# UNITED STATES MARINE CORPS

AVIATION TRAINING BRANCH
TRAINING COMMAND
MARINE CORPS COMBAT DEVELOPMENT COMMAND
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**LESSON GUIDE NUMBER: G-13**

# ELECTROSTATIC DISCHARGE (ESD) ELECTROMAGNETIC INTERFERENCE (EMI)

**A. LECTURE NUMBER:** G-13

**B. TIME:** TBD Minutes

**C. DATE PREPARED:** 3 August 2001

**D. DATE REVIEWED:** 10 August 2001

**E. TITLE:** ELECTROSTATIC DISCHARGE (ESD) ELECTROMAGNETIC INTERFERENCE (EMI)

**F. OBJECTIVE:** To familiarize personnel with what Electrostatic Discharge (ESD) and Electromagnetic Interference (EMI) are, common sources of ESD and EMI, the effects of ESD and EMI on equipment, protective measures for personnel and equipment, and program requirements and responsibilities.

**G. INSTRUCTIONAL AIDS:**

1. Movie "ESD: The Invisible Threat" 25 minutes videotape.

2. ESD sensitivity symbols, ESD protective materials, ESD protective tools and equipment.

3. Other visual aids such as VU-graph diagrams of grounded work stations, pictures and brochures of ESD protective tools and equipment, and photographs of damaged ESD items.

**H. REFERENCES:**

1. MIL-HDBK-263B, Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Initiated Explosive Devices).
2. MIL-STD-1686, Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment.
3. NAVAIR 01-1A-23, Standard Maintenance Practices Miniature/Micro-miniature (2M) Electronic Assembly Repair
4. NAVSUP Publication 484, Supply Afloat Fleet and Field Packaging Procedures
5. NAVSUPINST 4030.46, Protection of Items Susceptible to Damage from Electrostatic Discharge

6. NAVSUPINST 4440.179, Report of Discrepancy (ROD) Manual
7. NAVAIR 17-600-141-6-1, Pre-Operational Checklist for Micro-miniature Repair Station
8. NAVAIR 17-600-141-6-2, Micro-miniature Repair Station Naval Air Engineering Center (GHS2)
9. NAVAIR 17-600-193-6-2, PRC-2000-2M System Maintenance Requirement Cards
10. MIL-HDBK-773, Electrostatic Discharge Protective Packaging
11. NAVAIR 00-80T-117, Electromagnetic Compatibility Theory and Practice Manual
12. NAVSEA OP 3565, Electromagnetic Radiation Hazards, (Hazards to Personnel, Fuel, and Other Flammable Materials)
13. OPNAVINST 2450.2, Electromagnetic Compatibility Program within the Department of the Navy
14. OPNAVINST 4790.2H, Naval Aviation Maintenance Program (NAMP)
15. OPNAVINST 3750.6R, The Naval Aviation Safety Program
16. ANSI C63.14-1998, American National Standard Dictionary for Technologies of Electromagnetic Compatibility (EMC), Electromagnetic Pulse (EMP), and Electrostatic Discharge (ESD)

**I. PRESENTATION:** All personnel involved with handling storage, packaging, or maintenance of ESDS components/WRA's will be aware of the Electrostatic Discharge Control Program as outlined in references (1) through (16). Personnel safety cannot be overemphasized in this program. In the past, technicians have always been isolated from electrical shock by non-conductive material/devices. The technician is now tied to a "soft ground" that is tied to a hard 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 soft ground is dependent upon the voltage levels, which could be contacted by the personnel near the ground.

1. Electrostatic Discharge

   a. <u>ESD Terms and Definitions</u>

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

(2) Electrostatic: A non-moving electric charge.

(3) Triboelectric effect: Method of generating static electricity by friction(rubbing or separating materials).

(4) Electrostatic Discharge Sensitive (ESDS): Any device that is sensitive to damage from an electrostatic discharge.

(5) Human Body Model (HBM): Electrostatic discharge from a charged person.

b. ESD Theory

(1) Causes of ESD

(a) Tribo-electric charges cause at least 98% of all ESD damage. When two materials make contact, and are then separated (causing friction), electrons are stripped from one material and transferred to another. This imbalance creates a static charge to accumulate on the materials.

(b) Humidity has a definite effect on how easily a static charge is generated. The lower the relative humidity, the higher the potential static charges.

(c) The following is a list of typical static charges, and how they are generated:

| **Means of Generation** | **Relative Humidity and Voltage** |
|---|---|
| Walking across carpet: | 10-20% humidity = 35000v |
| | 65-90% humidity = 1500v |
| Walking over vinyl floor: | 10-20% humidity = 12000v |
| | 65-90% humidity = 250v |
| Worker at bench: | 10-20% humidity = 6000v |
| | 65-90% humidity = 100v |
| Padded Chair: | 10-20% humidity = 18000v |
| | 65-90% humidity = 1500v |

(2) Damage and failures caused by ESD

(a) Many ESDS devices have very low resistances to ESD. In many cases, the voltages are in the 20-1000v ranges.

