COMMONWEALTH GOVERNMENT

AUSTRALIAN DEFENCE STANDARD

DEF(AUST)1000C

ADF PACKAGING;

STANDARD

PART 7: PACKAGING FOR MATERIEL SUSCEPTIBLE TO DAMAGE BY ELECTROSTATIC DISCHARGE

*
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NSC PACK

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AUSTRALIAN DEFENCE STANDARD

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PART 7: PACKAGING FOR MATERIEL SUSCEPTIBLE TO DAMAGE BY ELECTROSTATIC DISCHARGE

STANDARD

JULY, 2000

Prepared by the ADF Packaging Committee under the Authority of the Defence Standardisation Coordinating Group.

Specific inquiries regarding the application of this Standard to Requests for Tender or contracts should be addressed to the Procurement Authority named in the Request for Tender, or to the Quality Assurance Authority named in the contract, as appropriate.

This Standard is mandatory for use by the RAN, Australian Army and RAAF, and Contractors to the ADF.

This Standard supersedes DEF(AUST)1000B PART 7 : Packaging of Materiel Susceptible to Damage by Electrostatic Discharge.

This Standard implements the requirements of QSTAG 1157 : Standard Packaging of Materiel Susceptible to Damage by Electrostatic Discharge (Related STANAG, STANAG 4434 - AEPP-2)

WARNING

This Standard may call for use of substances and test procedures that may be injurious to health if adequate precautions are not taken. It refers only too technical suitability and in no way absolves either the supplier or user from statutory obligations relating to health and safety at any stage of manufacture or use.

DEF(AUST)1000C is issued in 20 parts, with each part sub-divided into Sections. The 20 parts are:

PART 16: Creative Brief Template
PART 17: Packaging ILS Checklist
PART 18: Life Cycle Analysis
PART 19: Caching
PART 20: Techniques for Deployment, Packaging and Storage for Tropical Conditions

Two or more parts may apply to any one packaging requirement and it is essential that all parts be considered and used where appropriate.

This Standard does not apply to the packaging of ammunition and explosives (for packaging information refer to Joint Ammunition Logistic Organisation [JALO]).

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1. INTRODUCTION

1.1. Modern technology has produced devices that are susceptible to permanent damage due to the discharge of electrostatic potentials of the order that would be encountered in routine handling. They have extensive use throughout the services and industry.

1.2. The construction of devices employing metal oxide semiconductor (MOS) technologies results in very thin dielectric layers of material with breakdown voltage at present as low as 20 volts. Protective circuitry is generally incorporated at the inputs and outputs of these devices, however, this factor does not necessarily protect the device from electrostatic charges in the surrounding environment.

1.3. Static electricity is generated in many everyday ways; it can result from an operator moving around on a chair, brushing against a wall or bench, or simply walking across the floor. Devices handed from one person to another or being wrapped or unwrapped can be subjected to electrostatic discharge (ESD). The assembly area may itself induce electrostatic charges; for example, air conditioning systems and the spraying of synthetic materials (cleaning liquids, etc.) may result in electrostatic charges being generated. This electrostatic charge is not generally noticed by the operator, but its transfer can nevertheless result in the destruction of the device or degradation of its performance.

1.4. Materials, which are prime generators of electrostatic voltages, include common plastics (i.e. polyethylene, vinyls plastics, foam, and polyurethane's), synthetic textiles, fibreglass, glass, rubber, and other commonly used materials. Damaging electrostatic voltage levels are commonly generated by sliding, rubbing, and separating of these materials by industrial processes and personnel movement.'

2. SCOPE

2.1 This publication provides guidance and procedures that, if followed, will minimise the risk of ESD damage to static-sensitive devices; it also emphasises the need for all persons concerned with the handling of these devices to be fully aware of the problems involved. Details of identification requirements, including a caution symbol, have been included for use on related documentation, storage facilities, and directly associated material. General requirements and procedures contained herein are applicable to personnel engaged in packaging development or preparation for receiving, shipment, and storage. Additional requirements shall apply for areas with exposed conductors at potential's greater than 2.5kVa.c. or 2.5kVd.c.

2.2. Although this publication does not include requirements for personal safety, attention is drawn to the need for all concerned to comply with relevant local statutory requirements regarding the health and safety of all persons in all places of work, including those covered by this publication.

2.3. **This publication <u>does not</u> apply to static-sensitive explosive devices.** Use of this document or procedures defined herein do not apply to facilities where ordnance, flammables or explosives are handled or stored.

3. APPLICABLE DOCUMENTS

American, British, Canadian Australian (ABCA) Documents

QSTAG 1149 - Standard Method of Preservation (STANAG 4272)

QSTAG 1150 - Glossary of Packaging Terms and Definitions (STANAG 4279)

QSTAG 1151 - Levels of Packaging (STANAG 4280)

QSTAG 1154 - Marking for Shipment and Storage (STANAG 4281)

QSTAG 1155 - Packaging Test Procedures (STANAG 4272 - AEPP-3)

NATO Documents

STANAG 4434 - NATO Glossary of Packaging Terms and Definitions (AEPP-2)

AAP-23 - NATO Glossary of Packaging Terms and Definitions

European Norm

EN10015/1 - Protection of Electrostatic Sensitive Devices, Part 1: General Requirements

4. DEFINITIONS

4.1 **GENERAL.** The terms used throughout this publication and their interpretation shall be in accordance with the following definitions. Other relevant terms are defined in DEF(AUST)1000 PART 1.

4.2. **TERMS**

a. **ANTISTATIC FAST PACK**. Reusable container with antistatic cushioning and the word "antistatic" printed on both ends.

b. **ANTISTATIC PROPERTY**. Refers to the prevention of tribo-electric charge generation. Antistatic materials minimise the generation of static charges. This property is not dependent upon material resistivity.

c. **ANTISTATIC TOTE TRAY**. Container for static-safe storage, kitting, and in process handling and transporting of static sensitive assemblies or devices.

d. **CONFORMAL COATINGS**. Liquid materials applied directly to printed circuit boards (PCB) or electronic components during final manufacture. Once hardened, they provide physical, electrical, and environmental protection.

e. **DEVICE**. An individual part, separate component, integrated circuit, or electronic assembly, such as a microcircuit, semiconductor, - or electronic "black box".

f. **ELECTROSTATIC CONDUCTIVE MATERIAL**. Material with a surface resistivity of greater than 1×10^6 ohms per square and less than 1×10^5 ohms per square and a volume resistivity of greater than 1×10^2 ohms x centimetre and less than 1×10^5 ohms x centimetre.

g. **ELECTROSTATIC DISCHARGE (ESD).** A transfer of electrostatic charge between bodies at different electrostatic potentials caused by direct contact or induced by an electrostatic field.

h. **ELECTROSTATIC DISCHARGE (ESD) PROTECTIVE.** Preventing the generation of static electricity dissipating electrostatic charges over its surface or volume and providing shielding from ESD or electrostatic fields.

i. **ELECTROSTATIC DISCHARGE SENSITIVE (ESDS).** The relative tendency of a device's performance to be affected or damaged by an ESD event.

j. **ELECTROSTATIC SENSITIVE DEVICES (ESSD).** A separate component, integrated circuit, or electronic assembly likely to be damaged by ESD generated during routine handling, testing, or transit. (**NOTE**: Damage means destruction or deterioration during the performance of the product.)

k. **ELECTROSTATIC DISSIPATIVE MATERIAL**. Materials with a surface resistivity greater than 1×10^5 ohms per square and less than 1×10^{12} ohms per square or a volume resistivity greater than 1×10^4 ohms x centimetre but less than 1×10^{11} ohms x centimetre.

l. **ELECTROSTATIC FIELD**. A voltage gradient between an electrostatically charged surface and another surface of a different electrostatic potential.

m. **ELECTROSTATIC SHIELDING MATERIAL**. Is a multi-layer material in which the surface layer has a surface resistivity less than 1×10^4 ohms per square, or volume resistivity less than 1×10^3 ohms x centimetre per millimetre of material thickness, whilst an underlying layer is insulative.

n. **ESD-FIELD SERVICE KIT.** A portable ESD workstation kit used for handling ESSD items in situations when other ESD control workstations are not available or feasible to use.

o. **ESD-PROTECTIVE WORK AREA (PWA).** An area in which ESSD can be handled that is constructed and equipped with the necessary ESD-protective materials, static control equipment, and procedures, required to limit ESD voltages below the sensitivity level of ESSD handled therein.

p. **ESD-PROTECTIVE WORKSTATION**. A space located within an ESD-protective area that is specifically dedicated to single or related tasks and contains the workbench, equipment, and materials to handle and package ESSD.

q. **ESD-PROTECTIVE MATERIAL**. Material with one or more of the following properties: limits the generation of electrostatic charge; dissipates electrostatic charge; or provides shielding from electric fields. For the purpose of this publication, ESD-protective materials are classified as conductive or dissipative.

r. **ESD-PROTECTIVE PACKAGING**. Enclosing an ESSD in ESD-protective materials to minimise the chance of damage.

