ESD association standard

ANSI/ESD S541-2003

for the Protection of Electrostatic Discharge Susceptible Items

Packaging Materials for ESD Sensitive Items

Electrostatic Discharge Association
7900 Turin Road, Bldg. 3
Rome, NY 13440

An American National Standard
Approved 3/25/2003

ESD Association Standard
for the protection of electrostatic
discharge susceptible items –

Packaging Materials for ESD Sensitive Items

Approved February 9, 2003
ESD Association

Caution Notice

ESD Association standards and publications are designed to serve the public interest by eliminating misunderstandings between manufacturers and purchasers, facilitating the interchangeability and improvement of products and assisting the purchaser in selecting and obtaining the proper product for his particular needs. The existence of such standards and publications shall not in any respect preclude any member or non-member of the Association from manufacturing or selling products not conforming to such standards and publications. Nor shall the fact that a standard or publication is published by the Association preclude its voluntary use by non-members of the Association whether the document is to be used either domestically or internationally. Recommended standards and publications are adopted by the ESD Association in accordance with the ANSI Patent policy.

Interpretation of ESD Association Standards: The interpretation of standards in-so-far as it may relate to a specific product or manufacturer is a proper matter for the individual company concerned and cannot be undertaken by any person acting for the ESD Association. The ESD Association Standards Chairman may make comments limited to an explanation or clarification of the technical language or provisions in a standard, but not related to its application to specific products and manufacturers. No other person is authorized to comment on behalf of the ESD Association on any ESD Association Standard.

Published by:

Electrostatic Discharge Association
7900 Turin Road, Bldg. 3
Rome, NY 13440

Printed in the United States of America

ISBN: 1-58537-050-9

FOREWORD

Packaging is necessary to protect electronic items from physical and environmental damage during manufacture, transportation, and storage. While most types of packaging (not for static sensitive items) provide physical and environmental protection, it also may harm static sensitive electronic items by allowing the accumulation or the discharge of static electricity. (See appendix B for device damage information.)

Packaging for ESD sensitive items is commonly derived by modifying existing packaging to prevent the packaging itself from causing static damage. The packaging generally retains its physical and environmental protective qualities. ESD protective packaging has been modified further to prevent other sources of static electricity from damaging a packaged item.

This can be illustrated by considering bags. Polyethylene bags are useful packages for containing items and providing protection from physical and environmental damage. However, polyethylene bags accumulate potentially damaging amounts of static electricity. Chemicals (antistats) are added to the polyethylene bag to render it low charging. The result is a low charging (antistatic) polyethylene bag that is less likely to damage static sensitive items. By adding a conductive layer to the low charging polyethylene bag, an ESD shielding bag is created. This shielding bag is low charging, and shields packaged items from ESD and the electric field generated by other items.

Other standard packaging including paper corrugate and plastic boxes, trays, and clamshells have, or are presently, following similar paths.

A complete ESD Control Program, as defined by ANSI/ESD S20.20, requires the use of ESD protective packaging to properly manufacture, transport, and store ESD sensitive devices. This Standard provides requirements for ESD protective packaging that must be included inside and outside an Electrostatic Protected Area (EPA).

Because most physical and environmental considerations can be left to traditional packaging design and testing methodologies, only the material properties that provide reduction or prevention of damage from static electricity need be addressed.

This standard describes the packaging material properties needed to protect electrostatic discharge (ESD) sensitive electronic items, and references the testing methods for evaluating packaging and packaging materials for those properties. Where possible, performance limits are provided. Guidance for selecting the types of packaging with protective properties appropriate for specific applications is provided. Other considerations for protective packaging are also provided.

This document is a substantial refinement of Electronic Industries Association Standard EIA-541-1988. Updates include the adoption of surface resistance (Ohms) in place of surface resistivity (Ohms/square), volume resistance (Ohms) in place of volume resistivity (Ohm-cm), a shielding test that allows penetrating energy (nanoJoules) to be calculated in place of a voltage measurement (volts), and limits the use of static decay testing. While new to 541, these methods have been in use for five years. Resistance is no longer the only property that is used to classify ESD packaging. Low Charging, Electric Field Shielding and Direct Discharge Shielding have been added.

