

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

Contents

	Page
1 Scope	1
1.1 Applicable Users	1
1.2 Applicable Device Types	1
1.3 Personnel Safety.....	1
2 Technical References	2
3 Terms and Definitions	4
4 ESD Control Program	6
4.1 Non-Technical Requirements	6
4.1.1 Program Plan Documentation	6
4.1.2 ESD Program Manager	6
4.1.3 ESD Control Item Qualification	6
4.1.4 Compliance Verification.....	6
4.1.5 Training.....	6
4.1.5.1 Training Program.....	7
4.1.5.2 Training Records.....	7
4.1.6 Component Threshold Plan.....	7
4.1.7 Tailoring.....	7
4.2 Technical Requirements.....	7
4.2.1 Grounding for Protection of ESDS Devices	8
4.2.1.1 Equipment and Auxiliary ESD Grounds.....	9
4.2.1.2 Equipotential Bonding	9
4.2.1.3 ESD Protected Workstation ESD Ground	9
4.2.2 ESD Protective Worksurfaces.....	9
4.2.3 ESD Ground Connections.....	9
4.2.4 Managing Conductor Contact with ESDS (Essential Isolated Conductors)	9
4.2.5 Storage Areas	10
4.2.6 Mobile ESD Protected Workstation.....	10
4.3 Compliance Verification Records.....	14
4.4 ESD Signs and Labels.....	14
4.4.1 ESD Caution Labels for Packing and Shipping	14
4.4.2 Military Device Package ESD Caution Label.....	14

Contents (cont'd)

	Page
5 ESD Protective Packaging and Handling Requirements for ESDS Devices.....	15
5.1 ESDS Device Protective Packaging Requirement	15
5.2 Packing and Filler Materials	15
5.3 Simulated Tribocharging	15
6 Non-compliance.....	15
6.1 Handling Nonconforming Product.....	15
6.1.1 Mishandled ESDS devices	15
Annex A Example Initial Compliance Verifications and Frequencies.....	16
Annex B (Informative) (Example only) ESD Audit Checklist.....	17
Annex C (Informative) Reference Documents	19
Annex D (Informative) Differences between revisions of JESD625	20
 Figures	
Figure 1 — Typical ESD Protected Workstation (Side View)	8
Figure 2 — Example of ESD Protected Package Caution Label (ANSI/ESD 8.1)	14
 Tables	
Table 1 — ESD Grounding Requirements	8
Table A — Recommended Compliance Verifications and Frequencies.....	16

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

(From JEDEC Board ballot JCB-22-33, formulated under the cognizance of JEDEC JC-14.1 Committee on Reliability Test Methods for Packaged Devices and JEDEC JC-13 Government Liaison.)

1 Scope

This standard applies to devices susceptible to damage by electrostatic discharge greater than 100 volts human body model (HBM) and 200 volts charged device model (CDM). Processes that include items susceptible to lower withstand voltages may require additional control elements or adjusted limits. Processes designed to handle items with a lower ESD withstand voltage can still claim compliance to this standard. Device sensitivity to ESD is determined by test methods for Human Body Model (ANSI/ESDA JEDEC JS-001) and Charged Device Model (ANSI/ESDA JEDEC JS-002) or equivalent.

1.1 Applicable Users

- a) Semiconductor Manufacturers - from wafer processing through shipment of finished devices.

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

- b) Semiconductor Processing/Testing Facilities - from receipt through shipment of finished devices. The requirements apply to all ESDS devices until they are considered scrap.

NOTE ESDS Device Distributors and Users may use this standard or ANSI/ESD S20.20

1.2 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, hybrids, multi-chip modules, optoelectronic devices, thin film passive devices and any device identified as ESD sensitive by the suppliers.

1.3 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.

2 Technical References

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

ANSI/ESD-S1.1	ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items – Wrist-Straps
ANSI/ESD-S6.1	ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items – Grounding
ANSI/ESD-S8.1	ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items – Symbols
ANSI/ESD-S13.1	ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items – Electrical Soldering/Desoldering Hand Tools
ANSI/ESD-S541	ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items – Packaging Materials
ANSI/ESD-STM2.1	ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items – Garments – Resistive Characterization
ANSI/ESD-STM3.1	ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items – Ionization
ANSI/ESD-STM4.1	ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items - Worksurfaces – Resistance Measurements
ANSI/ESD-STM7.1	ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items – Floor Materials – Resistive Characterization of Materials
ANSI/ESD-STM9.1	ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items – Footwear – Resistive Characterization
ANSI/ESD-STM11.11	ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items – Surface Resistance Measurements of Planar Materials
ANSI/ESD-STM12.1	ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items – Seating – Resistance Measurement
ANSI/ESD-STM97.1	ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items – Footwear/Flooring System – Resistance Measurement in Combination with a Person

2 Technical References (cont'd)

ANSI/ESD-STM97.2	ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items – Footwear/Flooring System – Voltage Measurement in Combination with a Person
ANSI/ESD-SP9.2	Standard Practice for the Protection of Electrostatic Discharge Susceptible Items – Foot Grounders – Resistive Characterization
ANSI/ESDA/JEDEC JS-001	Human Body Model (HBM) Electrostatic Discharge (ESD) Sensitivity Testing Standard
ANSI/ESDA/JEDEC JS-002	Field Induced Charged Device Model Test Method for Electrostatic Discharge Withstand Threshold for Microelectronic Devices
ESD TR20.20	ESD Association Technical Report – Handbook for the Development of an Electrostatic Discharge Control Program for the Protection of Electronic Parts, Assemblies and Equipment
ESD TR53-01	ESD Association Technical Report for the Protection of Electrostatic Discharge Susceptible Items – Compliance Verification of ESD Protective Equipment and Materials
JESD471	Symbol and Label for Electrostatic Sensitive Devices
MIL-STD-129	Marking for Shipment and Storage

3 Terms and Definitions

For the purpose of this standard the following definitions apply.

auxiliary ground: A separate supplemental ground conductor for use other than general equipment grounding.

charged device model (CDM): An ESD stress model that approximates the discharge event that occurs when a charged component is quickly discharged to another object at a different electrostatic potential through a signal pin or terminal as specified in ANSI-ESD-JEDEC JS-002.

conductive material: A material that has a surface resistance less than 1×10^4 ohms or a volume resistance less than 1×10^4 ohms.

