

NOT MEASUREMENT
SENSITIVE

National Aeronautics and
Space Administration

This document has been CANCELLED NASA-STD-8739.7
[Click Here](#) to see the Cancellation Notice DECEMBER 1997

PREVIOUS VERSION PUBLISHED AS NHB 5300.4(3L)

NOTE: Cancelled or superseded standards may remain valid on contracts after the date of the standard's cancellation or supersession – always check the contract to determine the applicability of a specific standard.

ELECTROSTATIC DISCHARGE CONTROL

(EXCLUDING ELECTRICALLY INITIATED
EXPLOSIVE DEVICES)

NASA TECHNICAL STANDARD

FOREWORD

Effective Date: December 15, 1997

In order to maintain the high standards of the NASA Electrostatic Discharge (ESD) programs, this publication:

- a. Prescribes NASA's requirements for ESD avoidance and control.
- b. Describes basic considerations necessary to ensure static free work areas.
- c. Establishes the supplier's responsibility to train and certify personnel.
- d. Establishes the supplier's responsibility for documentation of procedures to be used for NASA work, including supplier innovations, special processes, and changes in technology.

NOTE: *FOR THE PURPOSE OF THIS DOCUMENT, THE TERM SUPPLIER SHALL BE DEFINED AS IN-HOUSE NASA, NASA CONTRACTORS AND SUBTIER CONTRACTORS.*

NASA Installations shall:

- a. Invoke the requirements of this publication as part of the specifications or statement of work in procurements involving the handling of ESD sensitive (ESDS) parts or assemblies. Appendix A is a requirement of this publication.
- b. Existing contracts that specify another ESD program may continue to invoke those requirements. This publication should be considered for all applications.
- c. For all new procurements, the latest revision of this publication, including page changes, shall be specified in the contract if no other NASA procuring Installation-approved ESD control programs exist. (For example, ESD control programs to MIL-STD-1686).
- d. Assure that NASA suppliers invoke the requirements of this publication in their subcontracts, purchase orders, and subtler suppliers.
- e. Furnish copies of this publication, in the quantities required, to NASA contractors, subcontractors, and subtler suppliers.
- f. Utilize the provisions of this publication for in-house operations and for training and certification of in-house personnel.

NASA-STD-8739.7

December 1997

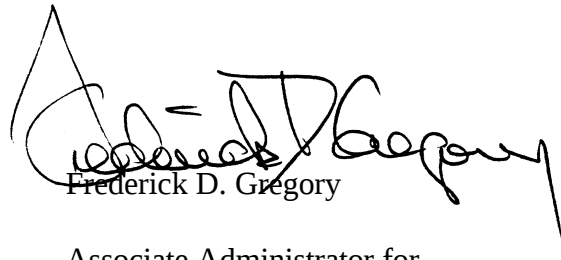
Questions concerning application of this publication to specific procurements shall be referred to the procuring NASA Installation or its designated representative.

This Standard cancels NHB 5300.4(3L), "Electrostatic Discharge Control (Excluding Electrically Initiated Devices)."

Comments and suggestions for improvement of this handbook may be submitted using the form "NASA Handbook Improvement Proposal." A copy of this form is included at the end of the handbook.

This publication shall not be rewritten or reissued in any other form.

This book is issued in loose-leaf form and will be revised by page changes.



Frederick D. Gregory

Associate Administrator for
Safety and Mission Assurance

DISTRIBUTION:

SDL1 (SIQ)

NASA-STD-8739.7
December 1997

**NASA TECHNICAL STANDARDS FOR SPACE FLIGHT AND MISSION
CRITICAL GROUND SUPPORT HARDWARE**

NASA Technical Standards can be found on the World Wide Web at URL address
<http://www.hq.nasa.gov/office/codeq/qdoc.pdf>

Title	Number
Management of Government Quality Assurance Functions for NASA Contracts	NHB 5300.4(2B-2)
Soldered Electrical Connections	NASA-STD-8739.3
Crimping, Interconnecting Cables, Harnesses, and Wiring	NASA-STD-8739.4
Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies	NAS 5300.4(3J-1)
Printed Wiring Boards	IPC-0-275
Rigid Printed Wiring Boards and Assemblies	IPC-RS-6011

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CHAPTER 1 - SCOPE

1.1 Purpose

1. This publication sets forth ESD control requirements for items that are ESD Sensitive (ESDS) (excluding electrically initiated explosive devices).

2. Special requirements may exist that will not be covered by or will not be in conformance with requirements of this publication. Engineering documentation shall contain the detail for these requirements, and shall take precedence over conflicting portions of this publication when they have been approved in writing by the procuring NASA Installation.

1.2 Applicability

This publication is applicable to all NASA programs involving ESDS components or assemblies, and wherever invoked contractually. These measures shall be implemented during all phases of receiving, inspection, assembly, testing, repair, storage, and packaging for shipping of all items designated as ESDS. The measures shall apply but not be limited to flight hardware, mission-support equipment and elements thereof.

CHAPTER 2 - APPLICABLE DOCUMENTS

2.1 Applicable Specifications

1. Copies of the following documents required in connection with a specific procurement may be obtained from the procuring NASA Center or as directed by the contracting officer. Unless otherwise specified, the issue and/or revision in effect on the date of invitation for bids or request for proposal shall apply to the extent specified herein.