s. **GROUND**. A mass such as earth, a ship, or vehicle hull capable of supplying or accepting an electrical charge.

t. **HARD GROUND**. A connection to ground either directly or through a low impedance.

u. **HANDLED/HANDLING**. Actions in which devices are hand manipulated or machine processed during actions such as inspecting, assembling, processing, testing, reworking, transporting, wrapping, packing, marking, labelling, etc.

v. **INSULATIVE MATERIAL**. Material with a surface resistivity greater than 1×10^{12} ohms per square or a volume resistivity greater than 1×10^{11} ohms x centimetre. Insulative materials are not classified as ESD-protective materials.

w. **INTIMATE PACKAGING MATERIAL**. Materials which make contact with a bare ESSD.

x. **PROXIMITY PACKAGING MATERIAL**. Material not making contact with a bare ESSD but which is used to enclose one or more wrapped devices.

y. **SECONDARY PACKAGING MATERIAL**. Material used primarily to give additional physical protection on the outside of a proximity package.

z. **STATIC-SAFE AREA**. Any area that is capable of controlling static charge on people and conductive materials.

aa. **SURFACE RESISTIVITY (Ps).** An inverse measure of the conductivity of a material and equal to the ratio of the potential gradient to the current per unit width of the surface, where the potential gradient is 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.)

ab. **TRIBO-ELECTRIC EFFECT**. The generation of static electricity caused by rubbing, contacting, or separating of two surfaces.

ac. **UNIT PACK**. The first tie, wrap, or container applied to a single item or a quantity thereof or to a group of items of a single stock number, preserved or unpreserved, which constitutes a complete or identifiable package.

ad. **VOLUME RESISTIVITY (Pv).** An inverse measure of the conductivity of a material and equal to the ratio of the potential gradient to the current density, where the potential gradient is measured in the direction of the current flow in the material. (**NOTE**: In the metric system, volume resistivity of an electrical insulating material in ohm x centimetre is numerically equal to the volume resistance in ohms between opposite faces of a 1 centimetre cube of the material. Volume resistivity in ohm x millimetre has a value of 0.01 the value in ohm x centimetre.)

ae. **WATER-VAPOURPROOF MATERIAL**. A barrier material offering a high resistance to the passage of water vapour; the water-vapour transmission rate (WVTR) shall not exceed 0.31 g/m^2 in 24 hours when measured at a temperature of 38°C with a relative humidity of 90 percent.

5. REQUIREMENTS

5.1. IDENTIFYING ESSD

5.1.1. Due to the large number of electronic devices presently used by the military and the methods needed to accomplish the task, identifying devices that are ESSD is essential. Electrical and electronic devices, which have been determined to be ESSD, include microelectronic discrete and integrated semiconductors; thick and thin film resistors, chips, and hybrid devices; and piezoelectric crystals. Subassemblies, assemblies, and equipment containing these devices are also ESSD. ESSD are categorised as follows:

a. All printed circuit boards (cards), wiring boards and, modules or assemblies with mounted ESSD components.

b. Appropriate devices within NATO supply classes:

5905 - Resistors, precision or thin film:

(i) Fixed, Film

(ii) Fixed, Film, Chip

(iii) Network, Fixed, Film

(iv) Capacitor Network, Fixed Film, and Ceramic Capacitor

5955 - Oscillators and Piezoelectric Crystals

5961 - Semiconductor Devices:

(i) Hybrid Semiconductors

(ii) Metal Oxide Semiconductor Field Effect Transistors (MOSFET)

(iii) Junction Field Effect Transistors (JFET)

(iv) Microwave Diodes

(v) Silicon-Controlled Rectifiers (SCRs)

(vi) Small Signal Schotty Diodes

(vii) Semiconductor Devices (operating at a frequency above one gigahertz)

5962 - Microcircuits, Very High Speed Integrated Circuits (VHSIC), and Small Scale Integrated (SSI), Medium Scale Integrated (MSI), Large Scale Integrated (LSI), Very Large Scale Integrated (VLSI), and Ultra Large Scale Integrate (ULSI) Circuits

5963 - Electronic Modules

7042 - Mini and Micro Computer Control Devices

(i) Optoelectronic Devices (LEDs, Phototransistors, Opto Couplers)

(ii) Surface Acoustic Wave (SAW) Devices

(iii) Operational Amplifiers (OP AMP)

c. Designated Subassemblies (ESSD components) of NATO Supply Classes:

1430 - Guided Missile Remote Control Systems

4935 - Guided Missile Maintenance Repair and Check-out Specialised Equipment

5999 - Miscellaneous Electrical and Electronic Components

d. Any complete system, "Black Box", Line Replaceable Unit (LRU), Shop Replaceable Unit (SRU), electronic test or repair equipment console/device or component containing the assemblies or parts mentioned above shall be considered ESSD.

5.1.2. ESD susceptibility stops when the devices are correctly packaged or the level of assembly is such that a complete electro-static shield exists around the device or until which time it can be shown by testing that the ESSD device is protected from static voltages above 16,000 volts.

5.2. PACKAGING GUIDELINES

5.2.1. Devices identified, as ESSD will be protected from the very beginning of the acquisition process to final disposal.

5.2.2. Unprotected ESSD shall be handled only at an ESD-protective workstation (safe handling area) by trained personnel who can effectively employ the protective materials and equipment provided.

5.2.3. The packaging of ESSD will preclude the use of ABCA Standard Method of Preservation (QSTAG 1149) by using static dehumidification because of uncontrolled low humidity levels. Intimate protection against the effects of the environment will be gained through other treatments that do not introduce an additional hazard, such as uncontrolled or excessively low humidity (20% r.h.) levels or a source of contamination.

5.2.4. The selection of electrostatic dissipative and conductive materials used, as part of the unit pack will conform to the performance criteria specified herein. Regardless of the material form, they will offer the antistatic property without affecting other material characteristics, introducing a corrosive environment, or losing this protection during long-term storage.

5.2.5. In all cases, the intimate packaging material(s) surface will be electrostatic dissipative. Such material may be in the form of a homogeneous single film of cushion thickness or a multilayered structure either as a flat film or cushioning pad, as in a pouch configuration.

5.2.6. Proximity shielding will be required to protect against the effects of electrostatic discharge or electrostatic fields. This protection is normally available in materials through the use of conductive layers attained by carbon loading, metallisation, or other manufacturing techniques. When applied,

whether as composite structure, pouches, or laminates, conductive (inside) surfaces of the electrostatic and electromagnetic shielding barrier material will not be permitted to be placed against bare devices.

5.2.7. Selection of the appropriate packaging material(s) will be based on the nature of the device and prescribed packaging data, if available. Where a possible projection hazard may exist, due to penetration through the electrostatic dissipative surface into the conductive portion of the material, additional wraps or a different form of ESD-protective material will be specified

5.2.8. Whenever an ESSD, assembly, or system is transported between work areas or workstations, prior to being packaged, the device shall be contained in electrostatic-conductive or electrostatic-dissipative tote boxes, trays, bags, fast packs with bonded polyurethane antistatic, flexible foam cushioning pads, etc. to provide protection from contamination and mechanical damage as well as electrostatic protection. (**NOTE**: At no time shall an ESSD be left unprotected.)

5.2.9. When an unprotected ESSD is dropped, it shall require functional testing (serviceability tests), prior to being packaged.

5.2.10. Only new unused ESD-protective packaging materials will be used to form the unit pack. However, when such materials are not available, reusable ESD-protective materials may be used for limited packaging of unserviceable field returns.

5.2.11. Removal of devices from interim protective packaging and subsequent handling shall be accomplished only within a protected area. (**NOTE**: Where tape is acting as a seal, it shall be cut to open the bag, box, or container and not stripped away.) Unnecessary repackaging of an ESSD constitutes excess handling and shall be avoided wherever possible.

5.2.12. Whenever an ESSD is to be exposed, workstation(s) will be cleared of any materials which are not ESD-protective to preclude the possible damage of items either through direct contact with such sources from electrostatic charge build-up or as the result of ESD produced within an electrostatic field created by these materials.

5.2.13. It is essential that the handling of ESSD be kept to an absolute minimum and then only in an ESD-protective work area by trained personnel.

5.2.14. ESD-protective pouches shall be used for technical manuals, drawings, work instructions, etc, within the protective work area.

5.2.15. Contractors may propose the use of their commercial packaging provided they can demonstrate that their packaging will provide equal or better protection than that specified by the cognizant procuring activity.

5.2.16. Levels of packaging, packaging test procedures, and resistivity, resistance, and measurement test procedures and test equipment are depicted in DEF(AUST)1000, PART 2, QSTAG 1155 and ANNEX D, respectively.