NOTE A conductive material is not necessarily low charging.

conductive worksurface: A surface whose material is made of conductive material such as stainless steel typically found in a cleanroom.

NOTE Reference Table 2.

electrostatic charge: Electric charge at rest.

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

ESDS device: Electrostatic-discharge-sensitive device.

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

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

ESD control item: Any fabricated or purchased item that provides some form of protection of ESDS devices from damage due to ESD during handling in manufacturing shipment or field use.

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.

EPA: A defined location with the necessary materials, tools, and equipment capable of reducing static electricity to a level that minimizes damage to ESD susceptible items.

ESD protected workstation: A work position with the necessary materials, tools and equipment capable of controlling static electricity to a level that minimizes damage to ESD susceptible items.

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

3 Terms and Definitions (cont'd)

ESD-protective worksurface: A table top or other surface that minimizes damage to ESD-susceptible items.

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.

human body model: An ESD event meeting the waveform criteria specified in ANSI/ESDA/JEDEC JS-001, approximating the discharge from the fingertip of a typical human being to a grounded component

insulative material: A material having a surface or volume resistance equal to or greater than 1×10^{11} ohms.

Low charging: A user defined level that will ensure that ESDS items will not be charged excessively (produces unacceptable risk of discharge). For more detail, reference ANSI/ESD-S541.

protected ESDS device: Any ESDS device that is within its ESD protective covering or packaging

static dissipative material: A material having a surface resistance between 1×10^4 ohms and 1×10^{11} ohms or a volume resistance between 1×10^4 ohms and 1×10^{11} ohms centimeters.

NOTE A static dissipative material is not necessarily low charging.

static dissipative worksurfaces: Worksurfaces intended for CDM/CBE control such as ESD work mats.

NOTE Reference Table 2.

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

NOTE Surface resistance is expressed in ohms.

triboelectric charging: The generation of electrostatic charges when two pieces of different material in intimate contact are separated (where at least one 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.

unit level protective packaging: Packaging that is in intimate contact with the ESDS device.

unprotected ESDS device: Any ESDS device without ESD protective covering or packaging.

volume resistance: The ratio of the DC voltage to current passing between two electrodes, of a specified configuration, that contact opposite sides of the material or object under test.

NOTE Volume resistance is expressed in ohms.

ESD protective worksurface: Any surface where any work or process can be performed on unprotected ESDS items. Reference Figure 1.

4 ESD Control Program

4.1 Non-Technical Requirements

4.1.1 Program Plan Documentation

An ESD Control Program Plan shall be documented in the organization's quality management system which addresses the elements of the program as described in this standard.

4.1.2 ESD Program Manager

An ESD Program Manager or Coordinator shall be assigned by the organization. The responsibility of the Program Manager or Coordinator shall be to ensure compliance to the elements of this standard.

4.1.3 ESD Control Item Qualification

All ESD Control Items shall be qualified for use. The requirements for product qualification are more extensive than the periodic checks made in a production facility. In some case the evaluations are done by third parties or by the item vendors. The requirements and referenced standards are given in Table 2. Ideally these evaluations are done during the product selection process and prior to full deployment. Qualification of previously installed items may be established using previously collected on-going compliance verification data that confirms the consistent performance of the item. When ongoing compliance verification is used for qualification, the qualification is only valid for the facility where compliance verification was performed. Qualification of items applies to a specific product and supplier.

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

4.1.4 Compliance Verification

The on-going performance of each specified item shall be demonstrated through a compliance verification plan. The test procedures and performance levels are also given in Table 2. The plan shall include test frequencies and a process for maintaining compliance verification records. An example (not required) set of test frequencies is given in Annex A.

4.1.5 Training

All personnel who handle ESDS devices shall receive ESD handling training prior to handling ESDS devices. The frequency for ESD refresh training shall be defined in the ESD control program. It is recommended to perform refresh training at least once every 24 months. Personnel entering ESD protected areas shall be trained or accompanied by personnel who are trained. Training shall include a method for ensuring comprehension.

4.1.5.1 Training Program

The ESD handling training should include awareness of ESD impact on product, electrostatic fundamentals, a review of applicable parts of this specification, and actual applications in the work area. The type of training used may be determined by the Organization and shall be documented in the training plan.

4.1.5.2 Training Records

Training records shall be maintained for each person. The records shall show dates of training and any test results if applicable. Records shall be maintained for at least two (2) complete years or as prescribed by the company quality management system.

4.1.6 Component Threshold Plan

It is highly recommended to establish a plan designed to determine, prior to initial use, that ESDS component thresholds are within the scope of this document. This plan does not apply to ESDS components in use by the Organization before the adoption of this standard.

4.1.7 Tailoring

The organization performing to this document may have reasons for making changes that relax some or all of the requirements herein. The rationale and technical justification for these changes shall be documented in the ESD Control Plan. Where required by contract, approval from the contracting organization or qualifying activity shall be obtained.