MILITARY SPECIFICATIONS:

MIL-E-17555 Electronic and Electrical Equipment Accessories,
Provisioned Items (Repair Parts), Packaging of

MILITARY STANDARDS:

MIL STD-129 Marking for Shipment and Storage

INDUSTRY SPECIFICATIONS:

EIA RS 471-80 Symbols and Labels for Electrostatic Sensitive Devices

2.2 Related Documents.

1. The following are documents are related to the subject of ESD control. Note that these are not applicable documents, but are identified for reference purposes.

MILITARY STANDARDS

MIL-STD-1686A Electrostatic Discharge Control Program for Protection
of Electrical and Electronic Parts, Assemblies and
Equipment (Excluding Electrically Initiated Explosive
Devices).

MILITARY HANDBOOKS

MIL-HDBK-263 Electrostatic Discharge Control Handbook for Protection
of Electrical and Electronic Parts, Assemblies and
Equipment

INDUSTRY SPECIFICATIONS

EIA-541 Packaging Material Standards for ESD Sensitive Items

CHAPTER 3 - DEFINITIONS AND ACRONYMS

3.1 Definitions

The following definitions apply to terms used in this standard.

Assembly. A functional subdivision of a component, consisting of parts or subassemblies which perform functions necessary for the operation of the component as a whole. Examples: regulator assembly, power amplifier assembly, gyro assembly, etc.

Certification. The act of verifying and documenting that personnel have completed required training, demonstrated specified proficiency, and have met specified requirements.

Component. A functional subdivision of a system, generally a self-contained combination of assemblies performing a function necessary for the system's operation. Examples: power supply, transmitter, gyro package, etc.

Contractor. The individual(s) or concern(s) who enter into a prime contract with the Government.

Conductive Material. ESD-protective material having a surface resistivity of 10 ohms per square maximum.

Deviation. A specific authorization, granted before the fact, to depart from a particular requirement of specification or related document.

Electrostatic Discharge (ESD). A transfer of electrostatic charge between bodies at different electrostatic potentials caused by direct contact or induced by an electrostatic field.

ESD-Protective Material. Material capable of one or more of the following characteristics: limiting the generation of static electricity; safely dissipating electrostatic charges over its surface or volume; or providing shielding from ESD spark discharge or electrostatic fields.

ESD-Protective Packaging. Packaging with ESD-protective materials to prevent damage to ESDS items.

ESD Sensitive (ESDS) Items. Electrical and electronic parts, assemblies and equipment that are sensitive to ESD voltages.

Electrostatic Field. A voltage gradient between an electrostatically charged surface and another surface of a different electrostatic potential.

Ground. A mass such as earth, a ship, or a vehicle hull, capable of supplying or accepting a large electrical charge.

Hard Ground. A connection to earth ground either directly or through low impedance.

Kit. A prepared package of parts with instructions for assembly and/or wiring a component or chassis.

Part. An element of a component, assembly, or subassembly which is not normally subject to further subdivision or disassembly without destruction of designed use.

Protected Area. An area which is constructed and equipped with the necessary ESD-protective materials and equipment to limit ESD voltage below the sensitivity level of ESDS items handled therein.

Qualification. The act of verifying and documenting that facilities, equipment, processes and materials comply with the requirements specified in this document.

Soft Ground. A connection to ground through an impedance sufficiently high to limit current flow to safe levels for personnel (normally 5 milliamperes). Impedance needed for a soft ground is dependent upon the voltage levels which could be contacted by personnel near the ground.

Static Dissipative Materials. ESD-protective materials having surface resistivities greater than 10^5 but not greater than 10^{12} ohms per square.

Subcontractor. The individual(s) or concern(s) who enter into a purchase agreement under a Government prime contract.

Supplier. In-house NASA, NASA contractors, and subtier contractors.

Surface Resistivity. The surface resistivity is an inverse measure of the conductivity of a material and equal to the ratio of the potential gradient to the surface, where the potential gradient is measured in the direction of current flow in the material.

NOTE: *SURFACE RESISTIVITY OF A MATERIAL IS NUMERICALLY EQUAL TO THE SURFACE RESISTANCE BETWEEN TWO ELECTRODES FORMING OPPOSITE SIDES OF A SQUARE. THE SIZE OF THE SQUARE IS IMMATERIAL. SURFACE RESISTIVITY APPLIES TO BOTH SURFACE AND VOLUME CONDUCTIVE MATERIALS AND HAS THE VALUE OF OHMS PER SQUARE.*

System. A system is a functional subdivision of a spacecraft generally composed of two or more components designed to perform an operation. An instrument is considered a system.

Triboelectric. Pertaining to electricity generated by friction.

Waiver. Granted use, or acceptance, of an article that does not meet specified requirements.

3.2 Acronyms

The following acronyms apply to terms used in this standard:

AC	Alternating Current
EIA	Electronic Industries Association
ESD	Electrostatic Discharge
ESDS	Electrostatic Discharge Sensitive
GSFC	Goddard Space Flight Center
IPC	Institute for Interconnecting and Packaging Electronic Circuits
JPL	Jet Propulsion Laboratory
NAS	NASA Assurance Standard
NASA	National Aeronautics and Space Administration
NHB	NASA Handbook
QA	Quality Assurance
QS	Safety and Risk Management Division of the NASA Office of Safety and Mission Assurance
RH	Relative Humidity
RMS	Root Mean Square

CHAPTER 4 - GENERAL

4.1 General

1. NASA personnel will advise and assist suppliers and authorized personnel in the proper and effective implementation of the provisions of this publication.
2. When related requirements or changes in requirements are specified, NASA quality assurance personnel will ensure that the authorized agent delegated to inspect at the supplier's site has received full instructions, so that the area will meet the actual contract requirements.
3. When the supplier proposes to use ESD control techniques not covered by this publication, the supplier shall document the details of the proposed techniques and inspection, and provide appropriate test data. This documentation shall be approved by the procuring NASA Installation prior to use.
4. The prime contractor is responsible for flow down of the requirements herein to their subtler suppliers as required.