COMMENTS

Beneficial comments (recommendations, additions, deletions) and pertinent data, which may be of use in improving future versions of this document, should be addressed to:

ESD Association
Chair, Packaging Standards Workgroup
7900 Turin Road, Bldg. 3
Rome, NY 13440

COMMITTEE MEMBERS

Brent A. Beamer, Chairman
Static Control Components, Inc

Joe Blanchard Bradford Company	Walt Gately Gately & Associates, Inc.	Kyung J. Kim BF Goodrich SCP
Rick Knight Ranger Plastic Extrusions, Inc.	Stephen Koehn 3M	William Metz Hewlett Packard
Carl Newberg River's Edge Technical Service / Microstat	Dale Parkin IBM	Charles Perry Monroe Electronics
Bob Vermillion RMV Technology Group, LLC	Stan Weitz Electro Tech Systems	

The following individuals made significant contributions to this document:

Ryne Allen	Ben Baumgartner ESD West
Steve Fowler Fowler Associates	Larry Fromm Finisar
Steve Gerken US Air Force	Ron Gibson Celestica
David E. Swenson Affinity Static Control Consulting	

Table of Contents

TABLES OF FIGURES

ESD Association Standard: Packaging Materials for ESD Sensitive Items

1.0 PURPOSE

This standard defines the packaging properties needed to protect electrostatic discharge susceptible (ESDS) electronic items through all phases of production, transport and storage. Application requirements are defined that support the intent and purpose of the packaging requirements stated in ANSI/ESD S 20.20. Test methods are referenced to evaluate packaging and packaging materials for these product and material properties. Performance limits are provided.

2.0 SCOPE

This document applies to packaging used to store, transport, and protect ESDS electronic items during all phases of production and distribution. This document does not address protection from EMI/RFI/EMP or protection of volatile materials. ESD protective packaging is a requirement of the overall ESD control program ANSI/ESD S20.20.

3.0 REFERENCED PUBLICATIONS

ESD S 8.1 ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items - Symbols - ESD Awareness[1]

ANSI/ESD STM 11.11 ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items - Surface Resistance Measurement of Static Dissipative Planar Materials [1]

ESD STM 11.12 ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items - Volume Resistance Measurement of Static Dissipative Planar Materials[1]

ESD STM 11.13 (Pending) ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items - Two-Point Resistance Measurement of Static Dissipative Materials[1]

ESD STM 11.14 (Pending) ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items - Resistance Measurement of Static Dissipative Loose Fill Materials[1]

ANSI/ESD STM 11.31 ESD Association Standard for Evaluating the Performance of Electrostatic Discharge Shielding Materials - Bags[1]

ANSI/ESD S20.20 ESD Association Standard for the Development of an ESD control program for the Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)[1]

4.0 DEFINITIONS

Terms used in this document are in accordance with the definitions found in ESD ADV1.0 Glossary of Terms.

ESD Protected Area (EPA)

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

Note: Refer to ANSI/ESD S20.20 for a discussion of safeguards.

Unprotected Area (UPA)

Any area outside an EPA.

5.0 PERSONNEL SAFETY

The Procedures and equipment described in this document may expose personnel to hazardous electrical conditions. Users of this document are responsible for selecting equipment that complies with applicable laws, regulatory codes and both external and internal policy. Users are cautioned that this document cannot replace or supersede any requirements for personnel safety.

[1] Electrostatic Discharge Association
7900 Turin Road, Building 3, Suite 2
Rome, NY 13440-2069

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 must be followed.

6.0 PACKAGING APPLICATION REQUIREMENTS

Transportation of electrostatic sensitive devices requires packaging that provides protection from electrostatic hazards in the transportation or storage system. In the case of an EPA designed with continuous grounding of all conductors and dissipative items (including personnel), packaging may not be necessary. Refer to Figures 1 and 2, and Appendix A for more information.

6.1 Inside an EPA

Packaging used within an EPA (that satisfies the minimum requirements of ANSI/ESD S20.20) shall be:

1. Low charge generation.
2. Dissipative or conductive materials for intimate contact.

Items sensitive to <100 Volts Human Body Model may need additional protection depending on application and program plan requirements.

6.2 Outside an EPA

Transportation of sensitive products outside of an EPA shall require packaging that provides:

1. Low charge generation.
2. Dissipative or conductive materials for intimate contact.
3. A structure that provides electrostatic discharge shielding.