5.2.17. The commodity identification and shipping markings shall be in accordance with DEF(AUST)1000, PART 5.

5.3. PACKAGING MATERIALS

5.3.1. Packaging materials are those materials which cushion, enclose, or protect the ESSD during handling, transporting, and storage such as bags, boxes, pouches, tubes, wraps, foams, loose fill[1], etc.

a. Materials shall maintain their antistatic, resistive, and shielding properties during application, storage, transporting, distribution, or to the point of disposal.

b. Materials that are prime generators of electrostatic charges, such as untreated plastic films, foams, synthetic fibres, self adhesive tapes, etc., shall not be used as intimate or proximity packaging materials and shall be excluded from the ESD-protective work area.

[1] Loose fill shall not be used in packages shipped to RAN Establishments

c. Materials which are in intimate contact with ESSD shall be electrostatic dissipative. The following shall not be used as intimate packaging or be allowed to make contact with ESSD: Exposed metal foils, laminates and other packaging materials with a surface resistivity of less than 1×10^3 ohms per square.

d. Materials used for proximity packaging, which surround or enclose an ESSD, shall be capable of dissipating electro-static charges in under 2.0 seconds.

e. Materials used as secondary packaging are primarily to give additional physical protection to the outside of a proximity package.

f. Proximity materials used as loose fill shall be electrostatic dissipative. Other loose fill materials maybe used but only as secondary packaging materials.[1]

g. If adhesive (sticky) tape is to be used, only Antistatic adhesive tape shall be used; eg taping the end of an IC Dip Tube and sealing Static Shielding Bags.

5.3.2. The Resistivity Chart for Packaging Materials, TABLE I, lists general guidance for the selection of intimate, proximity, and secondary packaging materials.

TABLE I

RESISTIVITY CHART FOR PACKAGING MATERIALS

<table>
<tr><th colspan="6">SURFACE RESISTIVITY OHM PER SQUARE - VOLUME RESISTIVITY OHM PER CM (SHOWN IN BRACKETS)</th></tr>
<tr><th colspan="2">INTIMATE PACKAGING MATERIAL NOTE 1</th><th colspan="2">PROXIMITY PACKAGING MATERIALS NOTE 1</th><th colspan="2">SECONDARY PACKAGING MATERIAL</th></tr>
<tr><td>Voltage sensitivity Note 2</td><td>Unpowered ESSD Device</td><td>Powered ESSD Device</td><td>Within ESD-PWA</td><td>Uncontrolled Conditions</td><td rowspan="4">Secondary packaging material including loose fill shall have no special requirements provided that:
a. ESSD remain in their proximity packaging when placed in or taken out of secondary packaging.
and
b. The secondary packaging is not bought into an ESD work area.
If either of the above conditions are not satisfied, then secondary packaging material shall be used.</td></tr>
<tr><td>0 - 3999</td><td rowspan="3">10^3 to 10^{12} (10^2 to 10^{11}) Note 3</td><td rowspan="3">10^8 to 10^{12} (10^7 to 10^{11}) Note 3</td><td>Electrostatic Shielding 10^3 to 10^6</td><td>Electrostatic Shielding</td></tr>
<tr><td>4000 - 14999</td><td>10^3 to 10^{12} (10^2 to 10^{11}) Note 3</td><td>10^3 to 10^6 (10^2 to 10^5)</td></tr>
<tr><td>15000 +</td><td></td><td></td></tr>
</table>

NOTES:

1. A single static shielding bag with an electrostatic dissipative inner surface may be used as both the intimate and proximity packaging, provided that the outer surfaces are not capable of holding an electrostatic charge when grounded and a box is provided for physical protection which will not generate an electrostatic charge.

2. Unless specified by the ESSD manufacturer requirements for voltage sensitivity of 0 - 3999 volts shall be used.

3 Where surface resistivity is $>10^{10}$ or volume resistivity of $>10^9$ is used then the material shall be procured with a static decay characteristic of 1000 V to 50 V in under 2 seconds.

Remarks:

1. These are minimum requirements and improved levels may be used if required. In particular packaging appropriate to more sensitive ESSD may be used.

2. Test procedures are included in ANNEX D.

3. Surface and volume resistivity measurements shall be taken at (25 $\pm$ 5) percent relative humidity.

5.3.3. ESD characteristics of materials are listed in TABLE II.

TABLE II

ESD CHARACTERISTICS OF MATERIALS

NOMEN-CLATURE	SURFACE RESISTIVITY RANGE	TYPICAL PRODUCTS	COMMENTS AND CAUTIONS
Conductive Material	> 1 x 10^3 ohms per square < 1 x 10^5 ohms per square	Conductive foam Conductive containers Electrostatic shielding with dissipative outer material Metallised bags	Generally acceptable for ESD damage prevention and control
Dissipative (or Electro-Static Dissipative Material)	> 1 x 10^5 ohms per square < 1 x 10^{12} ohms per square	Workbench tops, mats and chairs, Some tool handles, Some tote boxes, Finger cots, gloves and shoes Pouch or bag, plastic, cushioned and uncushioned, Container with polyethylene cushioning, Foams, polypropylene and polyethylene, Wraps and cushions, plastic	Generally acceptable for ESD damage prevention and control
Insulative Material	> 1 x 10^{12} ohms per square	Teflon, Plexiglas Cellophane tapes Untreated paper products Standard plastic tubes, caps, plugs, tools and sandwich bags Rubber/plastic coats and gloves	Provides little or no ESD protection and shall not be used for ESD damage prevention and control and shall not be present in ESD protected areas.
Shielding Material	< 1 x 10^4 ohms per square	Electrostatic shielding with dissipative outer material Trolley carts and wagons, Some tote boxes, Pouch and bags, Cushion wrap, Some containers	Generally accepted materials which are capable of attenuating an electrostatic field and electromagnetic radiation
Antistatic Material	> 1 x 10^{12} ohms per square < 1 x 10^{14} ohms per square	Poly bags Surface cleaners Finger cots Bubble wrap and packing materials, Foam, polyurethane,	Provides inadequate ESD protection when used alone may cause or promote contamination/ corrosion if used in contact with production hardware equipment. May be used for ESD damage prevention and control in combination with conductive and/or dissipative material

Notes:

1 Paper, fibreboard, and other natural fibre products are electrostatic dissipative under moderate or high relative humidity conditions, because of this variability and because they are often processed with corrosive agents, containers made from such materials are generally not acceptable for ESSD processing or storage, if used alone.

2. Bags, boxes, gloves, and work surfaces manufactured with carbon-filled plastics are usually conductive but may present a contamination hazard if rubbed or abraded; therefore, such materials should be used with caution

5.3.4. Some of the known approved packaging materials specifications, by description and number, are listed in ANNEX A. The list may not be all-inclusive because of the rapid technological changes, which affect materials available from supply sources.

5.4. PACKAGING PROCEDURES

5.4.1. **Unpowered and powered ESSD**.

a. Unpowered devices with leads may be mounted on electrostatic non-corrosive conductive foam to "shunt or short out" the pins.

b. Self-powered devices which may contain batteries, charge capacitors, or other energy sources shall be packed with intimate packaging materials with surfaces which are electrostatic dissipative or in a electrostatic protective container specifically designed to avoid contact with individual leads or circuit tracks.

c. Powered devices shall not be packed in direct contact with surfaces or materials, which have a surface resistivity of less than 1×10^7 ohms per square.

5.4.2. **Serviceable field returns**. When serviceable ESSD, assemblies, or systems are to be returned to the distribution system, the unit pack shall be as prescribed in paragraph 5.5.1a, 5.5.1b, or 5.5.1c, as applicable.

5.4.3. **Unserviceable field returns**.

a. Unserviceable, repairable ESSD, assemblies, or systems being returned through the distribution system for repair shall be given the applicable packaging protection as prescribed in paragraphs 5.5.1a, 5.5.1b, or 5.5.1c, as applicable.

b. Whenever new (unused) ESD-protective packaging materials are not available, reusable ESD-protective materials may be used for limited packaging of unserviceable field returns.

5.5. PACKAGING METHODS

5.5.1. **Unit pack**[1]

a. Electrostatic dissipative.

(i) Wrap the device with transparent/translucent, waterproof, electrostatic protective, static dissipative, heat-sealable barrier material (see TABLE II and ANNEX A) or;

(ii) Cushion the device with electrostatic dissipative, -flexible, closed cell, noncorrosive, heat-sealable, plastic film cushioning material; general purpose, static dissipative (may be fire retardant), polyethylene foam sheet cushioning material; hexagonal, electrostatic free, with or without top laminate, light-weight, transparent, flexible, open cell, heat-sealable cushioning material; or low density, resilient, unicellular, closed cell, electrostatic protective, polypropylene foam cushioning material (see TABLE II and ANNEX A) or;

(iii) Place the device in a flexible, electrostatic-free, reclosable (zipper type closure), three ply, transparent pouch or a single-ply, heat-sealable, lip closure cushioning pouch fabricated from flexible, transparent, waterproof, electrostatic protective, electrostatic dissipative barrier material (see TABLE II and ANNEX A).

[1] The unit pack is identified as the heat sealable electrostatic/electromagnetic shielding opaque bag. It is sometimes referred to as intimate packaging.

b. Electrostatic shielded.