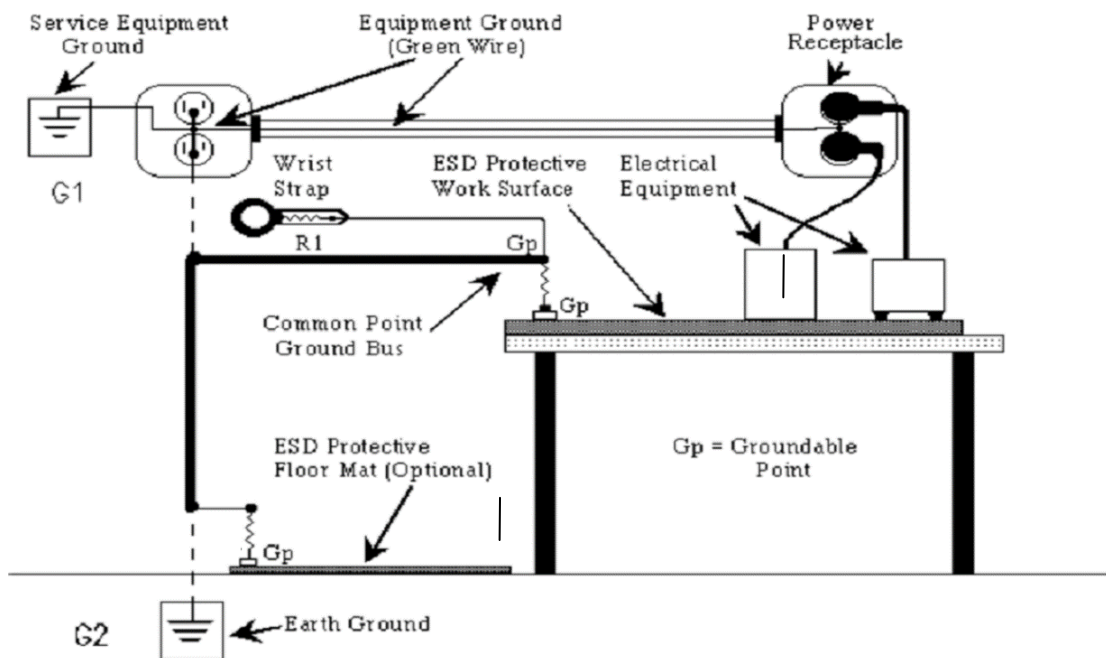
4.2 Technical Requirements

The minimum ESD control plan technical requirements are:

- methods and limits for the qualification and periodic compliance verification of all ESD control items defined in the program plan,
- proscribed methods for grounding of workstations and other surfaces that ESDS devices may contact,
- proscribed methods for grounding of personnel,
- plan for handling static generating insulators,
- plan for handling isolated conductors, and
- packaging plan.

4.2.1 Grounding for Protection of ESDS Devices

A typical grounding system for an ESD protected workstation is illustrated in Figure 1. ESD grounding requirements can be found in Table 1.



NOTE 1 G1 (equipment ground) or G2 (auxiliary ground) is acceptable for ESD ground.

NOTE 2 R1 is specified in table 2 for all wrist straps.

NOTE 3 See 4.2.1 of this standard for grounding details (Reference ANSI/ESD-S6.1).

Figure 1 — Typical ESD Protected Workstation (Side View)

The ESD ground shall be one of the implementing systems described in Table 1. Equipment ground is the electrical ground conductor at receptacles that has been tested to and meets the requirements of ANSI/ESD S6.1 or the applicable national electrical code. Verification that the ground receptacles meet these requirements shall be established at the time of qualification/installation of a given workstation.

Table 1 — ESD Grounding Requirements

Grounding Method	Installation Verification	
	Test Method	Requirement
Grounding / Bonding (See Figure 1) Three means for grounding are permitted		
Equipment Grounding Conductor (G1) (preferred)	ANSI/ESD S6.1	< 1.0 ohm impedance
Auxiliary Ground (G2)	ANSI/ESD S6.1	< 25 ohms to ECG (see 4.2.1.1)
Equipotential Bonding	ANSI/ESD S6.1	< 1.0×10^9 ohms (resistance between ESD control item and closest ground connection) (see 4.2.1.2)

4.2.1.1 Equipment and Auxiliary ESD Grounds

Equipment ground is preferred. When an auxiliary ground is used it shall be bonded to the service equipment ground in accordance with applicable national electrical code. If the national electrical code does not specify a requirement, then the resistance between the equipment grounding conductor and auxiliary ground shall not exceed 25 ohms.

4.2.1.2 Equipotential Bonding

In the cases where no ground is available, it is permissible to use equipotential bonding. In equipotential bonding, all ESD technical elements, the personnel within the work area, and the equipment under service are electrically connected, thus equalizing electrical charges between the items to allow safe handling of ESD susceptible items.

4.2.1.3 ESD Protected Workstation ESD Ground

Each ESD workstation shall be individually connected to the ESD ground. “Daisy chaining” is not permitted. When more than one ESD worksurface is used at a workstation, each surface shall be connected to a common point which is then connected to the ESD ground.

4.2.2 ESD Protective Worksurfaces

Two types are defined, dissipative worksurfaces (preferred) that provide removal of charge from items placed on the surface AND limits discharge current and conductive worksurfaces that provide charge removal only.

Conductive Worksurfaces - These surfaces may be used when required as long as use is compliant with the facility’s safety requirements. The more conductive a surface is the greater the attention required to charge on devices.

4.2.3 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 for ground connections should be avoided.

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.

4.2.4 Managing Conductor Contact with ESDS (Essential Isolated Conductors)

In the absence of other considerations, all conductors shall be grounded. The goal is to have zero potential difference between metals that come into contact.

NOTE The term conductor refers to the definition used in this document wherein the resistance is $< 10^4$ ohms.