4.2 Documentation

1. The supplier shall document the procedures proposed to incorporate the requirements of this publication into the ESD control program involved in the contract or purchase order.
2. Documents required herein shall be submitted to the procuring NASA Center or its designated representative as required by the contract or purchase order. Applicable supplier ESD control program documents, or portions thereof, accepted on other NASA contracts shall be included to avoid duplication of effort.

4.3 Approval of Departures from this Standard

1. This publication requires:
 - a. Written approval from the NASA contracting officer for technical changes, deviations or waivers initiated by the supplier.
 - b. All deviation and waiver requests shall be supported by objective evidence and data substantiating that quality and reliability of the hardware will not be compromised.
2. The supplier is responsible for assuring that any departures from this publication are evaluated by, coordinated with, and submitted to the procuring NASA Installation.
3. For in-house NASA projects, this publication requires the written equivalent of deviation and waiver requests, approved by the in-house NASA project management, for deviation from the provisions herein.

CHAPTER 5 - ESD CONTROL PROGRAM

5.1 General

1. The supplier shall establish, implement, and document an ESD control program in accordance with the requirements of this publication, to provide continuous protection for ESDS parts, assemblies, and equipment.

a. The applicable control program functions shall also be applied to subcontractors, suppliers and vendors to provide continuous protection for ESDS parts, assemblies and equipment.

b. Assemblies, components and equipment shall be designed to provide ESD protection for the sensitivity level of the most sensitive ESDS parts chosen for the design. The minimum protection for each ESDS design shall be as specified by the engineering documentation or 2000 volts for assemblies and 4000 volts for components and equipment.

5.2 ESD Control Program Requirements

1. The supplier's ESD control procedures shall be established to verify conformance to this Handbook and made available to applicable work areas. As a minimum, the procedures shall be implemented to include the following ESD control program requirements:

a. Conformance of protected areas and items listed in Table 7-1 to requirements set forth in this document. Verify the adequacy of these areas prior to their use.

b. Use of protective personnel clothing and proper personnel grounding at all necessary points where ESDS items will be handled.

c. Establishment and operation of a training program to ensure that all personnel handling ESDS items have received the necessary training, and have been certified/recertified to the appropriate working level as specified in paragraph 6.2.

d. Performance of audits and inspections to ensure the integrity of the ESD-protected areas and equipment in accordance with requirements listed in Table 7-1.

e. Inspection of documentation for ESD markings, precautions and handling procedures as applicable.

f. Proper ESD identification on ESDS items.

g. Inclusion of ESD requirements on purchasing documentation.

h. Handling of ESDS items only at static free and verified protected areas.

- i. Description of field operations and precautionary procedures, when applicable, to prevent ESD damage.
- j. Maintenance of auditable records and documentation for all measurements required by this Handbook listed in Table 7-1.
- k. Prepare and maintain internal records of each verification and audit to ensure compliance with the ESD control program plan.
- l. Internal reports shall be provided to management with results and recommendations from audits specified herein. Deficiencies noted during audits or verifications shall cause initiation of corrective action.
- m. Materials approved for use within ESD-protected areas shall be documented in an ESD-protective approved materials list.

5.3 Design reviews

- 1. During equipment design reviews, ESD control program plans shall be submitted by the supplier to the procuring NASA Installation for review to verify conformance to the requirements of this Standard.

5.4 Surveys and Inspections

- 1. Surveys shall be performed by the supplier to assess the adequacy of the following areas:
 - a. ESD control program plan implementation.
 - b. General design, construction and maintenance requirements for protected areas.
 - c. Protective procedures used to control handling and testing of ESDS parts, assemblies, components and equipment.
 - d. Methods and procedures for monitoring the continued effectiveness of protected areas.
 - e. Methods and procedures for performing audits and inspections of the ESD control program.
 - f. Training and certification program.
 - g. Packaging and storage of ESD parts, assemblies, and equipment.
 - h. Correction of deficiencies.
 - i. Precautionary procedures implemented during field operations when ESDS items are present.

- j. Verify certification of personnel who work on ESDS items
- k. Verify limited access to ESD-protected areas

CHAPTER 6 - TRAINING AND CERTIFICATION PROGRAM

6.1 General

1. The supplier is responsible for maintaining a documented training program that meets the requirements of this Handbook.

2. The supplier shall assure that all personnel who perform or supervise any of the following functions, are familiar with the ESD control techniques, other requirements of this document, and other pertinent ESD control requirements of the contract: design, production, inspection, test, storage, procurement, shipping, receiving, handling, installation, maintenance, and repair. The supplier shall implement and document a training program which provides the necessary training of personnel pertinent to their responsibilities in performance of the contract requirements. The supplier is responsible for certifying and maintaining the certification of each individual who is involved in ESD control.

