7.3/7.4.1/ 7.4.2
	b) ESD protective floor mat (e.g., cleanliness and freedom from tears).	Visual check	7.3/7.5
	c) ESD ground connections (e.g., wrist straps, mat ground wires).	Visual check	7.3/7.6
3. Recommended Monthly	ESD protected area and workstation static voltage surveys.	$\leq \pm 1,000$ volts within 12 inches of unprotected ESDS devices	6.5
4. Recommended Quarterly	a) ESD protective static dissipative worksurface to ESD ground resistance (See Note 5).	$\geq 10^5$ to $< 10^9 \Omega$	4.18/7.3/ 7.4.1
	b) ESD conductive worksurface to ESD ground resistance. (see Note 5)	$< 100 \text{ k}\Omega$ (with no series resistor)	4.3/7.3/ 7.4.2
	c) ESD protective floor to ESD ground resistance using EOS/ ESD S7.1.	$\geq 10^4$ to $< 10^9 \Omega$ (see Note 8)	7.5
	d) Wrist strap monitor check.	$\geq 500 \text{ k}\Omega$ to $\leq 10 \text{ M}\Omega$	6.4.3
	e) ESD ground continuity from the groundable point (e.g., shelving ground wires, mobile equipment ground wires, cord ground wires) using EOS/ESD-S6.1. (see Note 6)	$< 1.0 \Omega$	4.10/7.6/ 7.7/7.8/7.9
5. Recommended Semiannually	a) Ionizer balance using EOS/ ESD-S3.1. (see Note 7)	Balance $< \pm 35 \text{ V}$	11.3e
	b) Ionizer charge decay performance using EOS/ESD-S3.1. (See Note 9)	Charge decay performance per manufacturer's specification.	11.3f

6 Facilities for ESD protected areas and workstations (cont'd)

6.1 Minimum requirements (cont'd)

Table 2 — ESD protective item checks (cont'd)

FREQUENCY (see Notes 1&2)	ITEMS	ACCEPTANCE LIMITS	REF. PARA.
6. Recommended Annually	ESD system compliance to the requirements of this standard	Using the ESD Audit Checklist or equivalent.	9.2
<p>NOTES</p> <p>1 The ESD Item check frequencies should be established to ensure that the items remain compliant between checks.</p> <p>2 The ESD item checks shall be performed more frequently than listed when compliance is not continuously maintained.</p> <p>3 Wrist straps in use shall be checked at least once a day when continuous wrist strap monitors are not used.</p> <p>4 ESD protective footwear is available in a wide range of resistance values. Those with mid-to-lower resistance values provide shorter charge dissipation times.</p> <p>5 Use EOS/ESD-S4.1 except make a single measurement using the limits specified in this standard at a high wear point relative to the ground connection on the worksurface to the ESD ground (instead of several points to the groundable point). All ESDS devices shall be removed from the worksurface while making these measurements.</p> <p>6 If a resistor is used in the circuit, the resistance limit shall include the value of the resistor.</p> <p>7 Use EOS/ESD-S3.1, except a single measurement point can be used for benchtop ionizing systems. Air velocity measurements are not required.</p> <p>8 100K ohms is a suggested lower limit. However a lower value may be used if local safety requirements can still be met.</p> <p>9 Use EOS/ESD-S3.1 except the number of measurement points and locations may be selected based on the application.</p>			

6.2 ESD item check records

Records of the table 2 ESD item checks shall be maintained for a minimum of one year except for continuously monitored items and visual checks that do not require written records.

- a) Compliant resistance and electrical potential measurements may be recorded either as variables (the measured values) or attributes (pass).
- b) Noncompliant measurements must be recorded using variables (the measured values) when the measuring equipment is capable of providing variables. Otherwise, the attribute (fail) must be recorded.

6.3 Personnel grounding

Personnel handling or within twelve (12) inches of unprotected ESDS devices shall be grounded per table 1.

6 Facilities for ESD protected areas and workstations (cont'd)

6.4 Wrist strap and ESD protective footwear resistance path checks

While being worn, the resistance paths of wrist straps, heel/toe straps and conductive shoes shall be independently checked to the table 2 limits for minimum resistance (to provide current limiting characteristics) and maximum resistance (to ensure that adequate body contact is maintained).

6.4.1 Wrist strap resistance measurement path

The wrist strap resistance path is measured from the user's hand, through the user's body, the body-to-strap contact, the integral resistor, the strap wire, to the strap ground connector.