Notes: If electric field shielding materials are used to provide discharge shielding, a material that provides a barrier to current flow (insulator) must be used in combination with the electric field shielding material. Where this standard does not provide a test method, the user must determine the electrostatic discharge shielding properties of the packaging. See Appendix G for guidance about determining discharge shielding properties.

6.3 Tailoring

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

7.0 CLASSIFICATION OF ESD PACKAGING MATERIAL PROPERTIES

Materials and packages that are useful in preventing damage to sensitive electronic devices exhibit certain properties. These properties include:

- Low Charging (antistatic)
- Resistance:
  - Conductive
  - Dissipative
  - Insulative
- Shielding:
  - Electrostatic Discharge
  - Electric-field

7.1 Low Charging (Antistatic) Material Property

Materials with low charging properties have reduced amounts of charge accumulation when compared with standard packaging materials. Charge accumulation occurs when two materials are contacted and separated from each other. Charge magnitude and polarity are dependant on the materials involved, humidity, surface area, and other considerations. Mitigation of triboelectrification can be accomplished several ways.

- Increasing the amount of charge that flows back to the original material will reduce the total amount of charge either item retains. This can be accomplished by reducing the electrical resistance between the package and the contained device.
- Similar materials tend to charge less than dissimilar materials. Coating the package interior and the contained device with the same material will reduce charge accumulation.
- Reduction in the amount of relative motion between the package and contained device

will reduce the amount of charge accumulated.

A class of chemicals called antistats is most frequently used to make packaging low charging. Antistats reduce the resistance of the packaging material and provide a boundary of similar material between the package and the contained device. This reduces charge generation through like material contact and separation.

7.2 Resistance Material Property

Most standard packaging materials are electrically insulative, and insulative materials retain charge. Making the package less insulative provides a path for charge to dissipate from the package. Specific amounts of resistance are useful for different purposes. Packaging can be classified by the lowest resistance part of its construction. The Resistance Classifications are illustrated in Table 1.

Note: There is no correlation between resistance measurements and the ability of a material to be low charging.

7.2.1 Resistance of Conductive Materials (see Table 2)

Conductive materials may be surface conductive, volume conductive, or both. A surface conductive material shall have a surface resistance of less than 1.0×10^4 Ohms. Volume conductive materials shall have a volume resistance of less than 1.0×10^4 Ohms.

7.2.1.1 Resistance of Electric Field Shielding Materials

Within the conductive materials classification, Electric field shielding materials shall have a surface resistance of less than 1.0×10^3 Ohms or a volume resistance of less than 1.0×10^3 Ohms. Other methods may also define the Electric field shielding classification.

Note: These resistance values do not necessarily imply RFI/EMI/EMP shielding.

7.2.2 Resistance of Dissipative Materials (see Table 2)

A static dissipative material shall have a surface resistance of greater than or equal to 1.0×10^4 Ohms but less than 1.0×10^{11} Ohms, or a volume resistance of greater than or equal to 1.0×10^4 Ohms but less than 1.0×10^{11} Ohms. Packaging materials that are in intimate contact with devices should be dissipative.

7.2.3 Resistance of Insulative Materials

An insulative material shall have a surface resistance of greater than or equal to 1.0×10^{11} Ohms, or a volume resistance of greater than or equal to 1.0×10^{11} Ohms.

7.3 Static Shielding Property

Electrostatic shielding materials protect packaged sensitive electronic items from the effects of static electricity that are external to the package.

7.3.1 Electrostatic Discharge Shielding

Electrostatic discharge shielding materials are capable of attenuating an electrostatic discharge when formed into a container. The calculated energy allowed inside a static discharge shielding bag shall be less than 50 nanoJoules when tested according to Table 2.

7.3.2 Electric Field Shielding

Electric field shielding materials are capable of attenuating an electric field when formed into a container.

Note: Field-shielding materials classified according to section 7.2.1.1 may allow current flow through their volume.

8.0 ESD PACKAGING TECHNICAL REQUIREMENTS

8.1 Material Properties

Table 2 provides test methods for determining material classifications for finished packages and materials. When possible, testing should be performed on the finished package.

8.2 Material Identification

8.2.1 Warning Symbol

ESD protective packaging shall be marked with the ESD Protective Symbol as described in ESD Standard 8.1, or MIL-STD-2073 for Military applications.

8.2.2 Material Classification

ESD protective packaging should be marked with the proper material classification per section 7 as:

- Charge Generation: “Low Charging” (preferred) or “Antistatic”
- Resistance: “Conductive” or “Dissipative”
- Shielding: “Discharge Shielding” or “Electric field Shielding”

Use of multiple classifications is acceptable.