(i) Place the wrapped/cushioned/bagged device in a heavy duty, water-vaporproof, heat-sealable, electrostatic and electro-magnetic shielding opaque bag. The bag may be fabricated from one piece of material folded in half and heat sealed on three sides (see TABLE II and ANNEX A).

c. Antistatic Fast Pack.

(i) ESSD (e.g., circuit boards, resistors, semiconductors, microcircuits, etc.) may be packed in reusable boxes as described in ANNEX A or containers (e.g., plastic, conventional fibreboard, etc.) that provides equivalent protection against electrostatic discharge.

(ii) The container shall be sealed with minimum 50 mm (60 mm for ABCA) wide waterproof packaging tape placed over all seams, corners, and manufacturer's joints.

(iii) The container shall be marked "REUSABLE" and the word "ANTISTATIC" shall be marked on both ends.

5.5.2. **Intermediate - exterior container[1]**.

(i) When applicable, the use of intermediate and exterior containers is encouraged.

(ii) Proximity packaging materials, which surround or enclose an ESSD, shall be capable of dissipating electrostatic charges. Packaging materials may be constructed in a manner to fulfil the requirements of electrostatic shielding bags; or use electrostatic shielding bags; or use separate components such as dissipative foam-lined conductive boxes (see TABLE I and 2 and ANNEX A).

5.6. **WARNING LABELS AND MARKINGS**

5.6.1. **General guidance**.

a. All unit packs and intermediate and exterior containers of ESSD (or other electronic devices that are alone or are part of assemblies) that are susceptible to damage from an ESD event shall be labelled or marked with the appropriate and specified warning notice. The notice shall include the ESSD basic symbol, which is available in single use or reusable forms using the accepted industry standard symbols: JEDEC-14 (Joint Electronic Device Engineering Council) and Military Standard 129M (see FIGURE 1).

[1] Sometimes referred to as proximity and secondary packaging.

FIGURE 1
ESSD basic symbol

5.6.2. **Unit packs**.

a. All unit packs shall be marked with the ESSD warning label.

b. The label shall include the ESSD basic symbol (see FIGURE 1), and ESSD unit pack symbol with the words "ATTENTION - STATIC SENSITIVE DEVICES, HANDLE ONLY AT STATIC SAFE WORKSTATIONS" and the statement "REUSABLE CONTAINER DO NOT DESTROY" and be printed in black on a orange-background. The ESSD unit pack symbol is available in single use or reusable forms using the accepted industry standard symbols: JEDEC-14 (Joint Electronic Device Engineering Council) and Military Standard 129M (see FIGURE 2.)

FIGURE 2
Warning label for ESSD - unit packs

c. The label shall be located adjacent to the identification markings of the contents. Where an electronic assembly or housing contains one or more ESSD, it shall be labelled such that the warning can be clearly seen before an ESSD is placed at risk due to contact.

d. Where space does not permit the use of the ESSD warning label, as a minimum, the ESSD basic symbol, see FIGURE l, shall be applied. The minimum size of the symbol shall be 10 mm measured vertically at the base of the triangle.

e. If the label is temporarily unavailable, unit packs shall be marked as prescribed in paragraph 5.6.2b and 5.6.2g.

f. The marking can take the form of printed tapes, stencilling, or machine printing or stamping. The markings shall be printed in black or the same colour as the identification markings, if other than black.

g. Unit packs used as exterior containers shall be marked with the unit pack warning label.

5.6.3. **Primary, Intermediate[1] and Exterior Containers**

a. **Primary** anti-static bags or containers are to be closed by affixing an ESSD warning label (see FIGURE 2) in such a manner that the bags cannot be opened without tearing the label.

b. **Intermediate container** - one warning label placed adjacent to the identification marking of contents.

c. **Exterior container** (less than 0.012 m^3) - two warning labels shall be placed on each container, with one label placed on the identification - marked side (surface) and one label placed on the opposite side.

d. **Exterior container** (greater than 0.023 m^3) - two warning labels shall be placed on each container, with one label placed on the identification - marked side (surface) and one label placed on the opposite side.

e. If the label is temporarily unavailable, intermediate and exterior containers may be marked as prescribed in paragraph 5.6.3b and 5.6.3d.

f. The marking can take the form of printed tapes, stencilling, or machine printing or stamping. The markings, 10.5 mm measured vertically, shall be printed in black or the same colour as the identification markings, if other than black.

5.7. **ESD ENVIRONMENT**

5.7.1. **Protective work area.**

a. A controlled working environment provides the most effective means of preventing damage to unprotected ESSD.

b. The work area shall have defined boundaries and be designed to ensure that ESSD can be handled with minimum risk or damage.

c. An electrostatic-field strength metre may be required in the work area to measure and monitor static charges, and to identify unacceptable static charges on incoming devices and packaging materials.

d. The EPA relative humidity should be maintained above 20 percent. Low humidity will severely reduce the dissipation effectiveness of materials used in certain types of work surfaces, packagings, and clothes. However, high relative humidity (e.g. 70 percent) shall not be used as a prime means of controlling ESD. Excessive humidity can cause problems such as corrosion, possible leakage paths for high voltages, and moisture contamination within equipment.

e. The surface of racking, shelving, carousels and dispensers which are used to hold unprotected ESSD shall meet the requirements of a working surface material as specified in TABLE III and shall be grounded.

f. Only approved ESD-protective packaging material or containers shall be used or stowed within the work area.

g. The work area, including boundaries, entrances, and exits shall be clearly identified by specified signs.

h. A summary of requirements for an ESD-protective work area is given in ANNEX B.

[1] Sometimes referred to as proximity and secondary packaging.

TABLE III - RESISTIVITY AND RESISTANCE GUIDE FOR ESD PROTECTIVE AREA

ITEM (S)	SURFACE RESISTIVITY NOTE 1, 2, & 3	VOLUME RESISTIVITY NOTE 1, 2, & 3	RESISTANCE TO GROUND NOTE 3
Working surfaces including storage racks and floor (required for grounding personnel)	> 1 x 10^4 ohm/ground < 1 x 10^9 ohm/ground	> 1 x 10^3 ohm x cm < 1 x 10^8 ohm x cm	> 7.5 x 10^5 ohm < 1 x 10^9 ohm
Floor (not required for grounding personnel)	> 1 x 10^4 ohm/sq < 1 x 10^{12} ohm/sq	> 1 x 10^3 ohm x cm < 1 x 10^{11} ohm x cm	> 7.5 x 10^5 ohm < 1 x 10^{12} ohm
Trolley carts and wagons	> 1 x 10^4 ohm/sq < 1 x 10^9 ohm/sq (platform only)	> 1 x 10^{13} ohm x cm < 1 x 10^8 ohm x cm (platform only)	> 7.5 x 10^5 ohm < 1 x 10^9 ohm (frame) < 1 x 10^{10} ohm (platform)
Seating	> 1 x 10^4 ohm/sq < 1 x 10^9 ohm/sq	> 1 x 10^3 ohm x cm < 1 x 10^8 ohm x cm	> 7.5 x 10^5 ohm < 1 x 10^{12} ohm Note 4
Garments	> 7.5 x 10^5 ohm/sq < < 1 x 10^{12} ohm /sq		
Gloves and fingers cots	< 1 x 10^6 ohm/sq	< 1 x 10^5 ohm x cm	
Wrist strap/ground cord	< l x 10^7 ohm/sq		< 3.5 x 10^7 ohm
Cords			> 9 x 10^5 ohm < 5 x 10^6 ohm (end to end)
Hand to remote end of cord			> 9 x 10^5 ohm < 3.5 x 10^7 ohm
Footwear (required to ground personnel)			< 3.5 x 10^7 ohm

Notes:

1. Surface and volume resistivity measurements shall be taken at (25 $\pm$ 5) percent relative humidity.
2. Depending on the type of material, surface resistivity or volume resistivity figures shall be used.
3. Test procedures are included in ANNEX D.
4. < 10^9 ohm from seat back and arm pad to at least one foot.

5.7.2. **Protective workstation**

a. The outer perimeter of the workstation area will be identified as a restricted area for trained personnel to handle ESSD.

b. A workstation should consist of electrostatic dissipative table(s) or bench surfaces, drawers for components, accessories and packaging pouches, ionizer with monitor, personal wrist straps, heel grounds straps (as required), grounding cords, grounding attachments, conductive floor mats or floor covering, and electrostatic dissipative chairs/stools (see TABLE III for surface and volume resistivity). FIGURE 4 illustrates the typical layout of an ESSD device-protective workstation, whilst minimum equipment and components are listed in ANNEX C.

c. An ionizer is a precautionary device that, within its effective area of control to aid in removing electrostatic charges from ungrounded conductive and insulative materials.

d. An earth grounding point shall be established on all work surfaces and nonpermanent flooring. A separate earth grounding point is not required for permanent flooring which has a resistance to ground value within limits (see FIGURE 4 and TABLE III).

e. All working surfaces and floor covering materials, shall be capable of being brought to ground and shall have a surface resistivity greater than l x 10^4 and less than 10^{12} ohms to ground (see FIGURE 4 and TABLE III).

f. A wrist strap shall consist of a band that fits snugly around the wrist with a quick-release connection and a cord containing a safety resistor to connect the band to an earth-bonding point.

g. The wrist strap shall be made from materials that provide for the inner surface, next to the skin, with a surface resistivity of less than 1 x 10^7 ohms per square with the intention of making permanent contact with the wrist (see FIGURE 4, TABLE III and ANNEX C).

h. A dedicated earth-bonding point for the wrist strap cord shall be established adjacent to each workstation. It will be easily accessible without obstructing the work in hand nor presenting a possible hazard in the working environment. As an alternative, the wrist strap cord may be connected to earth via the work surface conductive element, provided that the total resistance to ground is less then 3.5 x 10^7 ohms.