6.4.2 Heel/toe straps and conductive shoes resistance measurement paths

Each heel/toe strap and conductive shoe resistance path shall be individually measured from the user's hand, through the user's body, the body-to-strap/shoe contact, the strap/shoe to the conductive plate.

6.4.3 Wrist strap monitor

When continuous wrist strap monitoring equipment is used, daily wrist strap checks and logs are not required. Corrective actions resulting from monitor alarms shall be documented.

6.5 Electrostatic potential measurements

An electrostatic fieldmeter shall be used to verify that electrostatic potentials are compliant to the table 2 limit.

6.6 ESD signs and labels

6.6.1 Sign content and posting

ESD caution signs shall be posted to clearly indicate the ESD protected area boundaries and workstations to all approaching personnel. These signs should indicate by words and/or symbol that ESD HANDLING IS REQUIRED in the area and/or at the workstation. An example of an acceptable ESD caution symbol is shown in EIA-471.

6.6.2 ESD caution labels for packing and shipping

Each ESD protective package shall have a contrasting ESD caution label. The caution label shall be legible to normal vision at a distance of three feet.

Monochromatic reproduction in any color that contrasts with the background may be used. Where the choice of color is arbitrary, it is suggested that the symbol be black on a yellow background. Wherever possible, the color red for the symbol should be avoided as red suggests a personnel hazard (Reference EIA-471).

6.6 ESD signs and labels (cont'd)

6.6.3 Package ESD caution label content

The label shall clearly indicate by words and/or symbol that ESDS devices are inside the package and that the package may not be opened except at a designated ESD protected area or workstation. An example of an ESD protected package caution label is shown in figure 2.

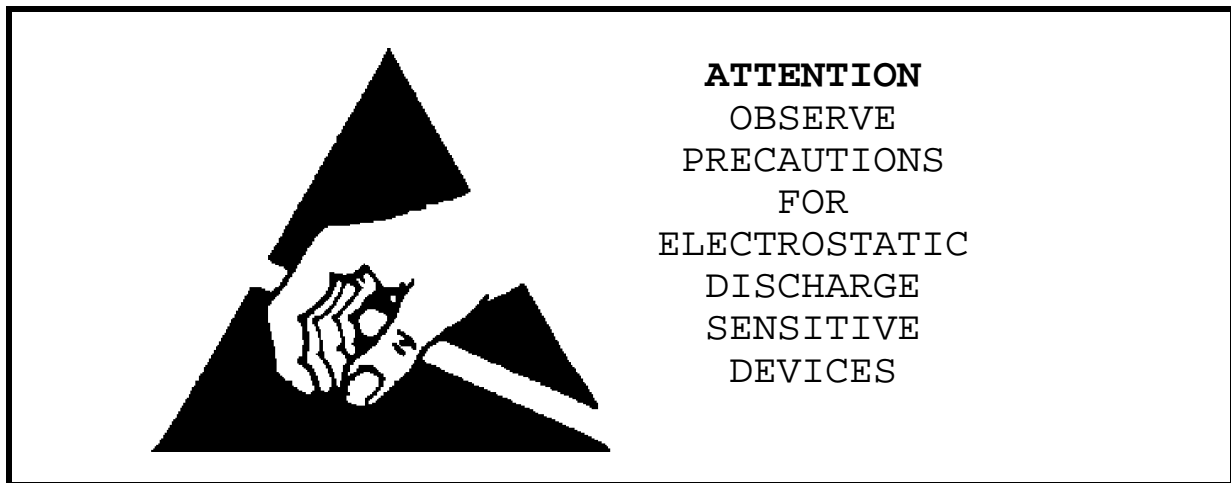


Figure 2 — Example of ESD protected package caution label

6.6.4 Commercial device package ESD caution label

For commercial devices, each ESD protective package shall have an ESD caution label placed in a standard location to ensure that people will be aware that ESDS devices are inside the packages. The ESD caution label on the package may be provided by a preprinted marking on the package or its sealing tape.

6.6.5 Military device package ESD caution label

For military devices, the ESD caution label and its position shall conform to the requirements of MIL-STD-129.

7 Grounding for protection of ESDS devices

7.1 ESD ground

The ESD ground shall be the equipment ground or earth ground. Equipment ground is the electrical ground (green) wire at receptacles that have been tested to and meet the requirements of NFPA-70 or local equivalent.