4.2.4 Managing Conductor Contact with ESDS (cont'd)

When an essential conductor cannot be grounded one of the following options must be followed:

- Provide an intervening dissipative material with resistance 10^6 to 10^9 ohms. Examples of this are worksurfaces and hand tools. If this is not practical:
- Assure that the absolute potential difference between the conduct and the ESDS is less than 35 volts.

Ionization or other charge mitigating techniques shall be used if the 35 volts cannot be met.

A device that is approaching a conductive worksurface may be considered an isolated conductor.

4.2.5 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 4.2.1, Table 1 and Table 2.

When the storage shelving does not meet these requirements, the ESDS devices shall be in ESD protective packaging.

4.2.6 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 2. Grounding requirements are listed in Table 1.

Table 2 — Minimum Requirements for ESD Protected Areas and Workstations.

ITEM	Product Qualification		Compliance Verification	
	Method	Requirement	Method	Requirement
1. ESD Protective Worksurface	Two types are defined: Dissipative Worksurfaces - provide removal of charge from items placed on the surface AND limits discharge current Conductive Worksurfaces - provide charge removal only ¹⁾			
a. Dissipative Worksurface (preferred requirement)	ANSI/ESD STM4.1	a) Point-to-point resistance greater than or equal to 10^6 ohms and less than 10^9 ohms. b) Point-to-groundable-point resistance greater than or equal to 10^6 ohms and less than 10^9 ohms.	ESD TR53	Point to ground resistance less than 10^9 ohms.
b. Conductive Worksurface	ANSI/ESD STM4.1	a) Point-to-point resistance less than 10^6 ohms. b) Point-to-groundable resistance less than 10^6 ohms.	ESD TR53	Point to ground resistance less than 10^9 ohms.

Table 2 — Minimum Requirements for ESD Protected Areas and Workstations (cont'd)

	Method	Requirement	Method	Requirement
2. Personnel Grounding	<p>Each person handling 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 continuous electrical path from the user 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. This requirement should be reviewed by the facility safety organization. 3) Be worn by operators handling unprotected ESDS devices when seated. <p>b) ESD protective footwear (heel straps, toe straps, and 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 through that specific path to ground appropriate for the highest power supply voltage that may be encountered. <p>ESD protective footwear shall <u>NOT</u> be relied upon for grounding of seated personnel.</p>			
a. Wrist Strap System	ANSI/ESD S1.1 (Section 6.11)	$< 3.5 \times 10^7$ ohms	ESD TR53	$< 3.5 \times 10^7$ ohms
b. Footwear/Flooring System	ANSI/ESD STM97.1 AND	$< 1.0 \times 10^9$ ohms	ESD TR53	$< 1.0 \times 10^9$ ohms ²⁾
	ANSI/ESD STM97.2	< 100 volts peak	N/A	N/A ³⁾
a. Wrist Strap	ANSI/ESD S1.1	0.8×10^6 to 1.2×10^6 ohms	N/A	N/A
b. Wrist Band	ANSI/ESD S1.1	Interior $< 1 \times 10^5$ ohms	N/A	N/A
		Exterior $< 1 \times 10^7$ ohms	N/A	N/A
c. Personnel Ground wrist strap connection (non-monitored)	ANSI/ESD S6.1	Point to Ground < 2 ohms	ESD TR53	Point to Ground < 2 ohms
d. Footwear	ANSI/ESD STM9.1	Point to Groundable Point $< 1.0 \times 10^9$ ohms	ESD TR53	System resistance $< 1 \times 10^9$ ohms
e. Foot Grounders	ESD SP9.2	Point to Groundable Point $< 1.0 \times 10^9$ ohms		
f. Flooring/Floor Mats	ANSI/ESD STM7.1	a) Point to Groundable Point $< 1.0 \times 10^9$ ohms b) Point to Point $< 1.0 \times 10^9$ ohms	ESD TR53	Point to Ground $< 1.0 \times 10^9$ ohms
g. Seating	ANSI/ESD STM12.1	Point to Groundable Point $< 1.0 \times 10^9$ ohms	ESD TR3	Point to Ground $< 1.0 \times 10^9$ ohms

Table 2 — Minimum Requirements for ESD Protected Areas and Workstations (cont'd)

	Method	Requirement	Method	Requirement
3. Static Generating Sources and Charged Surfaces	Simulated Tribocharging – Refer to section 5.3			
a)	Nonessential and personal items shall not be placed on ESD protective worksurfaces. (Items which are essential are determined by the process engineer and/or ESD coordinator)			
b)	For essential insulators within 2.5 cm (1.0 inch) of unprotected ESDS devices the measured electrostatic field shall be less than ± 50 volts/cm (± 125 volts/inch).			
c)	For essential insulators within 30cm (12 inches) of unprotected ESDS devices the measured electrostatic field shall be less than ± 400 volts/cm (± 1000 volts/inch).			
d)	If an essential insulator does not meet the requirements of b or c, it shall be neutralized or reduced to meet the required values.			
e)	Simulated Tribocharging: The ESD Coordinator and process engineer may in addition establish triboelectric charging simulations for assessing static generators. See section 6.4.			
4. Ionization	ANSI/ESD STM3.1 (See also ESD TR20.20 Section 13)	Decay Time User Defined	ESD TR53	Decay Time determined in Qualification
		Offset: $-35 < V < +35$	ESD TR53	$-35 < V < +35$
5. Static Control Garment(optional)	ANSI/ESD STM2.1 (See also ESD TR20.20 Section 18)	Point to Point $< 1 \times 10^{11}$ ohms	ESD TR53	Point to Point $< 1 \times 10^{11}$ ohms When ESD protective smocks are used they shall be worn in accordance with manufacturer's or local requirements.
a. Groundable Static Control Garment(optional)	ANSI/ESD STM2.1 (See also TR20.20 Section 18)	Point to Groundable Point $< 1.0 \times 10^9$ ohms	ESD TR53	Point to Groundable Point $< 1.0 \times 10^9$ ohms When ESD protective smocks are used they shall be worn in accordance with manufacturer's or local requirements.
b. Groundable Static Control Garment System(optional)	ANSI/ESD STM2.1 (See also ESD TR20.20 Section 18)	$< 3.5 \times 10^7$ ohms	ESD TR53	$< 3.5 \times 10^7$ ohms When ESD protective smocks are used they shall be worn in accordance with manufacturer's or local requirements.