3. All personnel listed in Paragraph 6.0.b, including instructors, shall be qualified to fulfill all requirements of this Handbook involved in their assigned tasks. Demonstration of proficiency and understanding of the requirements is a requisite for certification and recertification. Evidence of certification status shall be maintained in the work area.

6.2 Certification Levels

1. Certification of supplier personnel shall be provided by the supplier based on successful completion of the approved training program.

a. **Program Monitor or Design/Engineering Personnel.** This training is for those who play a major role in ESD damage prevention, i.e., ESD program officers, QA representatives, area supervisors, designers and engineers. The training shall encompass the following subject areas, at minimum:

- (1) ESD Control Program.
- (2) Principles/control methods of static electricity.
- (3) Identification of ESDS items.
- (4) Protective materials and equipment.
- (5) Protected areas and work stations.
- (6) Monitoring of the work place.
- (7) Handling ESDS items.

(8) Packaging, marking and shipping of ESDS items.

b. **Management Level.** Training at this level is intended to provide a working knowledge of ESD hazards for management personnel. The training shall encompass the following subject areas, at minimum:

(1) ESD control program organization and requirements.

(2) Principles of static electricity and methods of controlling damage from ESD.

c. **Operator Level.** This training is intended for technical personnel performing work on or with ESDS items, such as assembly, soldering, conformal coating, cleaning, inspections, testing, packaging, and shipping. The training shall encompass the following subject areas, at minimum:

(1) Principles of ESD and control methods.

(2) Identification of ESDS items.

(3) Protective material and equipment.

(4) Protected areas and work stations.

(5) Handling ESDS items

(6) Marking and protective packaging.

d. **Other Facility Personnel.** Training of all other facility personnel shall be tailored to the particular assignment of the individual.

6.3 Training Program Requirements

1. The supplier training program documentation shall be submitted to the procuring NASA Installation. A NASA Generic Training Plan from the NASA Training Centers is available for use as a guideline.

2. The training program shall:

a. Identify the criteria for qualification and certification of instructors, program monitor level managers, operators and other facility personnel.

b. Document the methods and procedures proposed to fulfill the requirements of this Handbook.

c. Utilize applicable illustrations in this Handbook, supplemented as necessary, for visual standards. Standards of unacceptable conditions may also be used for clarification or comparison.

6.4 Documentation

1. The documentation shall describe the training and certification program proposed to satisfy the requirements herein. This documentation shall include, but not be limited to, the following, as applicable:

- a. Qualification(s) of instructors.
 - b. Procedures for training, including who will be trained and for what purpose, (e.g., management, operators, inspectors).
 - c. Lesson plan(s)/student Handbooks.
 - d. Hours of instruction.
 - e. Procedures for certification and recertification.
 - f. Procedures for recording of training, recertification, and methods of identifying/recalling trained personnel.
 - g. Certification criteria
 - h. Record maintenance.
2. Records of training and certification shall become part of the supplier's quality data and shall be retained for a minimum of 5 years.

3. Evidence of certification status including limitations shall be available in the work area

6.5 Maintenance of Certification Status

1. Maintenance of certification for instructors, program monitors, managers, operators and other levels requires continuous proficiency.

2. Recertification of personnel shall include successful completion of retraining.

3. Recertification shall be required when:

- a. Proficiency requirements herein are not met.
- b. New ESD control techniques have been approved that require different skills.
- c. Certificate holder changes employment.
- d. Work period interruption of greater than 6 months occurs.

- e. Two years have elapsed since last certification.
- 4. Certification shall be revoked when:
 - a. Certificate holder fails recertification.
 - b. Employment is terminated.
 - c. Supplier training program fails to meet requirements set forth herein or set forth otherwise in the contract.

6.5 Training Resources

1. Instructor training is available at either the Goddard Space Flight Center (GSFC) or Jet Propulsion Laboratory (JPL). The NASA Generic Training Plan is also available and may be obtained by contacting the following sources.

GSFC	(301)731-8632
Training Center	FAX (301)731-8603
Code 300.1	
Greenbelt, MD 20771	

JPL	(818)354-4165
Training Center	FAX(818)393-0090
MS83-204	
4800 Oak Grove Drive	
Pasadena, CA 91109	

2. Suppliers may train personnel in-house for certification or recertification utilizing an approved training program, or arrange for this training at or by one of the NASA conducted schools.

3. Reimbursable cost may be charged (or levied). Contact either training center for additional information.

CHAPTER 7 - ESD CONTROL REQUIREMENTS FOR FACILITIES

7.1 General

1. This chapter contains requirements specific to ESD-protected facilities including work areas, equipment, tools and materials.

2. The effectiveness of ESD protection in eliminating and/or dissipating electrostatic charges shall be demonstrated by inspection of facilities in accordance with the requirements noted in Table 7-1 and specific requirements found throughout this chapter.

3. All supplier facilities where ESDS hardware is handled shall be qualified by the procuring activity. The following requirements shall be reviewed and approved by the procuring activity prior to qualification of the supplier's facility and ESD control program.

- a. ESD program procedures.
- b. Training and certification program.
- c. Records of control program verifications.
- d. Facility survey.

7.2 Protected Work Environment

1. **Identification and Access - ESD Areas.** The ESD-protected area, where ESDS items are to be processed, shall be clearly identified by prominently placed signs. Access to such areas shall be limited to trained and equipped personnel. A partition, rope guard, or similar means shall be set up to assist in prohibiting unauthorized and untrained personnel from entering the ESD-protected area. All other personnel shall be escorted and be equipped with standard protective clothing, as required.