8.2.3 Traceability

Packaging should be marked with information that allows traceability to the packaging manufacturer and to the manufacturer’s date/lot code information. The date/lot code should allow traceability to quality control information pertaining to the manufacture of the specific lot of packaging.

Table 1. Resistance Classifications

Designation	Resistance (ohms)	Exponent Format
	10	10^1
Shielding $<10^3$	100	10^2
Conductive $<10^4$	1,000	10^3
	10,000	10^4
	100,000	10^5
Dissipative	1,000,000	10^6
$\geq 10^4$ to $<10^{11}$	10,000,000	10^7
	100,000,000	10^8
	1,000,000,000	10^9
	10,000,000,000	10^{10}
Insulative $\geq 10^{11}$	100,000,000,000	10^{11}

ANSI/ESD S541

Table 2. TEST METHODS FOR ELECTROSTATIC PROTECTIVE PACKAGING

MATERIAL PROPERTY	Low Charging (Antistatic)	Resistance						Shielding
TEST METHOD	ESD-ADV11.21	ANSI/ESD STM11.11	ANSI/ESD STM11.11	ESD STM11.12	ESD STM11.12	ESD STM11.13	ESD SP11.14	ANSI/ESD STM11.31
METHOD DESCRIPTION	Tribocharging of tubes, planar materials, bags, unit packs (vibration)	Surface resistance of planar materials	Surface resistance of planar materials	Volume resistance of planar materials	Volume resistance of planar materials	Surface resistance 2-point electrode	Resistance of loose fill	ESD Shielding of Bags
LIMITS	User defined	$<10^4$ ohms	$>10^4$ to $<10^{11}$ ohms	$<10^4$ ohms	$>10^4$ to $<10^{11}$ ohms	$>10^4$ to $<10^{11}$ ohms	$>10^4$ to $<10^{11}$ ohms	<50 nanoJoules
RANGE		Conductive	Dissipative	Conductive	Dissipative	Dissipative	Dissipative	