Table 2 - Minimum Requirements for ESD Protected Areas and Workstations (cont'd)

	Method	Requirement	Method	Requirement
6. ESD Protected Area (EPA)				
a) ESD caution indicators shall be used to clearly indicate the ESD protected area boundaries and workstations to all approaching personnel. These could be signs, identifying tape or marked physical barriers. These should indicate by words and/or symbol that ESD HANDLING IS REQUIRED in the area and/or at the workstation.				
7. Electrical Soldering/Desoldering hand tools	ANSI/ESD S13.1	Tip to Ground < 2.0 ohms	ESD TR53 or ANSI/ESD S13.1 Section 6.1	Tip to Ground < 10 ohms
		Tip < 20 millivolts		
		Tip leakage < 10 milliamps		
8. Continuous Monitors	User Defined (See also TR20.20 Section 16)	User Defined	ESD TR53	Manufacturer Defined
9. Packaging				
a. Conductive Packaging	ANSI/ESD STM11.11 or ANSI/ESD STM11.12 or ANSI/ESD STM11.13	< 1×10^4 ohms	ESD TR53 Packaging Section	< 1×10^4 ohms
b. Dissipative Packaging	ANSI/ESD STM11.11 or ANSI/ESD STM 11.12 or ANSI/ESD STM11.13	1×10^4 to 1×10^{11} ohms	ESD TR53 Packaging Section	1×10^4 to 1×10^{11} ohms
c. Discharge Shielding (Bags only)	ANSI/ESD STM11.31	< 20 nJ	ESD TR53 Packaging Section	1×10^4 to 1×10^{11} ohms
¹⁾ Other Surfaces (when used to store unprotected ESDS). These include Shelving, Mobile Equipment and any other surface designated for placement/storage of ESDS without their protective packaging. See section 5.2 for more details. ²⁾ In some cases, lower limit may be needed for safety considerations. Reference §Personnel Safety. ³⁾ It is recommended to periodically perform the walking voltage test per ANSI/ESD STM97.2.				

4.3 Compliance Verification Records

Compliance verification records shall be kept as defined by the company's quality management system. If there is no quality management system requirement, records shall be kept for a minimum of 2 years.

As a minimum, compliance verification records shall specify what was audited, date of audit, audit results, corrective actions required (if applicable), and evidence of verification of satisfactory completion of any required corrective actions.

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

4.4 ESD Signs and Labels

4.4.1 ESD Caution Labels for Packing and Shipping

Each unit level ESD protective package shall have a contrasting ESD caution label. The caution label shall be legible to normal vision. An ESD susceptibility or protective symbol in JESD471 or ESD S8.1 is recommended. The ESD caution label shall be 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. Customer requirements shall supersede the requirements above. An example of an ESD protected package caution label is shown in Figure 2.

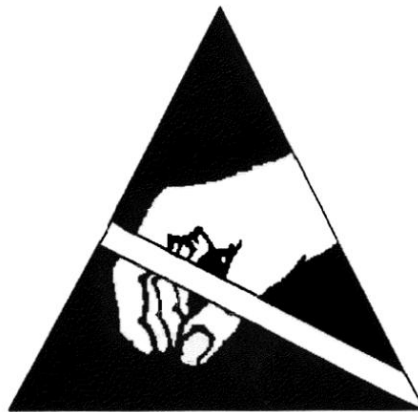


Figure 2 — Example of ESD Protected Package Caution Label (ANSI/ESD 8.1)

4.4.2 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.

5 ESD Protective Packaging and Handling Requirements for ESDS Devices

5.1 ESDS Device Protective Packaging Requirement

When not at an ESD protected area or workstation, all ESDS devices shall be packed in ESD protective packaging in accordance with ANSI/ESD S541. In addition, the surface resistance of packaging that will contact devices shall have a minimum resistance of 10^4 ohms when measured using ANSI/ESD STM11.11, STM11.12, or STM 11.13. (Note: ANSI/ESD S541 permits the use of highly conductive materials, which are not recommended).

5.2 Packing and Filler Materials

Packing and filler materials for ESDS devices shall be low charging and static dissipative. Packaging and filler materials that are part of the unit level packaging shall be static dissipative.

5.3 Simulated Tribocharging

The ESD Coordinator and process engineer may establish triboelectric charging simulations for assessing whether a given material could, under normal operating conditions, reach an electric field greater than 50 volts/cm (125 volts/inch). Use of materials which exceed this level shall require air ionization neutralization or specific process capability analysis that ensures the charged item will not cause ESD discharges/damage or removal or substitution of the material.

6 Non-compliance

When non-compliances to the requirements of this standard occur, they shall be addressed according to company's quality management procedures.

6.1 Handling Nonconforming Product

All non-conforming material shall be handled in accordance with the ESD control program until the product is considered non-customer shippable.

6.1.1 Mishandled ESDS devices

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

Annex A Example Initial Compliance Verifications and Frequencies

Table A can be used as a guide when determining the compliance verification plan of ESD control items. Users can tailor these recommendations to meet the needs of their ESD control program.