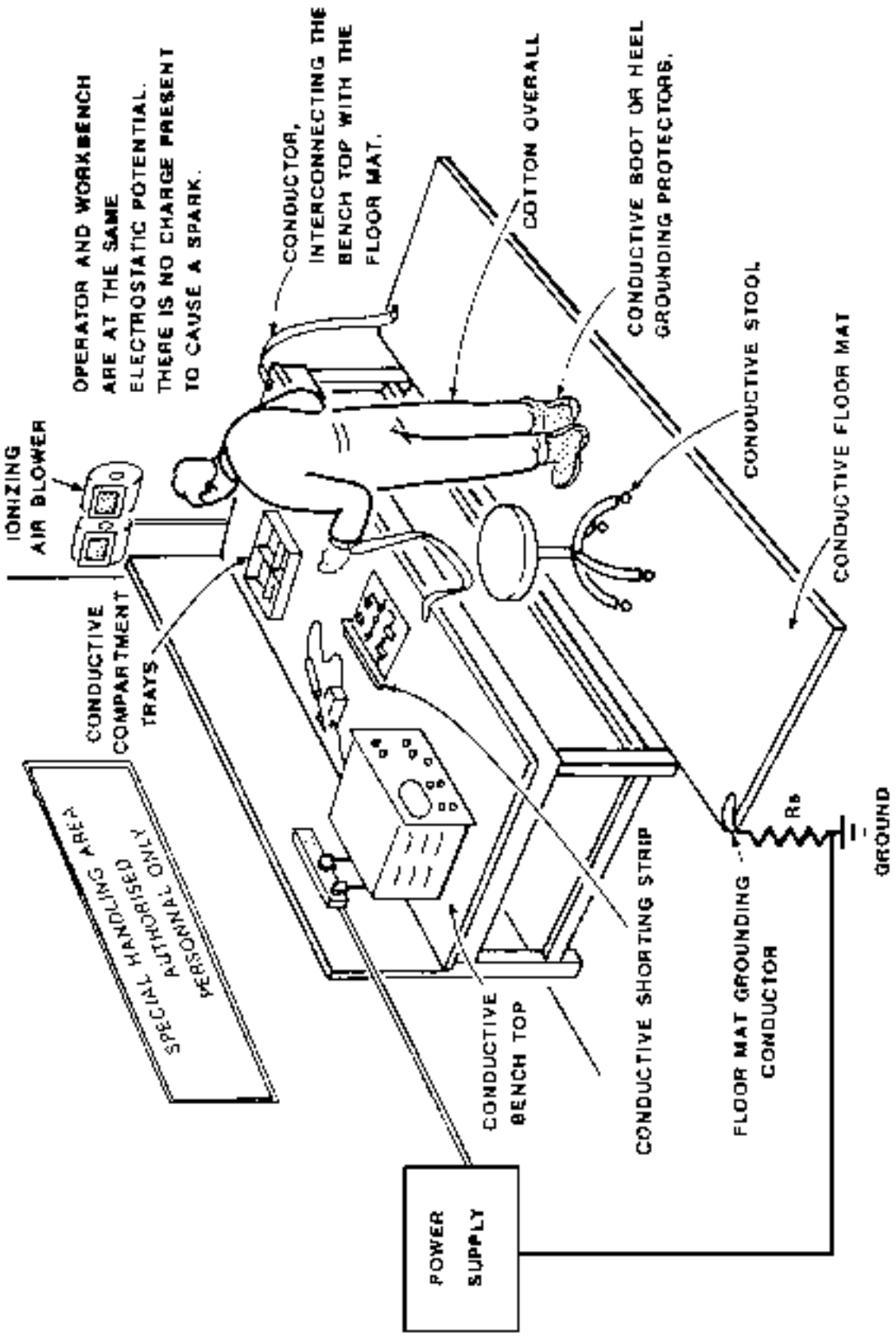

FIGURE 4

Typical packaging workstation layout

i. The connecting cord shall incorporate a quick release jack or plug and at least one insulated l x 10^6 ohms (min. 9 x 10^5 ohms - max. 5 x 10^6 ohms) current-limiting resistor at the identified wrist end of the cord. The total resistance from end to end shall not be greater than 5 x 10^6 ohms (see TABLE III). The power rating of this resistor shall be at least 0.25 watt per l x 10^6 ohms. The complete cord shall withstand a voltage test of 250 volts a.c. or 500 volts d.c. between ends for each 1 x 10^6 ohms for 20 seconds. The total resistance from the hand to the remote end of the cord (including the wrist strap and cord) shall be minimum of 9 x 10^5 and maximum of 3.5 x 10^7 ohms.

j. Where leg straps, toe and heel grounders, and electrostatic dissipative footwear are used as a prime or only means of grounding personnel, the floor shall be suitable for grounding personnel (see TABLE III), and shall be within the controlled boundaries of the work area.

k. Coats, jackets, smocks, and overalls shall be designed to completely enclose all outer clothing in the areas of the arms and chest as a minimum. These garments shall be capable of being bonded directly or indirectly to the operator's skin. There shall be electrical continuity greater than 7.5 x 10^5 and less than l x 10^{12} ohms per square between both sleeves and the body of the garment. The material of the garment shall have a surface resistivity on both the outward facing and inward facing sides greater than 7.5 x 10^5 and less than 1 x 10^{12} ohms per square and be capable of being grounded. (**NOTE:** Due to the redundancy of protection accorded by a workstation, special clothing or shoes may not be required. See TABLE III for change decay time requirements.)

l. All tools intended for use at the workstation shall, as far as is practical, be so constructed that they do not generate or hold an induced electrostatic charge, and any part of the tool which may touch an ESSD shall be at earth potential

m Those tools having insulated handles which generate or hold an electrostatic charge shall be treated with a suitable antistatic material, or the handles are replaced with electrostatic dissipative handles, or the tools must be replaced with tools equipped with electrostatic dissipative handles.

n. Heat-sealing equipment should be located adjacent to the workbench so the wrist strap will remain attached while heat sealing bags.

o. Clean dust and dirt from the tabletop and floormat as often as needed to prevent any accumulation, which will insulate ESSD and make them ineffective. Antistatic cleaners are recommended to be used on these mats where appropriate.

5.7.3. **Temporary Workstation**.

a. The ESSD temporary workstation (eg., a field surface kit) provides the required protection where formal workstations are not practical (i.e., remote locations such as shelters and vans).

b. The field service kit is a field expedient and contains only the minimum requirements for ESD control. Their primary use is in support of personnel who handle ESSD during which time devices are outside of prescribed packaging (see ANNEX C).

c. A field service kit will consist of a foldable, flexible electrostatic dissipative work mat with integral wrist straps, grounding cords, grounding attachment.

d. Proper use of the field service kit will be dependent upon training, prescribed usage, and the recommended practices in personnel handling of bare ESSD.

e. It must be noted that the electrostatic dissipative work mats with accessories are not a substitute for a complete ESD protective workstation.

5.8 PRECAUTIONS

5.8.1. Handle all ESSD items at an electrostatic-safeguarded workstation and transport all ESSD devices in electrostatic protective packages or containers.