ANSI/ESD S541

Figure 1. Application of ESD Packaging Properties

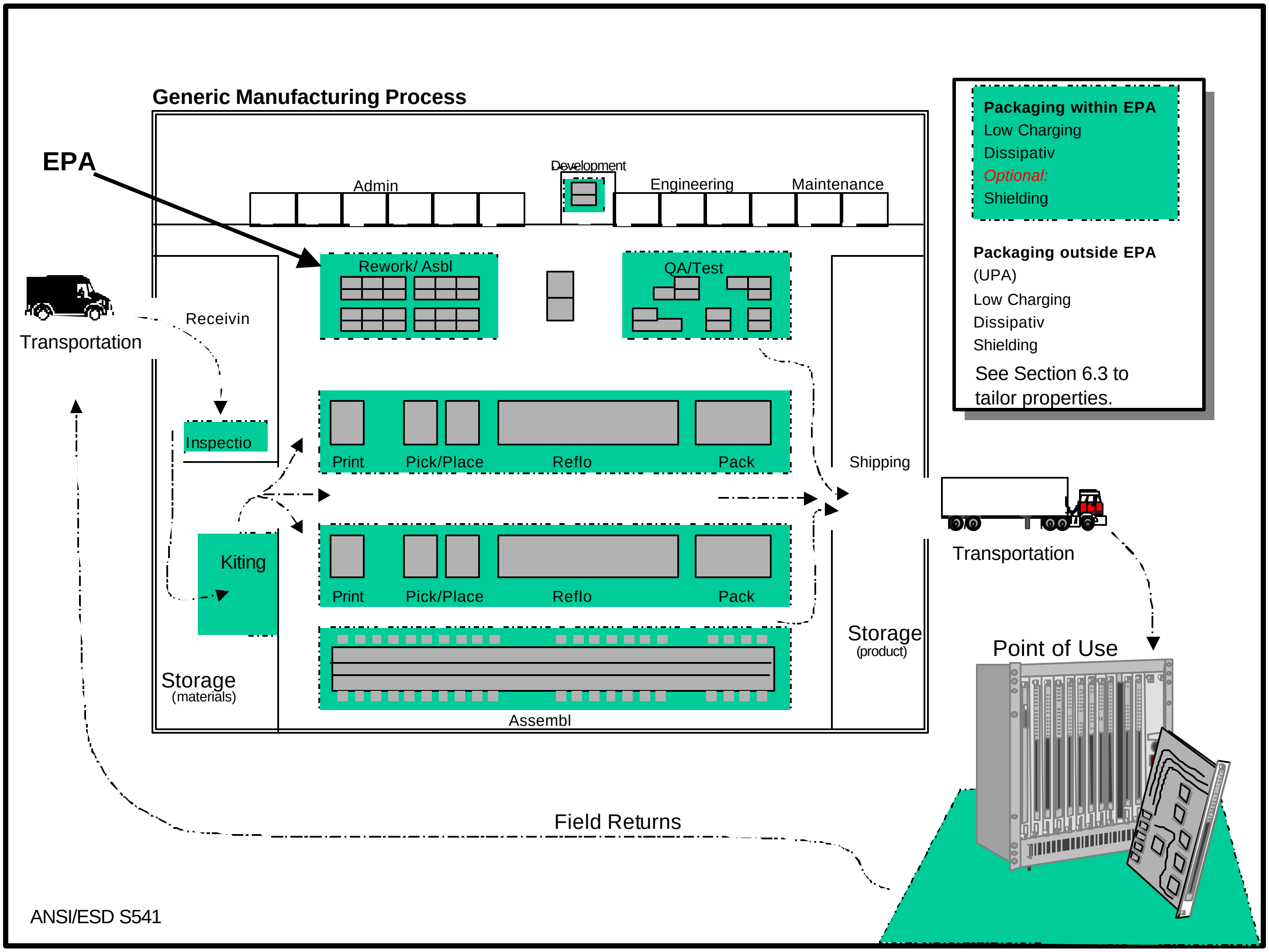
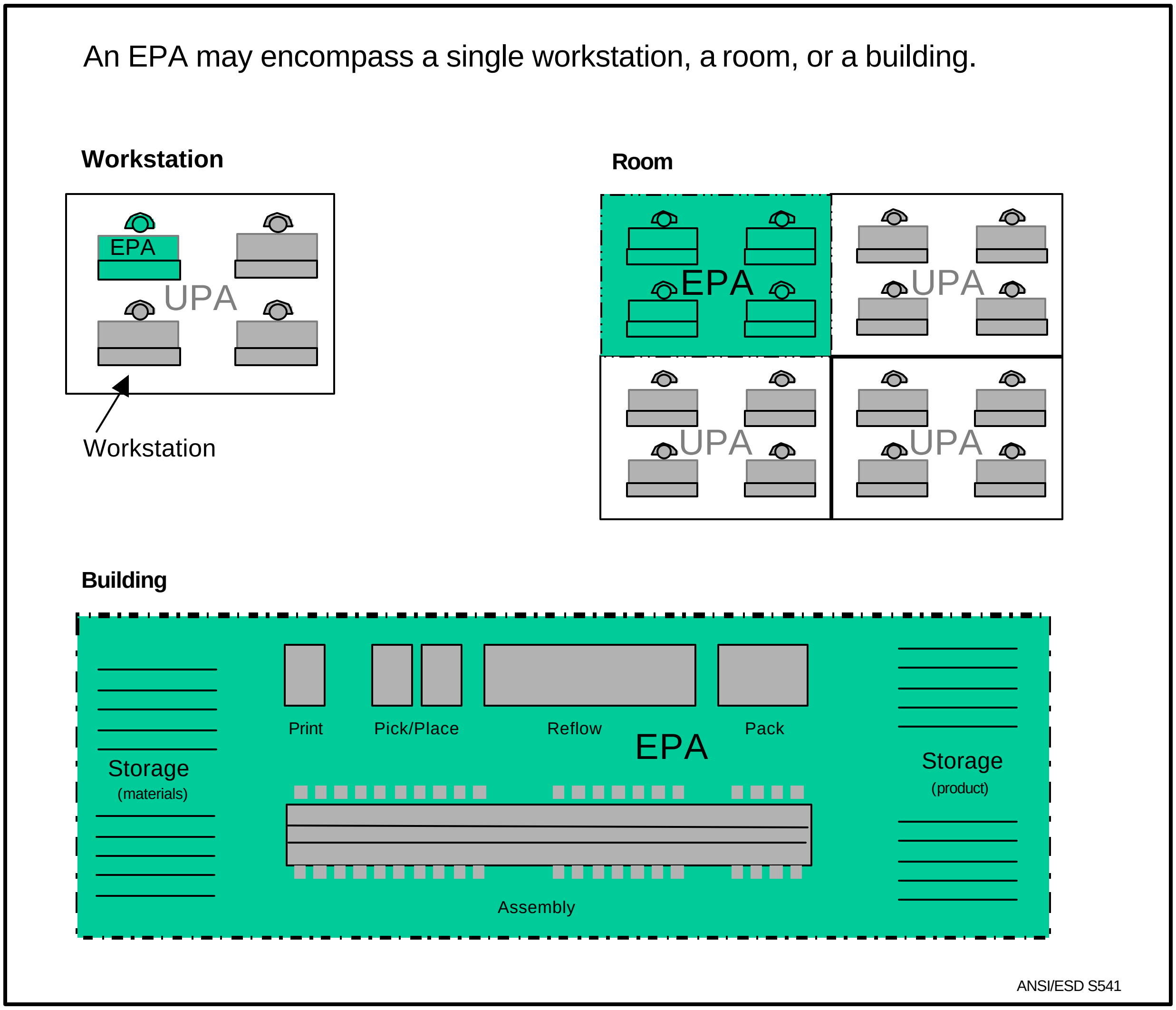