Table A — Recommended Compliance Verifications and Frequencies

FREQUENCY (see NOTES 1, & 2)	ITEMS (see NOTE 9)
1. Recommended Prior To First Use of Each Day	a) Wrist strap system (see Notes 3) (when continuous monitors are not in use.) b) ESD protective footwear (see Note 4). c) Visual verification of personnel ESD protective smock (e.g., buttoned smocks) on personnel. (see Note 8). d) Visual verification of wrist straps and/or ESD protective footwear on personnel. (see Note 8).
2. Recommended Weekly	a) Visual verification of ESD protected workstation. (e.g., ground connections, mat cleanliness) b) Visual verification of ESD protective floor mat (e.g., cleanliness and freedom from tears). c) Visual verification of ESD ground connections (e.g., wrist straps, mat ground wires).
3. Recommended Monthly	a) Ionizer balance (see Note 6 & 10). b) Ionizer charge decay performance (See Note 7 & 10). c) ESD protected area and workstation static voltage surveys of insulators and E-field sources. d) Wrist strap monitor check. e) ESD testing of smocks
4. Recommended Quarterly	a) Dissipative Worksurface and mobile equipment - ESD protective worksurface to ESD ground resistance (See Note 5). b) Conductive Worksurface and mobile equipment - ESD conductive worksurface to ESD ground resistance. (see Note 5). c) ESD protective floor/mat to ESD ground resistance. (see Note 6). d) Auxiliary ground resistance, if present, to equipment ground connection
NOTE 1 The ESD Item check frequencies should be established to ensure that the items remain compliant between checks. NOTE 2 The ESD item checks shall be performed more frequently than listed when compliance is not continuously maintained and less frequently when data supports it. NOTE 3 This test will be performed without gloves even if gloves are worn by the operator in production. NOTE 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. NOTE 5 Use ESD TR53 except make additional measurements where ESDS devices are placed. NOTE 6 Use ESD TR53, except measurements should be taken at the minimum and maximum locations of work activity. NOTE 7 Use ESDTR53, except the number of measurement points and locations may be selected based on the application. NOTE 8 ESD protective equipment shall be worn where required. NOTE 9 This is not a comprehensive list of all items that may be used in one's ESD program. Evaluation of other items may need be added. NOTE 10 Measurements should be taken before and after any needed cleaning.	

Annex B (Informative) (Example only) ESD Audit Checklist

Area: _____ Date: _____

Auditor: _____

<u>ITEM</u>	<u>Y/N/NA</u>	<u>QUESTIONS (TEXT REFERENCE)</u>
1.	—	Are all ESD measurement devices required by this standard calibrated?
2.	—	Are ESD items checked in accordance with the compliance verification plan defined in the ESD Control Program? (Annex A)
3.	—	Are there records showing that the frequency of compliance verifications as defined in the ESD Control Plan are being performed. (Annex A)
4.	—	Are records of ESD item checks maintained? (4.3) Note that continuously monitored items and visual checks do not require written records. (4.3)
5.	—	Are noncompliant measurements recorded as variables (the measured values) when the measuring equipment can provide variables or as attributes (pass/fail) when the equipment can only provide attributes? (4.3.b)
6.	—	Where unprotected ESDS devices are handled? Are they handled in a defined electrostatic protected area?
8.	—	Is each person handling unprotected ESDS devices properly grounded by either a wrist strap or an ESD flooring/footwear system? (Table 2)
9.	—	Have all ESD control items been qualified according to the requirements of this document? (Table 2)
10.	—	Are ESD wrist straps used for grounding seated personnel? (Table 2)
11.	—	Are nonessential and personal items kept off ESD protective worksurfaces? (Table 2)
12.	—	Has a documented plan been implemented for process-required insulators? (Table 2)
13.	—	Does the insulator plan include methods to neutralize or reduce electrostatic fields to acceptable levels when needed? (Table 2)
14.	—	When ESD protective smocks are used are they worn in accordance with manufacturer's or local requirements.? (Table 2)
15.	—	Are ESD protected areas identified with appropriate signs or markings? (Table 2)
16.	—	Does each ESD protective package have an appropriate ESD caution label? (4.5)
17.	—	Are the ESD grounds compliant with one of the three methods defined in Table 1?
18.	—	Are all ESD protected workstations and worksurfaces individually connected to the defined ESD ground? (4.2.1.1 – 4.2.1.3)

<u>ITEM</u>	<u>Y/N/NA</u>	<u>QUESTIONS (TEXT REFERENCE)</u>
19.	—	Are the specified ground connections used when grounding ESD worksurfaces? Are firm fitting connecting devices such as metallic crimps, snaps and banana plugs used for connections to the designated ESD ground points where applicable? (4.2.2.1.1)
20.	—	Does shelving that is being used for unprotected ESD sensitive items meet all of the requirements for an "ESD protected area or workstation"? (4.2.2.2) (Tables 2)
21.	—	When mobile equipment is used as an ESD protected workstation (e.g., cart, table), does it meet the requirements for an ESD protected workstation? (4.2.2.3) (Table 2)
22.	—	Are all ESDS devices in compliant ESD protective packaging per ANSI/ESD S541 when not at an ESD protected area or workstation? (6.1)
23.	—	Has an ESD Program Manager or Coordinator been designated? (4.1.2)
24.	—	Is the compliance verification being performed to the documented plan on a periodic basis? (4.1.4) Does the compliance verification plan cover each ESD control items? (4.1.4)
25	—	Is there documentation justifying the compliance verification frequencies chosen? Have all personnel handling ESDS devices received ESD handling training initially and at least every 24 months thereafter to maintain proficiency? (4.1.5)
26.	—	Does the ESD control plan cover all applicable operations and process that handle or store ESDS devices?
27.	—	When non-compliances to the requirements of this standard are found, are: processing of ESDS devices through non-compliant areas and/or workstations suspended until the non-compliances are corrected? (6.1)
28.	—	rejected (e.g., electrical, mechanical) ESDS devices that are being returned to suppliers handled and shipped in accordance with the requirements of this standard (unless specified otherwise)? (6.1)