A typical grounding system for an ESD protected workstation is illustrated in figure 1.

7.1 ESD ground (cont'd)

7.1.1 Earth and equipment ESD grounds

Equipment ground should be used instead of earth ground. When both equipment and earth grounds are used at the same ESD protective workstation they shall be bonded together at some point in the ground system.

7.1.2 Equipment grounding receptacle and conductor testing

The equipment grounding receptacle and conductors shall be tested in accordance with NFPA-70 after being installed or modified and prior to being used.

NOTES

- 1 ESD grounding conditions shall conform to the applicable building, electrical and safety codes and standards.
- 2 The ESD ground systems specified and described in this standard are in accordance with the EOS/ESD-S6.1 which is coordinated with and compliant to ANSI/NFPA-70 and ANSI/IEEE Standard 142 (IEEE Green Book).

7.2 ESD ground system safety review

The Site Safety Engineer (or designated person) should perform a safety review of all new or modified ESD Ground connections at the ESD Protected workstation prior to their initial use.

7.3 ESD protected workstation ESD ground

The design and construction of the grounded ESD protected workstation and associated equipment shall ensure that all external parts, surfaces, and shields of electrical equipment and power tools are at ground potential at all times. Each ESD workstation shall be individually connected to the ESD ground. When more than one ESD worksurface is used at a workstation, each surface shall be individually connected to the ESD ground.

7.4 ESD protective worksurfaces

7.4.1 Static dissipative ESD protective worksurfaces

Static dissipative ESD protective worksurfaces are preferred. A direct connection to ground is recommended. A resistor in the grounding wire is optional.

It is recommended that new and upgraded installations have a resistance to ESD ground of $\geq 10^5$ and $< 10^8 \Omega$.

7.4.2 Conductive ESD protective worksurfaces

Conductive ESD protective worksurfaces should be connected directly to ESD ground.

7.5 ESD Protective flooring/mats

ESD protective flooring/mats are required when floor grounding devices (ESD protective footwear and/or mobile ESD protected workstations) are utilized. ESD protective flooring/mats shall be connected to ESD ground.

ESD protective flooring shall be connected directly to ESD ground. An optional resistor may be used to connect ESD protective floor mats to ESD ground. It is recommended that ESD protective floor mats be connected directly to ESD ground without a series resistor.

7.6 ESD ground connections

Firm fitting connecting devices such as metallic crimps, snaps and banana plugs shall be connected to designated ground points. Wire splices should be crimped or soldered. Use of alligator clips is not recommended.

7.7 Ground wire mechanical considerations

The wire used to connect the ESD ground to equipment ground should be of sufficient strength not to be inadvertently broken or disconnected. The wire should be attached to physical structures to prevent mechanical damage.

7.8 Storage areas

Shelving used as an ESD protected area or workstation shall meet all of the requirements for an ESD protected area or workstation per paragraph 6 and tables 1 and 2.

When the storage shelving is not an ESD protected area or workstation, the ESDS devices shall be in ESD protective packaging.

7.9 Mobile ESD protected workstation

When mobile equipment is used as an ESD protected workstation (e.g., cart, table), it shall be connected to ESD ground and meet the requirements for an ESD protected workstation per table 1 (see 4.12). When a floor grounding device (e.g., drag chain, drag wire, conductive castor) is used to ground a mobile ESD protected workstation, an ESD protective floor/mat is required.

8 ESD Protective packaging requirements for ESDS devices

8.1 ESDS device protective packaging requirement

All ESDS devices shall be packed in ESD protective packaging (see 4.13) when not at an ESD protected area or workstation.

8.2 Packing and filler materials

Packing and filler materials for ESDS devices shall be antistatic or static dissipative.

8.3 Antistatic tubes, trays, magazines and carriers

Antistatic (antistat-solution-treated) tubes, trays, magazines and carriers provide mechanical protection for devices and minimize triboelectric charging. Applying or removing static generating tapes and labels to antistatic tubes, magazines and carriers shall not be done with ESDS devices inside.

NOTE — Typically treated tubes, trays, magazines and carriers tend to lose their static protective properties with use and should be evaluated periodically for acceptable performance.

8.4 Individual finished device carrier materials.

Insulating (see 4.16) carrier materials may be used for individual finished devices (e.g., to allow electrical testing) providing the handling methods minimize triboelectric charging of the carriers and surrounding materials.