Figure 2 Examples of EPA Configurations



APPENIX A
ESD PACKAGING MATERIAL GUIDANCE

A.1 Environment and Device Sensitivity

Environment and device sensitivity are two primary considerations for selecting ESD packaging material properties.

A.1.1 Environment

Since the threat to a sensitive item is usually undetermined when the item is outside an ESD Protected Area (EPA), ESD sensitive items should be placed in ESD protective packaging whenever the item is in an Unprotected Area (UPA), or needs physical and environmental protection within the EPA.

A.1.2 Device Sensitivity

If the item's sensitivity is unknown, it should be packaged in a manner that provides all of the protective properties.

By understanding these factors, the level of static protective properties may be reduced:

- Device sensitivity to ESD and ESD effects.
- ESD threats that device will experience.

Then the device should be evaluated for damage from those ESD threats, while being protected by the proposed level of packaging.

A.2 Equipotential Bonding

While not always recognized as being a packaging consideration, equipotential bonding, or the shunting of leads, can be an effective method to mitigate damage. By placing a conductive shunt across device leads or card connectors, the various parts of the item share the same electrical potential. While not necessarily at ground potential, the fact that parts of the item share the same potential means that damaging current will not flow between them. Shunting has limitations. Energy from direct discharge and Electric fields may impact the item in a manner that does not allow the energy to equalize through the shunt, but instead through the device. ESD packaging that offers other protective properties is usually used in conjunction with shunting devices.

Note: Care should be exercised to neutralize charge on devices prior to shunting to avoid charged device model (CDM) damage. See Appendix B for more information.

A.3 Dissipative Material for Intimate Contact

To avoid rapid discharge to sensitive items, dissipative materials should be used as the layer of packaging that contacts the item.

A.4 ESD Packaging Types

Many forms of packaging are available with electrostatic protective properties. This includes packaging such as bags, boxes (paperboard and plastic), Semi-rigid plastic trays, cushion wrap, foam, loose fill, tape, trays, tubes, tape and reel, shrink-wrap, and stretch-wrap. Refer to Appendix E for additional information.

A.5 Packaging from Incoming Material to the Point of Use

Figure 1 shows a simplified layout of a generic electronic packaging application. Each area has the recommended ESD packaging material properties noted. As discussed in section A.1.2, if the item sensitivity and threats are documented, the level of ESD packaging can be reduced after confirming packaging functionality.

Note: This layout shows an "islands of protection" approach to ESD safeguards. Many manufacturing processes employ a "total factory" approach, where the entire factory is a safeguarded area.

A.6 Periodic Verification

The static control properties of some packaging materials can deteriorate with time and use. Periodic verification of static control properties should be considered.

A.7 Other Considerations

A7.1 ESD Control Program

ESD packaging alone cannot protect ESDS devices. It is but one component of the comprehensive ESD control program described in ANSI/ESD S20.20.