Annex C (Informative) Reference Documents

EOS/ESD-ADV1.0	ESD Association Advisory for Electrostatic Discharge Terminology – Glossary
ANSI/ESD-S20.20	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/ESDA/JEDEC JS-001	Human Body Model (HBM) Electrostatic Discharge (ESD) Sensitivity Testing Standard
ANSI/ESDA/JEDEC JS-002	Field Induced Charged Device Model Test Method for Electrostatic Discharge Withstand Threshold for Microelectronic Devices
MIL-STD-750	Test Methods for Semiconductor Devices
MIL-STD-883	Test Methods and Procedures for Microelectronics
MIL-PRF-87893	Workstations, Electrostatic Discharge Control
NAVSEA SE 003-AA-TRN-010	Electrostatic Discharge Training Manual

Annex D (Informative) Differences between revisions of JESD625

This annex briefly describes most of the change history of JESD625. If the change to a concept involves any words added or deleted (excluding deletion of accidentally repeated words), it is included. Some punctuation changes are not included.

Differences Between JESD625B and JESD625A

Clause	Description of change
1&2	Per JM7, clause 1 and 2 were combined. Subsequently all clauses were renumbered. The clauses highlighted in this annex refer to their number in JESD625A, followed by the clause number used in this revision.
2.1/1.1	Applicable users were limited to semiconductor manufacturers and processing/testing facilities. Distributors and Users are given option of using ANSI/ESD S20.20
2.2/1.2	Optoelectronic devices were added to applicable device types
2.3/1.3	Personnel safety was moved to Clause 2
3/2	Applicable documents were updated
4/3	Definitions were added for auxiliary ground, conductive material resistance, electrostatic discharge shielding. Definitions were removed for conductive material resistivity, electrostatic shielding. Definitions for ESDS, equipment ground, ESD ground, ESD-work area, ESD-protected workstation, ESD protective worksurface, insulative material, static dissipative material, static electricity, triboelectric charging, volume resistivity were modified.
5/4	Section on calibration was removed since this is a function of the facility quality and maintenance system
5.1/4.1	Continuous e-field monitors were added. Requirements on acceptable electric fields near sensitive devices were added
6.1/5.1	<p>The following changes were made in Table 1 (Minimum requirements for ESD protected areas and workstations):</p> <ol style="list-style-type: none"> 1. Static dissipative range was established for protective worksurfaces. Conductive surfaces are allowed but not recommended 3. Specific current limit removed 4. Maximum electrostatic fields specified at 2.5cm and 30cm. 7. Equipment and bonding requirements per ANSI/ESD S6.1 added <p>Air ionization removed from this Table 1 because it did contain a specific minimum requirement</p> <p>Figure 1 was modified to show preference for using equipment rather than auxiliary (formerly called “earth”) ground.</p>

Annex D Differences Between JESD625B and JESD625A (cont'd)

Clause	Description of change
6.2/5.2	This section heading was added – Compliance Verification Baseline. The following changes were made in Table 2 (ESD protective item checks) 3. Monthly checks – Modified electrostatic field checks 4. Quarterly checks – ESD ground continuity changed from 1 ohms to 2 ohms Removed NOTE on measuring resistor in the worksurface to ground connection as these resistors are not recommended
6.5.3/5.5.3	Continuous wrist strap and workstation monitors – This section was expanded to add monitor types
6.5.4/5.5.4	ESD Protective Smocks was moved from clause 11
6.6/5.6	Air Ionization Deployment was moved from clause 11
6.7.1/5.7.1	Reference to EIA-471 ESD caution symbol was removed.
6.7.2/5.7.2	Reference to ANSI/ESD S8.1 ESD caution symbol was added
7.1/6.1	Reference to NFPA-70 replaced by ANSI/ESD S6.1
7.1.1/6.1.1	Referenced to earth ground replaced by auxiliary ground. Bonding resistance between equipment and auxiliary ground is specified
7.1.2/6.1.2	NOTE 2 removed. Relevant standards are quoted in other sections
7.2/6.2	Section on Safety Review moved to note in this section
7.3/6.3	Worksurface resistance ranges updated and consistent with Table 1. Note added explaining that there should not be a discrete resistor in the path to ground
8.3/7.3	Term “antistatic” removed. Note on shelf life moved to body of section. Section on Wafer and die packing removed. Other parts of this section cover die and wafers are out of scope.
9.2/8.2	Title changed from <i>Auditing</i> to <i>Frequency</i> . Note referring to checklist removed.
10/9	Maximum re-training interval changes from one to two years. Note removed.
11/10	Air ionization and ESD protective smocks sections moved to Section 6
12/11	Audit Checklist modified to be compatible with changes in the document