5.8.2. Adhere to the following precautions when using an ESD protective workstation:

a. When protective apparel is worn, it should be frequently checked, especially after cleaning, by scanning personnel with an electrostatic field meter to monitor for damaging ESD voltages.

b. No more than two earth-bonding points for the wrist strap cord shall be connected via the working surface earth-grounding point. Each wearer at the workstation shall be provided with an earth-bonding point.

c. Any packaging materials, equipment, or tools which are not electrostatic dissipative, or electrostatic conductive, including non-electrostatic sensitive devices, shall be packed in electrostatic dissipative materials before being taken into an ESD protective work area.

d. Ensure secure attachment of the wrist strap (mandatory) and toe and heel straps (if used) before handling any ESSD.

e. Regular monitoring of the wrist strap is essential to ensure that the protective resistor (usually one megohm) is still intact, and the skin resistance to ground is maintained. If the wrist strap resistance is less than 2.5×10^5 ohms or indicates an open circuit, do not use it.

f. Ensure that ionization is not used in an attempt to eliminate the use of either a wrist strap or protective work surfaces and floors.

g. Ensure that work surfaces are clean, tidy, and free from unnecessary materials.

h. A visual check shall be made to ensure that all trolleys have a complete earth-bonding system and that all connections are in place.

i. Avoid the presence of any non-antistatic or insulative material such as styrofoam cups, common plastic or masking tape, common wrapping or barrier materials (e.g., bubble pack, plain poly, etc.), cigarette packs, and synthetic materials (e.g., rayon, orlon, plastics of any type, etc.) in or near the workstation.

j. Do not store or use magnetic material near the workstation.

k. Do not perform stretch- or shrink-wrapping operations within the ESD-protective work area.

l. If more than one ESD-controlled workstation is located in the same area, do not connect the tabletops or floormats in series; individually ground each one.

m. Do not use waxes, polishes, or similar materials on the floormat or tabletop. They may deposit an insulating layer of residue thus reducing or eliminating the effectiveness of the floormat or tabletop. For the same reason, the use of topical antistatic spray is not recommended on packaging materials.

n. Ensure that cleaning personnel do not apply silicone type polish to any static dissipative work surfaces, flooring, etc., and hence degrade the performance of same.

o. Perform continuity checks of all ground wires weekly to ensure that total resistance from top surface to ground is less than 7.5×10^5 ohms and 1×10^9 ohms to ground.

p. When is specified, A check shall be made to ensure that relative humidity (r.h.) conforms to requirements. This shall be checked at the start of every work period and then at suitable intervals.

q. Care should be taken when using large shunts, which may cause inducted voltage to occur. The maximum inducted voltage may not exceed 100V.

r. Wrist straps should be checked daily when handling ESSD.

5.9 TRAINING, QUALITY AND AUDITS

5.9.1 Details of the proper training, prime quality responsibilities, and the conducting of periodic audits associated with protection of ESSD can be found in EN00015.

6. INQUIRIES AND AMENDMENTS

6.1 General inquiries or suggested amendments, particularly stock numbers, should be addressed to:

Army Program Coordinator
Land Engineering Agency
Defence Plaza Melbourne
3rd Floor 661 Bourke St,
MELBOURNE VIC 3000

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ANNEX A

PROTECTIVE PACKAGING MATERIALS FOR ESSD

DESCRIPTION	SPECIFICATION
Bags, plastic, flexible, single-wall, transparent, waterproof, electrostatic protective, static dissipative with reclosable interlocking type closure: **NOTE**: Bags fabricated from MIL-B-81705, Type II, barrier material.	MIL-B-117
Bags, sleeves, and tubing, heat sealable, flexible, opaque or transparent plastic: Type I - Heavy duty - Class A - Waterproof, electrostatic free Style 2 - Transparent Type I - Heavy duty - Class F - Water-vaporproof, electrostatic free Style 1 - Opaque **NOTE**: Bags fabricated from MIL-B 81705, Type 1 and Type II, Class 1 or 2, respectively.	MIL-B-117
Barrier materials, flexible, electrostatic protective, heat-sealable: Type I - Water-vaporproof, electrostatic and electromagnetic shielding (opaque foil) Type II - Transparent, waterproof, static dissipative (plastic) Type III - Transparent, waterproof, electrostatic shielding	MIL-B- 81705
Box, fibreboard, shipping, reusable with preformed polyurethane, antistatic, flexible, foam:[1] Type II - Triple slide, modified (omit middle tube), corrugated fibreboard, weather-resistant (ASTM D 5118) Style D - Cushioning, polyurethane foam (MIL-P-26514, type III, class 2, grade A, B, or C) **NOTE**: Additional Types and Styles are listed in PPP-B-1672.	PPP-B-1672
Cushioning material, lightweight, transparent flexible, open cell, heat-sealable, plastic: Type III – Hexagonal, electrostatic free Style A – Without top laminate Style B - With top laminate	A-A-3129
Cushioning material, polyethylene foam: Type VII – Packaging material Class 3 – Special purpose sheets, planks, and shapes Grade B – Static dissipative Grade D – Static dissipative and fire retardant	A-A-59135 A-A-59136
Cushioning material, resilient, low density, unicellular (closed cell), polypropylene foam (temperature range from -54°C to +71°C): Type II - For electrostatic protective cushioning applications	PPP-C-1797
Pouches, cushioned, flexible, electrostatic-free, transparent plastic, reclosable interlocking (zipper-type) closure or heat-sealable lip: Type I - Three-ply; two outer plies, barrier material (MIL-B-81705, type II); inner ply, cushioning material (A-A-3129, type III, styles A or B) Type II - Single-ply; cushioning material (A-A-3129, type III, styles A or B)	MIL-P-81997

[1] Commonly referred to as an antistatic fast pack.

PROTECTIVE PACKAGING MATERIALS FOR ESSD

DESCRIPTION	NSN
BAG,PLASTIC,STATIC,SHIELDING, INSIDE SHIELDING CAPABILITY, METAL OUT TYPE, 15 IN WIDTH OPENING SIZE, 18 IN DEPTH, SEMI-TRANSPARENT, TRANSLUCENT	8105-66-110-6512
BAG, PLASTIC, ANTISTATIC, SHIELDING, 16.0 IN.H,12.0 IN.W	8105-66-110-6513
BAG, PLASTIC, ANTISTATIC, SHIELDING, 12.0. IN H ,10.0 IN.W	8105-66-110-6514
BAG, PLASTIC, ANTISTATIC, SHIELDING, 10.0 IN.H,10.0 IN.W	8105-66-110-6515
BAG, PLASTIC, ANTISTATIC, SHIELDING, 8.0 IN.H,5.0 IN.W	8105-66-110-6516
BAG, PLASTIC, ANTISTATIC, SHIELDING, 5.0 IN.H,3.5 IN.W	8105-66-110-6517
BAG, PLASTIC, ANTISTATIC, SHIELDING, 10 IN.by 12 IN.	8105-01-120-3375

STATICALLY SHIELDED FOAM LINER BOXES

DESCRIPTION	NSN
BOX, SHIPPING & STORAGE, FOAM,LINED ESSD 250 x 165 x 60mm	8145-66-121-6912
BOX, SHIPPING & STORAGE, FOAM,LINED ESSD 450 x 345 x 60mm	8145-66-121-6917
BOX, SHIPPING & STORAGE, FOAM,LINED ESSD 275 x 245 x 60mm	8145-66-121-6918

NON-CORROSIVE CONDUCTIVE FOAM

DESCRIPTION	NSN
CUSHIONING PACKAGING MATERIAL LOW DENSITY 3MM x 900MM x 900MM	8135-66-112-2186

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ANNEX B

PROTECTIVE WORK AREA REQUIREMENTS

General Requirements Access only to trained personnel Designed and constructed using ESD-protective materials and equipment ESD characteristics certified, recorded, monitored, and corrected
Minimum Requirements No prime static generators ESD-protective work surface (bench top and/or flooring) Personnel wrist (and heel) ground straps (soft ground) Ground strap checker/analyser Electrostatic field strength metre ESD-protective packaging material Paperwork segregated, unbound, or encased in ESD-protective material
Supplementary Requirements Air ionizer(s) Static sensor/monitor/alarm ESD-protective clothing Humidity controls All energised tools and equipment grounded
NOTE: This summary is provided for reference only. (Requirements of 5.7.1 and 5.7.2 apply.)

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ANNEX C

PROTECTIVE WORKSTATION KITS

DESCRIPTION	SPECIFICATION
Wrist strap, electrostatic discharge, 1.5 m long coiled cord; used to tie on testers wrist and to test set, prevent static electricity from damaging instrument being tested. Contains adjustable wrist strap with a 1 megohm resistor	MIL-W-87893 (NSN: 5920-01-274-0486)
Wrist strap, general, 3.0 m long coiled cord; used to tie on testers wrist and to test set to prevent static electricity from damaging instrument being tested.	MIL-W-87893 (NSN: 5920-01-274-0487)
Workstation kit[1], electrostatic control, consisting of: 2 static dissipative rigid table mats, 1 common point ground system, 1 adjustable wrist strap cuff, 1 wrist strap cord with current limiting resistor, and 1 alligator clip, to be used in clean room environments or laminar flow booths where particulate control is necessary and ESSD are handled	MIL-W-87893 Type I (NSN: 4940-01-250-4235)
Workstation kit, electrostatic control, consisting of 1 static dissipative soft table mat, 1 common point ground system, 1 adjustable size wrist strap cuff, 1 wrist strap cord with current limiting resistor, and 1 alligator clip to be used in all areas other than clean rooms or laminar flow booths where ESSD are handled and where physical shock protection against dropping is required.	MIL-W-87893. Type II (NSN: 4940-01-250-4236)
Workstation kit, electrostatic control, consisting of 1 static dissipative soft flexible portable work surface, 1 common point ground system, 1 adjustable size wrist strap cuff, 1 wrist strap cord with limiting resistor, and 1 alligator clip to be used in situations where other static control work-stations are not available, such as remote sites.	MIL-W-87893 Type III (NSN: 4940-01-250-4237)
Workstation kit, electrostatic control, consisting of: 3 transparent waterproof electrostatic-protective, electrostatic-dissipative, heat-sealable flexible pouches; 3 water-vapourproof electrostatic-protective, electrostatic and electromagnetic shielding heat-sealable flexible barrier bags; 2 adjustable snap wrist straps; 1 mat electrostatic dissipating; and 1 ground cord with a 1 megohm resistor.	MIL-W-87893 Type III (NSN: 4940-01-253-5368)

[1] Commonly referred to as the field service kit.