A7.2 Contamination in Packaging
Items packaged in static control packages may require protective considerations beyond the scope of this document. These considerations could include chemical corrosion, plastic stress crazing, and contamination from outgassing, particulate matter, or moisture. Guidance for plastic stress crazing can be found in EIA-564.Guidance for moisture considerations can be found in IPC/JEDEC J-STD-033 or EIA[2]-583.

References

IPC/JEDEC J-STD-033
Standard for Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices

EIA-564
Standard Test Method for Chemical Compatibility of Polycarbonate by Stress Crazing Evaluations [2]

EIA-583
Packaging Materials Standards for Moisture Sensitive Items [2]

APPENDIX B
Device Damage

B.1 Damage From ESD

Damage to devices usually occurs in one of two situations.

1. Electrostatic discharge to a device.
2. Electrostatic discharge from a charged device.

This distinction is important for packaging considerations because different properties are required to manage each situation. Consider the source of the static electricity and then the path the charge must travel to damage the device.

B.2 Discharge to a Device.

B.2.1 Human Body and Machine Models

Common items that discharge to packaged devices include the human body and conductive objects used to handle packages like conveyors, carts, and vehicles. Triboelectrification is usually the charge source. Since the discharge must pass through the package to reach the device, the package can be used to protect the device from the ESD event.

B.2.2 Retained Charge

The package can gain charge from ESD or triboelectrification. Where the package exterior is isolated from the package interior and therefore the device, it is possible for charge on the package to discharge to the device as it is removed from the package

B.3 Discharge from a Device.

B.3.1 Charged Device Model (CDM)

If a device is momentarily grounded in the presence of an electric field emanating from an electrostatically charged item, a discharge occurs and the device retains a charge of opposite polarity. When the device contacts an object with a different potential, like a grounded hand removing the device from a package, an electrostatic discharge occurs. Since the electric field must pass through the package, the package can be used to shield the device from the electric field. The package may also isolate the device from ground.

B.3.2 Triboelectrification

As a device and package move in relation to each other, charge is accumulated on the package and on the device. When the device contacts an object with a different potential, like a grounded work surface, an electrostatic discharge occurs. By modifying the package interior, the amount of tribocharging can be controlled, and any residual charge can be dissipated evenly throughout the package surface.

Notes: Detailed information about ESD models is located in the appendices section of ANSI/ESD S20.20. Triboelectrification is discussed in ESD ADV 11.2.

APPENDIX C
Limitations for the Use of Static Decay Testing Method

C.1 Electrostatic Decay

The test method (FTMS 101 Method 4046) for electrostatic decay measurements is dependent upon the ability of a non-contacting electrostatic voltmeter to observe the decay of the electric field

[2] Electronic Industries Association, 2500 Wilson Blvd., Arlington, VA 22201

emanating from the charge on the test item as the potential drops from 5,000 Volts to effectively zero volts. For the observation to be valid, the sample must be planar, homogeneous, and electrically dissipative (conductive enough to accept the initial 5,000Volt charge, but not so conductive that the electric field collapses when the sample is grounded). Static decay testing is inappropriate for shielding and conductive materials.

Reference:

FTMS 101 MTH 4046
Federal Test Method Standard, Test Procedures for Packaging Materials. Method 4046, Electrostatic Properties of Materials GSA, Specifications and Consumer Information Distribution Branch Building 97 Washington, DC 20407

APPENDIX D
Future Test Methods

Future development may provide additional test methods to classify packaging materials.

They may also provide new tools, like voltage retention, or voltage decay, to better examine complete package configurations.

APPENDIX E
ESD Packaging and Material Types

These general descriptions of commonly available ESD-protective packaging are provided for background information and are not intended to define mandatory features of packaging.

E.1 Adhesive Tape

Tape designed to be low charging when unwound from the roll or removed from packaging or devices. It may also be static dissipative. Tape made with a conductive layer is intended to provide shielding. Tape is sometimes printed with the ESD protection symbol to differentiate it from non-ESD tape.

E.2 Bags

ESD-protective bags are typically formed from flexible plastic, which has been modified with antistat and/or conductive materials. Conductive bags are extruded plastic combined with conductive materials and exhibit the same properties on both surfaces. Dissipative bags are extruded plastic combined with or coated with chemical antistat, and exhibit the same properties on both surfaces. Shielding bags are made from metallized plastic laminated to dissipative plastic. The metallization and plastic form a shield against discharge and Electric fields. Other constructions are used for bags.