8.5 ESDS Device Wafer and Die Packing

ESDS wafers and dice shall be packed using materials that do not triboelectric charge under normal/intended use (antistatic per 4.2).

NOTE — ESD controlled packing materials that will be inside wafer and die containers should be selected to avoid contamination of the devices.

8.6 ESDS device shipping and receiving operations

All ESDS devices must be shipped and received in ESD protective packaging, which must not be opened except at an ESD protected area or workstation.

9 Compliance verification

9.1 ESD coordinator/team

Each site or manufacturing area shall have a designated ESD coordinator/team. The coordinator/team is responsible for assuring that the requirements of this standard are met.

9.2 Auditing

An audit is to be performed for each operation involving the processing, handling or storage of ESDS devices, at least annually to verify compliance with the requirements and recommendations of this standard (see Table 2).

NOTE — The included ESD checklist or a locally controlled equivalent can be used to perform the audit.

9.3 Noncompliance

When noncompliances to the requirements of this standard are found, both the noncompliance and their causes shall be corrected and the corrective actions shall be documented.

9.3 Noncompliance (cont'd)

9.3.1 Noncompliant ESD protected areas and workstations

When noncompliant ESD protected areas and/or workstations are found, no additional devices can be processed through that area and/or workstation until the noncompliance are corrected.

9.3.2 Mishandled ESDS devices

Documented procedures shall define the dispositioning of ESDS devices/ wafers that have **NOT** been continuously handled, packaged and transported according to this standard.

9.3.3 Returning rejected ESDS devices to suppliers

Rejected (e.g., electrical, mechanical) ESDS devices being returned to suppliers, shall be handled and shipped in accordance with the requirements of this standard. When the supplier's original packing materials and containers are noncompliant to this standard, the ESDS devices shall be rejected and returned in the original materials and containers.

9.4 Records

Written records shall be kept of all audits per 9.3 and inspection, measuring and test equipment calibrations for at least 2 years. As a minimum, audit records shall specify what was audited, the auditor's name, date of audit, audit results, corrective actions required (if applicable), and evidence of verification of satisfactory completion of any required corrective actions.

10 ESD handling training

All personnel handling ESDS devices shall receive ESD handling training initially and refresh training as needed to maintain proficiency at least annually thereafter.

NOTE — Personnel entering ESD protected areas should receive ESD awareness training or instructions to stay at least 12 inches away from unprotected ESDS devices.

10.1 Training program

The ESD handling training should include static fundamentals, a review of applicable parts of this specification, and actual applications in the work area.

10.2 Training records

Training records shall be maintained for each individual. As a minimum, the records shall show dates of training, length of training session, topics covered, and the name of the trainer. Records shall be maintained for at least two (2) complete years.

11 Methods for minimizing static charging

Static charge preventive actions shall be utilized at ESD protected areas and workstations where electrostatic potentials greater than ± 1000 volts **ARE** measured **AND** unprotected ESDS devices are within twelve (12) inches of the charged sources.

Charge prevention/neutralization methods include, but are not limited to, antistatic solution treatments, relative humidity control, air ionizers, sleeve protectors, and ESD protective clothing.

11.1 Antistatic solution

Antistatic chemicals (antistat solutions) can be used to prevent static charge generation on static generating/charging materials in the work or storage areas. During application of any antistatic chemical, the user must consider the following:

- a) The antistatic solutions should be chosen to avoid contamination of ESDS devices.
- b) Antistatic spray or solutions must not be applied in any form to energized electrical parts, assemblies, panels, or equipment.
- c) Antistatic solutions should not be applied when devices and/or packages are directly exposed to spray mists.
- d) The need for initial application and frequency of reapplication can only be established through routine electrostatic field measurements during normal operations using an electrostatic fieldmeter.

11.2 Relative humidity control

Relative humidity has a significant impact on the generation of static electricity and its control is recommended where practicable.

NOTE — The recommended minimum humidity is 40% R.H.

11.3 Air ionizers

Air ionizers, when used, shall conform to the following:

- a) Table ionizers shall be positioned so that the devices at the ESD-protected workstations are within the ionizer manufacturer's specified coverage area. The ionizer shall be aimed at the devices and operator's hands rather than at the operator.
- b) Ceiling ionizers shall be oriented in relation to the worksurfaces in accordance with the ionizer manufacturer's instructions.
- c) Devices shall not be brought closer to the ionizer than specified by the ionizer manufacturer.
- d) There shall be an unrestricted, straight line air flow between the ionizers and the unprotected devices.