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ANNEX D

TEST PROCEDURES AND TEST EQUIPMENT

D1. **SCOPE.**

D1.1 The information provided in this ANNEX is designed to aid personnel performing testing of materials and equipment associated with the protection of items from electrostatic discharge damage. In addition to the test procedures listed herein, other appropriate armies' test procedures or relevant alternatives may also be used to satisfy a specific or special test requirement.

D2. **GENERAL**.

D2.1. Verification of specified test requirements may be done with the test equipment specified in paragraphs D4.1 through D4.10. The equipment may be obtained, as required, to verify that the electrical integrity of the electrostatic discharge (ESD) control products is maintained throughout the ESD-control products usable lives. Relevant alternatives or additional equipment may be needed to satisfy a specific or special test requirement.

D2.2. Periodic testing of items or materials used to control ESD is required in the time intervals specified. The standard test voltage for most ESD-controlled materials that require periodic testing is 500 volts.

D2.3. Additional tests may be carried out by mutual agreement between the supplier and the procurer. It should be emphasised that the tests in this section should be only carried out by personnel with the appropriate skills.

D3. **TEST PROCEDURES**.

D3.1. **Work Surface**.

a. The test equipment required to do work surface testing is specified in paragraph D4.5.

b. The work surface shall be tested annually in its existing environment

c. All resistance measurements shall be taken at a minimum of 5 seconds after applying test voltage (500 volts).

d. Connect the positive lead from the megohmmeter to one of the 2.5 kg electrodes and the negative lead to the common ground point. Place the electrode near the rear edge of the work surface and approximately 900 mm from the common ground point. Apply test voltage of 500 volts. Take reading and record. Repeat procedure placing the electrode in the centre of the work surface and again near the forward edge of the work surface. Additional measurements taken should be between 2 and 4 measurement per square metre. Total resistance from top of work surface to ground point for each measurement shall be between 1×10^6 and 1×10^9 ohms.

e. If the measurements taken do not fall within the specified range, clean the work surface with cleaners specially made for Static control mats/surfaces, which is a water based liquid that leaves no tacky or corrosive residue. Repeat step D3.1d, to this annex. If the measurements taken still do not fall within the specified range, the work surface shall be discarded and replaced.

f. For temporary work surfaces the ground-connecting terminal shall be attached to the temporary work surfaces such that the grounding cord is connected to the top working surface. The connecting method for the earth ground point to the work surface shall be such that it does not permit any non-insulated earth grounding point component on the underside of the temporary work surface. The material for the temporary work surfaces shall be such that the surface resistivity and resistance to ground requirements given in TABLE III are met.

D3.2. **Storage Cabinets and Shelves**

a. The test equipment required to test shelves, cabinets, and storage units is specified in paragraph D4.5.

b. All shelves, cabinets, and storage units shall be tested in their existing environment.

c. All resistance measurements shall be taken 5 seconds after applying test voltage (500 volts).

d. Connect the positive lead from the megohmmeter to one of the 2.5 kg electrodes and the negative lead to the ground point. For components mounted on a workstation, the negative lead will be the common point ground embedded in the work surface. The negative lead connection for shelves and cabinets not on static dissipative floors shall be to the verified ground point. For shelves and cabinets (not workstations) mounted on static dissipative floors, the negative terminal shall be a 2.5 kg electrode placed on the floor. Place the positive lead on a shelf/drawer and apply 500 volts. Three measurements shall be taken per drawer/shelf and recorded. This resistance from the surface of the component being tested to the ground point shall be between l x 10^6 and l x 10^9 ohms.

e. If the measurements taken do not fall within the specified range, clean the work surface with cleaners specially made for Static control mats/surfaces, which is a water based liquid that leaves no factory or corrosive residue..Repeat step D3.2d.

f. If the measurements taken still do not fall within the specified range the components shall be discarded or covered with a material that meets the prescribed resistance.

D3.3. **Static Dissipative Flooring**.

a. The test equipment required for testing installed flooring is specified in paragraph D4.5.

b. Flooring shall be tested annually in its existing environment and normal state of cleanliness.

c. All resistance measurements shall be taken 5 seconds after applying test voltage (500 volts).

d. The installed floor shall be subjected to surface to ground resistance measurements using the specified megohmmeter and electrode. The applied open circuit test voltage shall be 500 volts for each measurement.

e. Raised Floors:

(i) Resistance measurements are made by connecting the positive lead from the megohmmeter to the electrode and connecting the negative lead to the ground point. Remove a panel from the floor and connect the negative lead to an installed pedestal beneath the floor. Apply the test voltage (500 volts). Take the measurement and record. Repeat for each measurement taken.

(ii) A total of 5 equally spaced resistance measurements shall be taken for every 15 m^2 area of flooring. For floors with less than 15 m^2, one resistance measurement shall be taken for each 5 m^2 of flooring (equally spaced) with a minimum of 3 measurements per area. The average of the total surface to ground resistance measurements shall be between 1 x 10^6 and 1 x 10^9 ohms with no individual measurement being above 5 x 10^9 or below 1 x 10^6 ohms.

(iii) If the floor fails to meet these specifications, the floor shall be thoroughly cleaned in accordance with the manufacturers recommendations and retested as per paragraph D3.3f.

(iv) If the floor still fails to meet these specifications, verify the calibration of the megohmmeter and retrieve the initially installed floor test results. Compare test results and determines if the readings are higher or lower than the initial readings. If higher, this may suggest that the floor has been waxed or coated. If so, the floor must be stripped and recleaned before retesting. If the readings are lower, a coating may have been added but with conductive properties. Again, stripping and recleaning will be necessary. These procedures should bring the floor within the specified resistance range.

f. Other Floors. The resistance measurement procedure is the same as for raised floors with the exception that the negative lead from the ohmmeter is connected to a point electrically the same as one of the acceptable points at which the floor is grounded. The number of test points, specified resistance range and retest processes are as specified in paragraph D3.3e(ii) through D3.3e(iv) of this annex.

D3.4. **Wrist Strap**.

a. The test equipment required for testing wrist straps is a wrist strap tester as specified in paragraph D4.2.

b. The wrist strap shall be tested before use in its existing environment while being worn.

c. Insert wrist strap banana plug into the banana jack on the wrist strap tester. With the hand opposite that on which the wrist strap is being worn, press the metal contact plate until either the green or red pass/fail light is illuminated. Ensure at the same time that the battery check light illuminates. If it does not, check the batteries. If it does then observe the pass/fail light.

d. If the green light illuminates, the wrist strap and cord are both good.

e. If the red light illuminates, disconnect the wrist strap cuff from the cord and connect the cuff end of the cord to the wrist fastener connection on the tester. Press the contact with a bare hand. If the green light illuminates, the cord is good. Discard the wrist strap cuff. If the red light illuminates, discard the cord.

f. Replace the wrist strap cuff or cord accordingly and repeat steps D3.4c through D3.4e.

D3.5. **Static Dissipative Footwear**.

a. The test equipment required for testing static dissipative footwear is specified in paragraph D4.3.

b. A non-corrosive, 300 mm x 300 mm flat metal plate (min 1.5 mm thick) is also required as a test footplate. Other materials (not aluminium) with a resistance of less than 1×10^4 ohms may be used to form the footplate.

c. The wearer should stand with both feet on the footplate.

d. The resistance from a contact with the hand to the footplate shall be less than 3.5×10^7 ohms.

e. Toe and heel grounders shall be constructed such that the contact made with both feet meet the requirement for an electrical path from the wearer to contact points on each foot of the footwear in both toe and heel regions. A discrete resistor need not be incorporated in the toe or heel strap, as there is no minimum resistance requirement for this path.

f. Shoes shall be lab tested by random sampled lots annually. The Armies' national test method and resistance specification may be used.

g. Shoes will be replaced on an as needed basis determined by wear and condition of shoe in general.

D3.6. **Conductive/Static Dissipative Finger Cots and Gloves**.

a. The equipment required for testing finger cots and gloves is specified in paragraph D4.3 of this annex.

b. The finger cots and gloves shall be checked prior to being used.

c. The conductive material shall have a maximum surface resistivity of 1 x 10^6 ohm/sq and maximum volume resistivity of 1 x 10^5 ohm/cm.

d. If the measurements exceed the maximum allowable resistivity, they will be replaced.

e. No reuse is allowed, and such items will .be discarded after each use.