Differences Between JESD625C and JESD625B

Clause	Description of change
TOC	Revised to include new sections and reflect new placement of existing sections
1	Entire section revised. Included specific HBM and CDM voltage levels standard applies to, possible additional needs for processes with lower withstand voltages, and compliance of existing programs designed to handle items with lower withstand voltages.
1.1a	Changed wafer electrical probe to wafer processing. Note revised to indicate that “some” requirements of this standard are not “applicable” prior to probe.
1.1b	Included statement that all requirements apply to ESDS devices until they are considered scrap. Note 2 removed and added to 1.1b
1.2	Included hybrid devices and any devices suppliers identify as ESD sensitive.
2	Updated and included all technical references in document
3	Removed all terms not used in document. Added/updated definitions for Charge Board Event, Charged Device Model, conductive material, conductive worksurface, ESD control item, EPA, Human Body Model, protected ESDS device, static dissipative material, static dissipative worksurface, unit level protective packaging, volume resistance, and worksurface.
4	Changed from “Inspection, measuring, and test equipment” to “ESD Control Program”.
4.1	Changed from “Recommended inspection ,measuring, and test equipment types” to “Non-Technical Requirements”.
4.1.1	New section “Program Plan Documentation”. Added requirement of documenting ESD Control Program Plan in a company’s quality management system.
4.1.2	Moved and revised JESD625 Rev B section 8.1 to new section 4.1.2 “ESD Program Manager”. Added requirement of assigning an ESD Program Manager or Coordinator and responsibility of Program Manager/Coordinator.
4.1.3	New section “ESD Control Item Qualification”. Added requirement and details of qualifying ESD control items prior to use.
4.1.4	Moved and revised JESD625 Rev B section 8.2 to new section 4.1.4 “Compliance Verification”. Update and added more details for compliance verification requirements.
4.1.5	Moved JESD625 Rev B section 9 to new section 4.1.5 “Training”. Minor verbiage edits.
4.1.5.1	Moved and revised JESD625 Rev B section 9.1 to new section 4.1.5.1 “Training Program”. Added more details into what should be included in ESD training program.

Annex D Differences between JESD625C and JESD625B (cont'd)

Clause	Description of change
4.1.5.2	Moved JESD625 Rev B section 9.2 to new section 4.1.5.2 “Training records”. Minor verbiage edits.
4.1.6	New section “Component Threshold Plan”. Details recommendation to establish plan designed to determine what ESDS component thresholds are within ESD Control Program Plan.
4.1.7	New section “Tailoring”. Details requirements for tailoring ESD Control Program Plan to meet company’s needs.
4.2	Moved and revised JESD625 Rev B sections 5 and 5.1 to new section 4.2 “Technical Requirements”.
Figure 1	Moved from JESD625 Rev B section 5.1 to new section 4.2.1 “Grounding for protection of ESDS devices ESD ground”. Removed R2 and R3 from illustration and applicable notes.
Table 1	Separated from JESD625 Rev B Table 1 and added to new section 4.2.1 “Grounding for protection of ESDS devices ESD ground”. Revised to align with ANSI/ESD-S20.20 Table 1 Grounding/Equipotential Bonding Requirements. Removed “Compliance Verification” column.
4.2.1.1	Added requirements of meeting applicable national electrical code and details if requirement cannot be met.
4.2.1.2	New section “Equipotential Bonding”. Added details and requirements for equipotential bonding.
4.2.1.3	Moved and revised JESD625 Rev B section 6.2 to new section 4.2.1.3. Removed note.
4.2.2	Moved and revised JESD625 Rev B section 6.3 to new section 4.2.2. Added details about dissipative and conductive worksurfaces.
4.2.3	Moved and revised JESD625 Rev B section 6.5 and 6.6 to new section 4.2.3.
4.2.4	New section “Managing Conductor Contact with ESDS (Essential Isolated Conductors). Details requirements for essential isolated conductors.
4.2.5	Moved and revised JESD625 Rev B section 6.7 to new section 4.2.5.
4.2.6	Moved and revised JESD625 Rev B section 6.8 to new section 4.2.6.
Table 2	Revised to align with ANSI/ESD-S20.20 Table 3-EPA ESD Control Items. Formatted table into sections of common items. Added dissipative, conductive worksurface, static generating sources, charged surfaces and packaging requirements. Revised footnotes.

Annex D Differences between JESD625C and JESD625B (cont'd)

Clause	Description of change
4.3	Moved and revised JESD625 Rev B section 5.3 to new section “Compliance Verification Records”. Added record retention requirements for ESD control item check records.
4.4	Moved and revised JESD625 Rev B section 5.7 to new section 4.4.
4.4.1	Moved and revised JESD625 Rev B sections 5.7.1 and 5.7.2 to new section 4.4.1.
4.4.2	Moved and revised JESD625 Rev B section 5.7.5 to new section 4.4.2
5	Moved JESD625 Rev B section 7 to new section 5.
5.1	Moved and revised JESD625 Rev B section 7.1 to new section 5.1.
5.2	Moved and revised JESD625 Rev B section 7.2 to new section 5.2. Added requirements for unit level packaging for packaging and filler material.
5.3	New section “Simulated Tribocharging”. Details tribocharging simulations and requirements for materials with electric fields exceeding 50 volts/cm (125 volts/inch).
6	New section “Non-compliance”
6.1	Moved JESD625 Rev B section 8.3 to new section 6.1.
6.2	Added requirements for processing non-conforming material.
6.2.1	Moved JESD625 Rev B section 8.3.2 to new section 6.2.1.
Annex A	Moved JESD625 Rev B Table 2 ESD Protective item checks to new section Annex A. Removed Acceptance Limits and Ref. Para. Columns. Updated activities for each frequency. Updated applicable notes for each section. Added new Notes 9 and 10.
Annex B	Updated checklist questions to reflect changes made to standard.
Annex C	Updated and included all technical references in document.
Annex D	Updated to include change history of JESD625C from JESD625B.



Standard Improvement Form

JEDEC JESD625C

The purpose of this form is to provide the Technical Committees of JEDEC with input from the industry regarding usage of the subject standard. Individuals or companies are invited to submit comments to JEDEC. All comments will be collected and dispersed to the appropriate committee(s).

If you can provide input, please complete this form and return to:

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1. I recommend changes to the following:

☐ Requirement, clause number _____

☐ Test method number _____ Clause number _____

The referenced clause number has proven to be:

☐ Unclear ☐ Too Rigid ☐ In Error

☐ Other _____

2. Recommendations for correction:

3. Other suggestions for document improvement:

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