11 Methods for minimizing static charging (cont'd)

11.3 Air ionizers (cont'd)

- e) Ionizer balance (positive and negative ions) shall be verified per table 2.
- f) Ionizer charge decay performance shall be verified using the method described in EOS/ESD-S3.1 per table 2.

11.4 ESD protective smocks

ESD protective smocks, when worn, shall accomplish the following:

- a) The ESD protective smocks shall be buttoned (except for the collar) whenever the wearer is at an ESD protected workstation or in a designated ESD protected area.
- b) The ESD protective smock manufacturer's cleaning instructions should be followed to gain maximum effectiveness and utility from the smocks.

11.5 Gloves/finger cots

When gloves or finger cots are required, only cotton gloves, antistatic/ conductive gloves, or antistatic/conductive finger cots should be used when handling ESDS devices.

ESD AUDIT CHECKLIST

Area: _____

Date: _____

Auditor: _____

<u>ITEM</u>	<u>Y/N/NA</u>	<u>QUESTIONS (TEXT REFERENCE)</u>
1.	—	Does the calibration system for all inspection, measuring and test equipment used to perform required ESD item checks listed in table 2 meet the requirements of ANSI/ASQC-Q9001/Q9002 and ANSI/NCSL Z540-1? (5.1) The system should include: a) For continuous wrist strap monitors, alarming (audio and/or visual) when a wrist strap exceeds the limits and when there is a broken or missing connection to the user? (5.2b) b) Are the electrostatic fieldmeters used in ionized air streams constructed (e.g., chopper stabilized) to operate in that environment? (5.2c)
2.	—	Where unprotected ESDS devices are handled, are grounded static dissipative (preferred) or conductive worksurfaces used? (table 1-1)
3.	—	Are grounded flooring or floor mats covering the floor areas where personnel or mobile ESD protective workstations are using floor grounding methods? (table 1-2)
4.	—	Is each person handling or within twelve (12) inches of unprotected ESDS devices grounded by either a wrist strap or ESD protective footwear? (table 1-3a, b)
5.	—	When wrist straps are used, are they providing a continuous electrical path from the user's body directly to ESD ground? (table 1-3a1)
6.	—	Do the wrist straps have an integral resistance at the wrist band end of the grounding wire that limits current through that specific path to less than 0.5 mA at the highest power supply voltage that can be encountered? (table 1-3a2)
7.	—	When personnel floor grounding methods are used, does the ESD protective footwear (heel straps, toe straps or conductive shoes) provide a continuous electrical path from both of the user's feet to the ESD protective flooring or floor mat? (table 1-3b1)
8.	—	Are ESD wrist straps used for grounding seated personnel? (table 1-3b4)
9.	—	Are nonessential and personal items kept off of the ESD protective worksurfaces? (table 1-4a)
10.	—	Are the electrostatic potentials generated by essential materials/items less than $\pm 1,000$ volts within twelve (12) inches of unprotected ESDS devices? (table 1-4b)
11.	—	When operations, equipment or clothing are capable of generating electrostatic fields greater than $\pm 1,000$ volts within twelve (12) inches of unprotected ESDS devices, are the electrostatic fields neutralized or reduced to less than $\pm 1,000$ volts? (table 1-4c)
12.	—	When ESD protective smocks are used to prevent clothing generated electrostatic fields greater than $\pm 1,000$ volts from being within twelve inches of unprotected ESDS devices, do the smocks cover all personal garments above the waist except at the neck area? (table 1-5)