E.3 Boxes

A box constructed from plastic, solid fiberboard, combined board, or corrugated paperboard can be made ESD safe by the use of conductive, dissipative or shielding materials incorporated in the construction. Plastic boxes are injection molded or thermoformed. Boxes made from paper products are assembled by folding, stapling or gluing. Many application-specific box configurations are available with partitions, slots, handles, lids and dunnage for shipping.

E.4 Cushioning Materials

E4.1 Air

Cushioning materials are rendered ESD-protective with antistat or carbon black, and are formed by creating an array of bubbles on a plastic sheet. The bubbles may be closed to form a pillow, or open to form a slowly collapsing cell. The sheet is usually wrapped around items, or formed into bags to protect from shock, vibration and ESD.

E4.2 Foam

Foams can be treated or manufactured with antistats, carbon or inherently conductive polymers to impart low charging, dissipative or shielding properties. Plastics such as polyurethane, closed-cell polyethylene, and PVC are used in the electronics industry as cushioning materials, working surfaces, and interior dunnage materials that hold assemblies and devices in place while protecting them from shock, vibration, and ESD.

E.4.3 Loose Fill

Loose fill material occupy voids inside packaging, providing protection from shock and vibration. They are typically rendered ESD-protective with antistat, carbon, or hygroscopic material. Forms include polystyrene or soybean foam pellets, paper, and air filled bladders.

E.5 Shrink Wrap

The application of heat shrinks this plastic film to form a tight skin around the packaged item. Static dissipation is achieved with topically applied antistat. Shrink films may be used to bind together multiple items for bulk packages, and may be used to package non-sensitive items, which are used in ESD safe areas, replacing static generating over wraps.

E.6 Stretch Wrap

Very extensible thin plastic films can be used to bind items together such as in bulk packages on pallets. Static dissipation is achieved with topically applied antistat. "Tackifiers" are used to allow the film to stick to itself. ESD-protective stretch films may be used to package non-sensitive items that are used in ESD safe areas, replacing static generating over wraps.

E.7 Tape and Reel

Devices (parts and components) can be fed to production equipment from carrier tape that is shaped to hold the device. The carrier tape is wound on a reel similar to motion picture film. A cover tape applied to the carrier tape keeps the devices on the carrier. Both tape and reel can be made from plastic or paper and derive ESD protective properties from antistat, carbon, or inherently dissipative/conductive materials. Plastic carrier tape is thermoformed and paper carrier tape is die cut.

E.8 Thermoformed Trays

Semi-rigid plastic trays are formed into product-shaped containers for devices or assemblies providing shock protection. They are made by thermoforming plastic sheet, usually PVC, PETG, HIPS, or PP, that is topically coated or volume loaded with antistat or carbon, or made from inherently dissipative/conductive material, rendering the trays ESD-protective.

E.9 Injection Molded Trays

Injection molded rigid trays are designed to contain and transport devices. ESD-protective properties are imparted with antistat, carbon, conductive particles/fibers or inherently dissipative/conductive plastic. A vast assortment of configurations accommodates device package sizes. The choice of plastic and ESD treatment determines heat tolerance.

E.10 Tubes

Devices can be fed to production equipment from extruded plastic tubes with a profile that matches the device. ESD-protective properties are imparted with coatings or loadings of antistat, carbon, or inherently dissipative/conductive plastic. A vast assortment of configurations accommodates device package sizes.

APPENDIX F
Related Documents

The following documents are listed for further reference.

ESD ADV 1.0 ESD Association Advisory Glossary of Terms

ESD TR20.20 ESD Association Technical Report for the Development of an Electrostatic Discharge Control Program for the Protection of Electronic Parts, Assemblies and Equipment – Handbook

ESD ADV 11.2 ESD Association Advisory for the Protection of Electrostatic Discharge Susceptible Items - Triboelectric Charge Accumulation Testing

APPENDIX G
Guidance for Determining Discharge Shielding Properties

Where this standard does not provide a test method, the user must determine the electrostatic discharge shielding properties for packaging. Some options for making this determination include:

- Use of existing surface and volume resistance test methods (see Table 2) to assist in determining whether discharge shielding properties exist. The user can use these tests to determine the location (i.e. Inside or outside) of conductive, dissipative and insulative materials within the material or package and assess whether it is discharge shielding.
- Use of a modified test method that uses concepts outlined in ANSI/ESD STM 11.31.