D3.7. **Static Dissipative Seating**

a. The equipment required for testing seating is as specified in paragraph D4.5 of this annex. A non-corrosive, 915 mm x 915 mm flat metal plate (min 1.6 mm thick) is also required as part of the test electrode.

b. Seating shall be tested annually in its existing environment. Do not clean the chair. Recover only those items that might interfere with the test.

c. All resistance measurements shall be taken 5 seconds after applying test voltage (500 volts).

d. The resistance of each tested seat shall be between 1 x 10^4 and 1 x 10^9 ohms.

e. Place the seat on top of the metal plate ensuring that the plate is clean (no oxidation) and all casters of the seat are on the plate. Place one of the 2.5 kg electrodes from the test kit on the test plate between 2 seat casters.

f. Place the other 2.5 kg electrode from the test kit in the middle of the seat. Ensure that the contact surface of the electrode is clean (no oxidation).

g. Connect the positive lead from the megohmmeter to the electrode that is on the seat. Connect the negative lead from the megohmmeter to the electrode that is on the test plate.

h. Apply test voltage and record the resistance value.

i. If the measurement does not fall within the specified range, disconnect the negative lead from the electrode on the test plate and connect it directly to a metal point on the seat base. Reapply the test voltage and record the resistance value.

j. If the measurements in step D3.7i of this annex falls within the specified range, clean the casters of the seat thoroughly with 70 per cent isopropanol-water solution using a clean, lint-free cloth. Allow to dry.

k. Repeat steps D3.7e through D3.7h. If the reading is still outside the specified range, replace the casters.

l. If the seat still does not meet the resistance requirement after changing the casters, replace the seat.

D3.8. **Relative Humidity**.

a. The hygrometer required for monitor the relative humidity (RH) is specified in paragraph D4.10 of this annex.

b. The hygrometer shall be mounted at the workstation not more than 1 metre above the level where ESSD are handled.

c. Where more that one workstation is contained in an area, which has the same environment, a single hygrometer may be used to monitor the whole area.

d. When practicable, levels of 40 to 60 percent RH should be maintained.

(i) Excessive humidity can cause problems such as corrosion, possible leakage paths for high voltages and moisture contamination within equipment.

(ii) Low humidity severely reduces the dissipation effectiveness of materials used in certain types of work surfaces, packaging, and clothing.

D3.9. **Bench Top Electrical Ionizers**.

a. The test equipment required for testing bench top electrical ionizers is specified in paragraph D4.8 and D4.9. A standard measuring tape (min 2 m) is also required.

b. The ionizer shall be tested quarterly in its existing environment with the heater off, if so equipped. The ionizer shall be tested with filters in place, if so equipped, and at a maximum airflow rate of 168 m/min. The air velocity shall be measured and recorded in the test results.

D3.10. **Discharge Time**.

a. The equipment required to monitor the discharge time is specified in paragraph D4.8.

b. Place the charge plate monitor directly in front of the ionizer with the plate parallel to the front face of the ionizer at a distance of 0.30 m.

c. Turn the ionizer on, wait 30 seconds, charge the plate to +1000 volts and allow it to discharge to +50 volts. The charge plate monitor will measure the time it takes to discharge. Record the discharge time. Repeat procedure for -1000 volts. The discharge time for both the + and - initial plate voltages shall be less than 2 seconds.

d. Repeat steps D3.10b and D3.10c of this annex for plate to ionizer distances of 0.60 m, 0.90 m, and 1.20 m. The discharge times for these distances shall be less than 4 seconds, 7 seconds, and 10 seconds, respectively.

e. If the voltages do not discharge in the specified time, clean and balance the ionizer in accordance with the manufacturer's instructions.

f. Repeat steps D3.10b and D3.10c.

g. If the voltages still do not discharge in the specified time limit, the ionizer shall be discarded.

D3.11. **Offset Voltage**.

a. The equipment required to monitor the offset voltage is specified in paragraph D4.8.

b. Place the charge plate monitor directly in front of the ionizer with the plate parallel to the front face of the ionizer at a distance of 152 mm.

c. The plate shall be momentarily grounded to remove any residual charge and to verify zero for the monitor's circuitry.

d. Turn the ionizer on and allow it to operate for 1 minute or as necessary to allow reading to stabilise (max 5 min). Record the plate voltage. The voltage shall not exceed 25 volts.

e. If the measurement exceeds the maximum of 25 volts, follow the manufacturer's instructions for ion balancing. If the unit is self-balancing or has no ion balancing ability, the unit shall be discarded.

f. After balancing, repeat steps D3.11b through D3.11d,

g. If the measurement still exceeds the maximum of 25 volts, the unit shall be removed from service and inspected

D3.12. **Shielding Bags**.

a. A visual inspection of shielding bags will be accomplished prior to each use. If the bag is torn, ripped, or the surface resistance of the bag is greater than 1×10^4, it will be discarded.

D4. **TEST EQUIPMENT**.

D4.1 **Electrostatic Field Meter**. This device detects the presence of electrostatic fields emanating from a charged object. It is basically a tool for verifying whether or not electrostatic fields exist in the work place. It should not be used to make precise measurements. The ability of a material to generate charge can be roughly seen with the meter.

D4.2. **Wrist Strap Tester**. This device will allow the operator to check the integrity of his/her wrist strap cuff and cord. The tester allows for electrical continuity and resistance checks of both the wrist strap cord alone and of the entire wrist strap system while the operator is wearing it. It ensures that the wrist strap surface resistivity is less than 1×10^7 ohms, the resistance to ground is less then 3.5×10^7, and the total resistance to ground is minimum of 9×10^5 and maximum of 3.5×10^7ohms.

D4.3 **Variable Voltage Megohmmeter**. This instrument measures static dissipative work surfaces, floors and shoes; single layer static dissipative garments; and the resistance of any other static control materials that require resistance in the 1×10^6 to 1×10^9 ohms range. The standard test voltage for most ESD-controlled materials that require periodic testing is 500 volts.

D4.4 **Resistance Test Electrodes**. This device consists of two, 2.5 kg ($\pm$ 0.5 kg), 64 mm ($\pm$ 1.5 mm) diameter, flat-surfaced, non-corrosive metal (i.e., gold plated brass or stainless steel) electrodes of equal length are required to make the resistance measurements within the megohmmeters mentioned in paragraph D3.3. The electrodes are prepared by placing a piece of heavy tin foil on a flat, hard, and smooth surface. On top of the foil, place a 64 mm diameter disk of 6.4 mm thick rubber that has a hardness of 50 $\pm$10 as measured on a Shore Type A Durometer. Place the electrode on top of the rubber pad, draw the foil up around the rubber pad, and electrode, and secure the foil with a hose clamp. Repeat procedures for the second electrode. Electrodes that have conductive rubber do not need the tin foil, but the rubber pads need to be cleaned with 70 percent isopropanol alcohol solution. Conductive rubber electrode pads (64 mm diameter x 6 mm thick) can be used with the electrodes in lieu of the aluminium foil/rubber combination specified for the construction of the electrodes.

D4.5 **Megohmmeter Test Kit**. The kit contains the variable voltage megohmmeter and the 2.5 kg electrodes referenced above.

D4.6 **Ohmmeter**. The ohmmeter is used to check the integrity of grounding conductors and bonding devices for ESD-controlled workstations, cabinets, and floors.

D4.7 **Ground Impedance and Utility Wiring Verification Meter**. This meter is required for measuring the wiring accuracy in electrical systems and assuring that ground conductors (third wire) in power systems are effective for static dissipative and safe for personnel usage. The meter is capable of analysing the hot, neutral, and equipment ground conductors of an electrical system. It will measure the impedance of equipment ground conductors to verify the integrity of the ground point used in grounding static control workstations, cabinets or floors.

D4.8 **Charged Plate Monitor**. A charged plate monitor is used to verify the performance of bench top ionizers by measuring charge decay times and offset voltages. It shall have a 152 mm x 152 mm conductive plate (20 pf capacitance maximum) for a sensor. The monitor shall be capable of measuring decay times from initial plate voltages of + 1000 volts to $\pm$ 100 volts, respectively.

D4.9 **Air Velocity Meter**. An air velocity meter is required to measure the speed of the air flowing from bench top ionizers when conducting periodic performance tests. The meter shall be capable of measuring velocities of a least 167 m/min at a distance of 152 mm from the ionizer

D4.10 **Hygrometer**. A hygrometer is required to measure the percent of relative humidity (RH) within a specified work area. The instrument is a precision hair direct reading hygrometer with 185 degree scale, 100 mm diameter, calibrated in RH percent, and has an accuracy of better than 3 percent over the range 25 to 80 percent RH.

D4.11 **Equilateral Triangle Plate Electrode**. This electrode is used for surface resistance testing using a tripod electrode base on a conductive plate in the shape of an equilateral triangle (each side 180 mm). Soaking of the surface of the measured material with a liquid with a measured resistance of 10 - 100 ohms is required. An electrode of 750N is required for floor measurement and 250N for, wall tables, and transport boxes.

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