2. **Prohibited Materials and Activities.** The area shall be maintained in a clean and orderly condition. Smoking, eating and drinking in ESD-protected areas shall not be permitted. Materials unessential to the fabrication area are also prohibited at the work station.

3. ESD-Protective Work Surfaces.

a. All work surfaces in an ESD-protected area shall be static dissipative and electrically connected to the common point ground (see Figure 7-1).

b. Homogeneous materials shall have surface resistivity in the range of 10^5 to 10^9 ohms/square. Non-homogeneous materials should have comparable static dissipative properties. A low resistance ground connection is recommended. However, if safety codes and/or other authorities require inclusion of a series resistor, it is permitted.

TABLE 7-1 ESD Control Program Verification Schedule and Required Measurements

NOTE 1: All of the items listed below shall require the maintenance of records for verification prior to use. NOTE 2: All items that are not in compliance with this document shall be refurbished or replaced and/or rendered unusable until corrective actions are complete.							
ITEM	PARAGRAPH REFERENCE	VERIFICATION INTERVALS					
		Continuous	Daily	Weekly	Monthly	Semi-annual	Annual
Work Surface Resistivity	7.2-3b				X		
Work Surface Grounding	7.2-3b				X		
Work Surface Solvent Resistance	7.2-3d						X
Work Surface Static Charge Dissipation	7.2-3a					X	
Conductive Floor Resistivity	7.2-4c				X		
Wrist Strap Release Force	7.2-5a(2)					X	
Wrist Strap Resistance	7.2-5a(3)		X				
Foot Grounding Device Integrity	7.2-5b		X				
¹ Equipment and Facility Grounding	7.2-6a				X		
¹ Stool and Chair Grounding	7.2-6a(1)					X	
Humidification (RH)	7.2-7	X					
¹ Cart, Wagon, and Tram Grounding	7.2-6b					X	
¹ Nuclear ionizer	7.2-8a					X	
¹ Corona Discharge ionizer	7.2-8b				X		
Soldering Iron Tip to Ground	7.2-9b			X			
Electrostatic Monitor Operation	7.6		X				
¹ These items require that proof of verification was performed by some form of identification (i.e., label, tab or sticker)							

NOTE: WORK SURFACES SHOULD BE SOFT GROUNDED TO ELIMINATE THE SAFETY HAZARD OF TOUCHING A HIGH VOLTAGE CIRCUIT WITH ONE HAND AND A HARD GROUND WITH THE OTHER. A WORK SURFACE WHICH IS CONNECTED TO HARD GROUND REQUIRES THAT THE ELECTRICAL POWER LINE BE PROTECTED WITH A GROUND FAULT CIRCUIT INTERRUPTER.

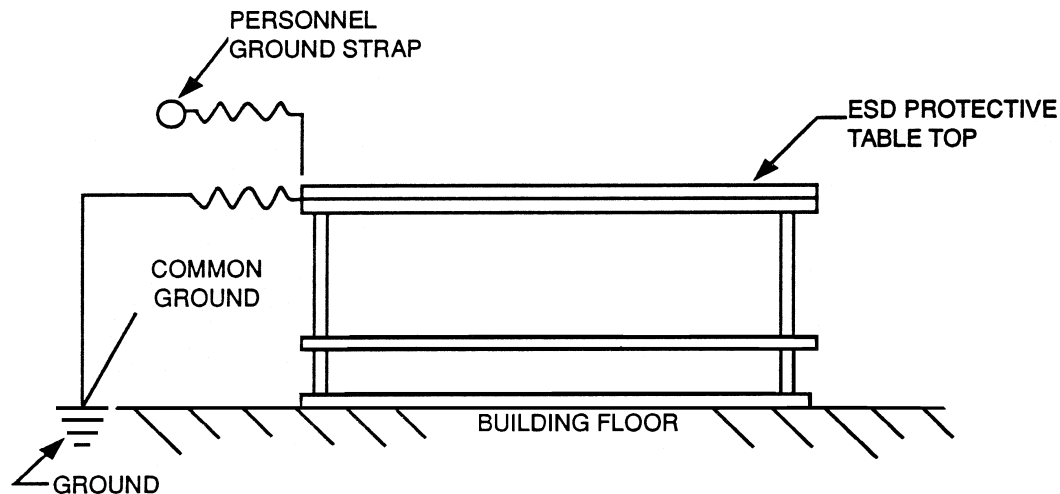


Figure 7-1. Typical ESD Grounded Work Bench

c. The protective work surface shall be sufficiently large to encourage the resting of common hand tools on the protective surface rather than on an adjacent nonprotected surface.

d. The protective work surface shall not release particle contaminants and shall resist attack by common solvents or cleaners. Solvent resistance shall be determined during initial verification by exposing test specimens to 1-hour exposure to each of the solvents that can be expected to be used at the work station.

CAUTION: SOME SOLVENTS ARE HAZARDOUS AND VOLATILE AND SHALL BE USED IN ACCORDANCE WITH THE MANUFACTURER'S GUIDELINES.