ESD AUDIT CHECKLIST

<u>ITEM</u>	<u>Y/N/NA</u>	<u>QUESTIONS (TEXT REFERENCE)</u>
13.	—	When air ionizers used, are electrostatic fields generated by operations, equipment or clothing less than $\pm 1,000$ volts within twelve (12) inches of unprotected ESDS devices? (table 1-6)
14.	—	Are ESD caution signs posted at each ESD protected workstation and/or at the entrances of defined ESD protected areas? (table 1-7)
15.	—	Are the daily ESD item checks of Table 2, Item 1 being performed? (table 2-1)
16.	—	Is data available showing that the recommended weekly, monthly, quarterly, semiannual and annual check items are continuously compliant? (table 2-2 to 6)
17.	—	Are records of ESD item checks maintained for a minimum of one year? (6.2)
		NOTE — Continuously monitored items and visual checks do not require written records. (6.2)
18.	—	Are noncompliant measurements recorded as variables (the measured values) when the measuring equipment is capable of providing variables or as attributes (fail) when the equipment is only providing attributes? (6.2.b)
19.	—	Are the wrist strap and footwear resistance measurement path checks in compliance with the paths described in paragraph 6.4? (6.4)
20.	—	Is an electrostatic fieldmeter used to verify that electrostatic potentials are compliant to the table 2 limit? (6.5)
21.	—	Are ESD caution signs posted to clearly indicate the ESD protected area boundaries and workstations to all approaching personnel? (6.6.1)
22.	—	Does each ESD protective package have an ESD caution label? (6.6.2)
		NOTE — Single color labels in any color that contrasts with the background may be used. (6.6.2)
23.	—	Are the ESD grounds compliant equipment/earth grounds? (7.1)
24.	—	Does the design and construction of the grounded ESD protected workstation and associated equipment ensure that all external parts, surfaces, and shields of electrical equipment and power tools are at ground potential at all times? (7.3)
25.	—	Are static dissipative and conductive ESD protective worksurfaces connected directly to ESD ground or to ESD ground through an optional series resistor? (7.4)
26.	—	When floor grounding devices (ESD protective footwear and/or mobile ESD protected workstations) are being utilized, are compliant ESD protective flooring and/or mats used? (7.5)
27.	—	Are firm fitting connecting devices such as metallic crimps, snaps and banana plugs used for connections to the designated ESD ground points? (7.7)
28.	—	Does shelving that is being used as an ESD protected area or workstation meet all of the requirements for an "ESD protected area or workstation" per paragraph 6 and tables 1 and 2? (7.8)
29.	—	When shelving is NOT an ESD protected area or workstation, are all ESDS devices in ESD protective packaging? (7.8)

ESD AUDIT CHECKLIST

<u>ITEM</u>	<u>Y/N/NA</u>	<u>QUESTIONS (TEXT REFERENCE)</u>
30.	—	When mobile equipment is used as an ESD protected workstation (e.g., cart, table), does it meet the requirements for an ESD protected workstation per paragraph 6 and table 1? (7.9)
31.	—	Are all ESDS devices in compliant ESD protective packaging per paragraphs 4.13 and 8. when not at an ESD protected area or workstation? (8.1)
32.	—	Has an ESD coordinator who is responsible for assuring that the requirements of this standard are met been designated? (9.1)
33.	—	Is an ESD audit performed of each operation that processes, handles or stores ESDS devices at least once a year to verify compliance to all requirements of this standard using the ESD Audit Checklist or an equivalent checklist? (9.2)
34.	—	When noncompliances to the requirements of this standard are found, are: — The noncompliances, their causes and corrective actions corrected and documented? (9.3) — Processing of ESDS devices through noncompliant areas and/or workstations suspended until the noncompliance are corrected? (9.3.1)
35.	—	Are ESDS devices that have NOT been continuously handled, packaged and transported according to this standard dispositioned per documented procedures? (9.3.2)
36.	—	Are rejected (e.g., electrical, mechanical) ESDS devices that are being returned to suppliers, handled and shipped in accordance with the requirements of this standard? (9.3.3)
37.	—	Are written records kept of all audits and ESD equipment calibrations for at least two (2) years? (9.4)
38.	—	Have all personnel handling ESDS devices received ESD handling training initially and at least every 12 months thereafter to maintain proficiency? (10)
39.	—	Are static charge preventive actions utilized at ESD protected areas and workstations where electrostatic potentials greater than $\pm 1,000$ volts ARE measured AND unprotected ESDS devices are within twelve (12) inches of the charged sources? (11)

Annex A Informational/Reference Documents

ASTM-D257	DC Resistance or Conductance of Insulative Materials
ASTM-D991	Rubber Property - Volume Resistivity of Electrically Conductive and Antistatic Products
EOS/ESD-ADV1.0	EOS/ESD Association Glossary of Terms
EOS/ESD-S1	Standard for Protection of Electrostatic Discharge Susceptible Items - Personal Grounding Wrist-Straps
MIL-STD-750	Test Methods for Semiconductor Devices
MIL-STD-883	Test Methods and Procedures for Microelectronics
MIL-STD-1686	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
MIL-PRF-87893	Workstations, Electrostatic Discharge Control
NAVSEA SE 003-AA-TRN-010	Electrostatic Discharge Training Manual