4. ESD-Protective Floor Coverings.

a. Conductive floors and/or grounded conductive floor mats are mandatory in areas where personnel are not wearing wrist straps. Under these conditions, the use of leg straps, heel straps or conductive shoes is mandatory.

b. Conductive floors or mats shall be kept free of dust, dirt and other contaminants.

c. After each cleaning, conductive floor resistivity shall be verified in accordance with supplier's ESD program documentation and the results shall be recorded. The use of waxes and

the buffing of conductive floors shall be prohibited. A notice stating these restrictions shall be prominently displayed in the areas having conductive floors.

d. Use of carpeting in an ESD-protected area is prohibited. This includes carpeting advertised as "conductive" or "static-eliminating."

5. **Personnel Grounding Devices.** Personnel grounding devices shall be supplied to all personnel working with or handling ESDS items to prevent the accumulation of dangerous electrostatic charge levels. A grounding device shall be worn by all personnel coming within 1 meter (3.3 feet) of any ESDS items.

The types of approved grounding devices are as follows:

a. **Wrist Straps.** The wrist strap is composed of four major elements:

(1) **Cuff.** The design of the wrist strap cuff shall ensure conductive contact with the wearer's skin. Metallic cuffs are preferred over plastics. Bead type chains are prohibited.

(2) **Lead.** For operator safety, the wrist strap release force of the cuff and the lead shall occur with at least 8.9 Newtons (2 pounds) but not more than 22.2 Newtons (5 pounds) of force.

(3) **Safety Resistor.** All wrist straps shall contain an integral current-limiting safety resistor (1 meg ohm $\pm$ 20%). The preferred location of the safety resistor is at the cuff end rather than the ground termination end of the lead.

(4) **Ground Termination.** The wrist strap ground termination shall ensure a positive and durable connection between the lead and the soft ground. All wrist straps within a protective area must utilize a common type of termination.

b. **Foot Grounding Devices.** Leg, toe or heel straps or conductive shoes worn in conjunction with a conductive floor and/or conductive floor mats, are acceptable alternatives to a wrist strap in those situations where the operator needs to be mobile and the use of a wrist strap is impractical or unsafe. The integrity of foot grounding devices shall be verified in the same manner as wrist straps.

NOTE: FOOT GROUNDING DEVICES SHOULD BE KEPT CLEAN SO THAT CONTAMINANTS DO NOT INHIBIT THEIR CONDUCTIVE INTERFACE WITH THE FLOOR.

6. Equipment and Facilities Grounding.

a. The preferred practice is to use the third wire AC line ground for grounding all items at the ESD-protected work station. When a separate grounding line is present or used in addition to the equipment ground, it should be bonded to the equipment ground at each ESD-protected work station to minimize the difference in potential. The resistance of the conductor from the common point ground to the equipment ground (AC ground) should not be greater than

1.0 ohm. The impedance from the work station common point ground to the neutral bond at the main service box should not be greater than 2.0 ohms. See Figure 7-2.

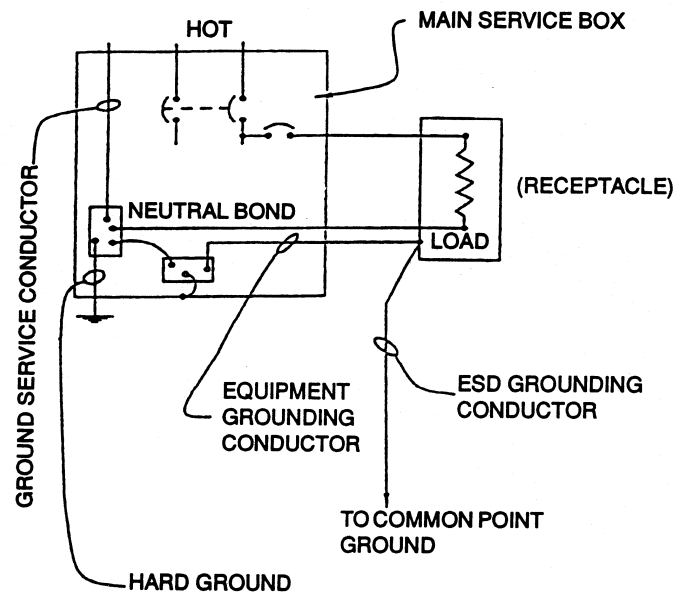


Figure 7-2. Main Service Box

(1) To establish grounding of stools and chairs, it is recommended that they be constructed of conductive material and the cover material fabricated from static dissipative materials. Where chairs and stools are required to be grounded and approved conductive flooring is utilized, positive electrical contact between the floor and metallic structure of the chair or stool is required.

b. Where cart, wagons or trams are required to be grounded and approved conductive floors are utilized, positive electrical contact must be made between the floor and conductive structure of the cart, wagon or tram. If the floor is non-conductive, the vehicle will be grounded before ESDS items are loaded or removed from the vehicle.

7. **Humidification.** The relative humidity shall be maintained in ESD-protected work areas at 30% to 70%. At levels below 30%, additional precautions shall be employed (e.g., air ionizers, humidifiers). If other precautionary methods are not available, work shall be halted until the required humidity level is obtained.

NOTE: SURFACE RESISTIVITY CHANGES EXPONENTIALLY WITH HUMIDITY CHANGES. THEREFORE, RELATIVE HUMIDITY LEVELS MAINTAINED BETWEEN 40% AND 60% ARE RECOMMENDED.

8. **Air Ionizers.** Air ionizers are recommended where grounding is impractical. The following types of air ionizers are recommended for use:

- a. Nuclear ionizer
- b. Corona discharge ionizer.

CAUTION: THE USE OF ANY TYPE OF AIR IONIZER IS PROHIBITED IN THE PRESENCE OF HIGH-VOLTAGE OR RF SENSITIVE EQUIPMENT TO AVOID BREAKDOWN IN THE PRESENCE OF IONIZED AIR.

9. Hand Tools, Equipment and Fixtures.

- a. a Uninsulated metal hand tools such as pliers, cutters, tweezers and wire strippers are preferred in ESD-protected areas. Hand tools shall be kept on the grounded work surface when not in use. Only antistatic solder extractors made of metal, or having a metallized plastic barrel and tip, shall be used in an ESD-protected area
- b. Electrical tools used in ESD-protected areas shall have a three-wire grounded power cord or be double insulated. The area making contact with the workpiece shall be grounded (e.g., solder iron tip). When measured from the work piece contact point to ground, the resistance shall not exceed 2.0 ohms and the potential difference shall not exceed 2 millivolts RMS using methods which are indicated in supplier's process documentation.

7.3 Protective Packaging

1. **General.** Electrostatic protective packaging requires both the prevention of charge generation (e.g., triboelectric contact and separating) and protection from strong electrostatic fields. The surface resistivity of any material should not exceed 10^{12} ohm/square. Protective packaging is considered ESD protective based on the following application methods.

2. Protective Bags and Pouches.

- a. Materials used in protective bags and pouches shall satisfy the resistivity requirements to avoid triboelectric charge buildup.
- b. Bags and pouches used for electrostatic shielding shall be constructed from a single folded piece of material. Two-piece construction is prohibited. If bags or pouches are not transparent to allow identification of contents without removal, a label shall be placed on the outside of the bag or pouch that identifies its contents.

3. Magazines, Chutes and Diptubes.

- a. Non-metallic conductive and static dissipative magazines, chutes and diptubes shall be used for shipping integrated circuits.
- b. Neither static dissipative impregnated nor topically treated plastics provide electrostatic shielding. Both types shall be enclosed in an outer container which will provide such protection during shipping.

4. **Tote Boxes and Other Holders.** Tote boxes shall be made of conductive or static dissipative material. All tote boxes shall be fitted with covers of the same conductivity as the bottom sections. The fit of this cover shall be such as to assure the conductivity across this interface.

7.4 Temperature Chambers and Cooling Agents

1. Gas flow is a significant generator of electrostatic charges. Precautions must be taken when gas flow is utilized in the area of ESDS items.

2. Cold chambers shall have the conductive baffles and shelves within the chamber grounded. The ESDS items shall be contained within or mounted on conductive material.

3. When pressurized cryogenic cooling agents are used for localized cooling, as in troubleshooting, they shall be electrostatically safe.

4. The stability of ESD-protective materials, which are used in temperature chambers, should be suitable for the test temperature and humidity ranges.

7.5 Cleaning and Cleaning Agents

1. Cleaning agents and methods used on ESD-protective items (e.g., work surfaces and floor coverings) shall not reduce the effectiveness of these items. They shall not cause leaching or leave insulating residues.

2. In addition to other required properties (e.g. solvency) cleaning agents used on ESDS items shall be chosen for low electrostatic charging propensity.

3. Only natural fiber materials shall be used for cleaning ESDS items. Synthetic materials are prohibited.

7.6 Electrostatic Survey Meters, Voltmeters and Monitors

1. Electrostatic survey meters shall be used to detect the presence of electrostatic charges. Static survey meters shall be of the type which read the electrostatic charge on a surface area without requiring contact. Such instruments shall be capable of measuring the voltage on a sample not more than 8 inches in diameter with a minimum resolution of 100 volts and a range of at least 1 Kilovolt (Kv).

2. The use of electrostatic monitors designed to actuate an alarm when an electrostatic field reaches a preset level, is recommended in an ESD-protected area.

3. A wrist strap tester shall be available in all areas where ESDS items are handled.

7.7 Clothing Requirements

Non-static generating clothing shall be worn in ESD-protected areas or static dissipative smocks shall be worn as an outer garment. Finger cots and gloves, when worn in an ESD-protected area, shall be made of static dissipative materials.

CHAPTER 8 - OPERATING REQUIREMENTS

8.1 Requirements for Handling ESDS Items

1. ESDS items shall be handled only in an ESD-protected area. Outside ESD-protected areas, ESDS items shall be enclosed in ESD-protective packaging.

2. Paperwork accompanying an ESDS item (e.g., QA records, routings, instructions) shall be contained in static dissipative bags or envelopes. Paperwork shall not come in physical contact with an ESDS item.

3. Shunts, such as bars, clips, or conductive covering, shall be used to protect an ESDS item which is not being tested or worked on.

4. All containers, tools, test equipment, and fixtures used in ESD-protected areas shall be grounded before and during use. A common ground shall be established between an ESDS item and any test equipment before connecting or disconnecting test cables.

5. Personnel handling ESDS items shall avoid physical activities that produce static charges (e.g., wiping feet, adding or removing items of clothing) while in the vicinity of ESDS items.

8.2 Receiving, Internal Handling, and Shipping

1. The following requirements shall be complied with during receipt, internal handling, and shipping.

a. All ESDS items received shall be examined for proper ESDS precautionary marking and for ESD-protective packaging.

(1) Inadequate precautionary markings shall be corrected prior to further processing.

(2) When an item is received that has not been protected during shipment or internal transfer, it shall be rejected as defective and processed as non-conforming material.

b. When a kit is assembled that includes an ESDS item, the entire kit shall be packaged and marked as ESDS. Accompanying documentation shall identify the kit as ESDS.

c. ESDS items packaged for shipping shall be packaged and marked as required by the contract and by this publication.

8.3 Equipment Level Test and Maintenance

1. The following requirements are applicable, both within a facility and in the field, when servicing equipment containing ESDS items:

- a. Personnel grounding shall be made using a wrist strap before each maintenance action. Maintenance actions include adjustments, restoring covers, and tightening fasteners.
- b. Protective packaging of a replacement ESDS item shall be grounded to the equipment to dissipate any static charge before the package is opened.
- c. As an ESDS item is installed, contact with parts, electrical terminals, and circuitry shall be minimized.
- d. Failed ESDS items shall be placed in protective packaging after removal from the equipment.
- e. Probing ESDS items with test leads shall be conducted while taking maximum precautions such as ensuring proper grounding and using ionized air, when available.

8.4 Equipment Level Installation

1. ESD-protective covering or protective caps on external terminals, interconnecting cables, and connector assemblies shall not be removed until necessary to permit the installation.
2. The cable connector pins and cable shield (connector outer shell) shall be grounded prior to engaging a de-energized connector and cable with a mating receptacle connected to an ESDS item.

8.5 Identification and Marking

1. ESDS items, equipment, and assemblies shall be identified in compliance with the following requirements. Identification shall be placed so as to warn personnel before any ESD damaging procedure can be performed. Packing lists, inspection reports, travelers, and other paperwork accompanying the hardware shall contain ESDS labels and cautionary notes.
 - a. Equipment containing ESDS items shall be identified internally with either the sensitive electronic device symbol from MIL-STD-129 or the EIA specification RS-471 symbol. These symbols are illustrated in Figure 8-1. The following caution statement shall be placed adjacent to the ESDS symbol, if room is available.

CAUTION: CONTAINS PARTS AND ASSEMBLIES SUSCEPTIBLE TO DAMAGE BY ELECTROSTATIC DISCHARGE (ESD).

2. Equipment having external sensitivity shall have ESDS symbols affixed to their exterior.
3. The ESDS cautionary mark on an assembly shall be visible when the assembly is installed in the next higher assembly. Alternative identification shall be used as approved by the procuring NASA Center when the prescribed marking is not possible.

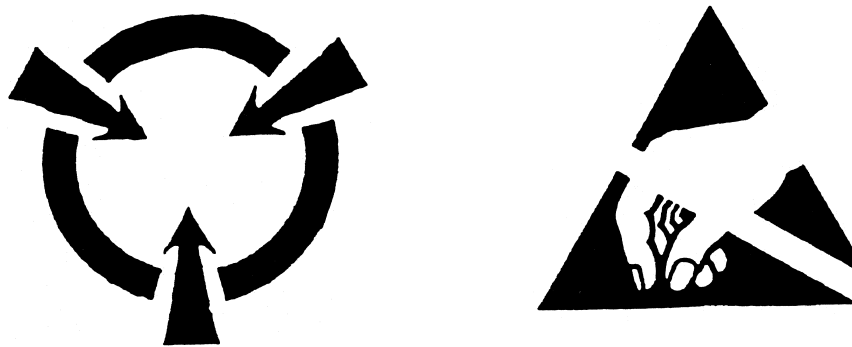


Figure 8-1: Sensitive Electronic Device Caution Symbols

CHAPTER 9 - QUALITY ASSURANCE PROVISIONS

9.1 General

1. The delegated quality assurance personnel shall be responsible for ESD control measures for all ESDS parts or assemblies. These control measures shall be implemented during all phases of procurement, assembly, disassembly, testing, repairs, handling, inspection, storage, and packaging for shipping.

9.2 Quality Assurance

1. The following functions shall be performed:

a, **Design.** All hardware designs containing ESDS parts shall be reviewed by Quality Assurance to ensure incorporation of all pertinent ESD specifications or standards.

b, **Procurement.** The cognizant entity shall ensure coordination of quality assurance with procurement to ensure incorporation of the requirements of this document.

c, **Supplier Verification.** Suppliers of ESDS items, materials, or services shall be reviewed for compliance to the requirements of the document.

d, **Facility Verification.** Quality assurance shall verify the facility qualification in accordance with paragraph 7.1.

e, **Receiving and Shipping Facility.** Quality assurance shall verify that all requirements applicable to the shipping and receiving facilities, where ESDS items are present, are properly implemented and documented as defined in paragraph 8.2.

f, **Assembly, Testing, Operation and Repair Procedures.** All assembly, test, operation and repair procedures for ESDS items shall be reviewed by Quality Assurance for ESD control adequacy.

g, **Personnel Garments, Materials, Tooling and Equipment Verification.** Quality assurance shall verify that all personnel garments, materials, tools and equipment utilized in ESDS operations meet the requirements of Chapter 7. The verification shall document the type(s) of tests performed, results, date performed, expiration date(s), name(s) of verifying personnel and organization.

h, **Internal Audits.** Quality assurance shall be responsible for the internal auditing of the ESD-protected areas. The audits shall be made on an agreed upon established schedule to ensure compliance with the ESD procedures defined herein. A formal report shall be made available to the audited group and the procuring NASA Center on request. This report shall include date of audit, performing personnel, requirements audited, documented results, and recommended corrective action.

NASA TECHNICAL STANDARD IMPROVEMENT PROPOSAL

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