It should be noted that the human body couldn't feel, hear, or see an electrostatic discharge that is below around 3000 volts. Many times the human body has a charge that is less than that, resulting in a discharge (and damage) that is undetectable by conventional means.

(b) Two types of failure:

1 Catastrophic Failure: The device no longer meets design performance standards.

2 Latent Defect (Intermittent Defect): The device meets design performance standards, but will fail before the end of intended design life, or will fail intermittently.

c. ESD Control

(1) ESD Safe Area and ESD Control

(a) Maintain Packing Integrity: Proper packaging, as described in MIL-HDBK-773 and MIL-STD-2073, must be maintained until the ESDS device is in a designated ESD Safe Area, where it can be properly handled.

(b) Grounded Dissipative Surfaces: The work surfaces used in an ESD Safe Area must be grounded and specifically designed to slowly dissipate an electric charge (i.e., ESD Mat).

(c) All Safe Areas and ESDS items must be properly labeled: The ESD Safe Area and all ESDS devices should always be plainly labeled.

(d) Wrist Strap: A grounded wrist strap should always be worn when handling ESDS devices.

(e) Common Ground: All grounded items in an ESD Safe Area must be grounded to one common point.

(f) ESD Safe Storage Area: When an ESDS device is awaiting parts, or is being stored; the device should be properly packaged and kept in an ESD Safe Storage Area.

(g) No Prime Generators: Keep all of the following out of ESD Safe Areas, as they are prime generators of electrostatic charges:

Plastic tape
Styrofoam cups
Clear bubble-wrap
MAF bags
Regular plastics
Aerosol cans
Cellophane tape
Paper
Document protectors
Masking tape

2. Electromagnetic Interference

d. <u>EMI Terms and Definitions</u>

(1) Electromagnetic Interference (EMI): Any electrical, electronic, or electromagnetic disturbance, signal, or emission (man-made or natural) that interrupts, obstructs, or otherwise impairs the performance of electronic equipment.

(2) Airframe/hull generated EMI: EMI caused by the interaction of radiated signals with the elements of the airframe/hull.

(3) Bonding: Connecting together the metal parts of an aircraft, vehicle, structure, or housing to prevent interference-producing static or RF voltage buildup between adjacent metal parts.

(4) Conducted Interference: Undesired electromagnetic energy that is propagated along a conductor, usually defined in terms of a voltage and/or current level.

(5) Corona Discharge: An electrical discharge due to ionization of the surrounding air by high voltage that appears as a glow on the surface of, and adjacent to a conductor.

(6) Cosmic/galactic/solar noise: Interference caused by electromagnetic phenomenon outside the earth's atmosphere.

(7) Electromagnetic Compatibility (EMC): The ability of electronic equipment to operate in its intended electromagnetic environment without causing or undergoing unacceptable degradation because of undesired electromagnetic radiation or response.

(8) Electromagnetic Disturbance: A random or periodic electromagnetic phenomenon, usually impulsive, that is superimposed on a desired signal.

(9) Electrostatics: The science that deals with electricity at rest.

(10) Filtering: A network of one or more electronic components designed to offer comparatively little opposition to certain frequencies (or to direct current) while blocking other frequencies.

(11) Functional EMI: EMI generated by electrical or electronic systems designed to generate, distribute, and radiate electromagnetic energy.

(12) Grounding: Provides equipment with a common potential reference point anywhere in the system so that no voltage exists between any two grounded points.

(13) Incidental EMI: Any EMI generated by a device that is not designed to generate such energy during normal operation.

(14) Precipitation static: Electromagnetic disturbance caused by the random electrostatic discharge created as a result of the potential buildup caused by the charge transfer between air, moisture, and airborne particles and the structure of a vehicle moving in the atmosphere, such as an aircraft or spacecraft.

(15) Radiated EMI: The free space transference of electromagnetic energy.

(16) Shield (electromagnetic): A conductive housing or screen that substantially reduces the effect of electric or magnetic fields on devices or circuits.

(17) Time Sharing: Essentially, while one system is operating, other system(s) are turned off to prevent interference.

e. EMI Causes: The EMI triangle - In order for EMI to exist, there must be a source, a victim, and a coupling path for the interference. Sources are either natural or man-made. Natural sources of EMI include cosmic, solar, and galactic radiation, lightning, precipitation static, and electrostatic discharge. Man-made sources of EMI include incidental EMI, functional EMI, airframe/hull generated. Coupling paths can be radiated, conducted or a combination of the two.

f. Prevention and Control: The most practical methods for preventing and controlling EMI are grounding, bonding, shielding, and filtering.

g. Other Considerations:

(1) During an airframe’s life cycle, it can undergo many changes. Every change, whether structural or electronic, can impact the aircraft's EMI environment. While you may not control these changes, be aware of the other aspects of system performance.

(2) Equipment placement is designed to reduce mutual interaction between systems equipment by

placing them so that they are separated by distance or shielded by enclosures.

(3) Frequency management is the separation of two or more electronic systems by operating frequencies, harmonics, and spurious responses.

(4) Time-sharing is a system management tool that should only be used when other corrections have failed.

(5) Blanking is the disabling susceptible equipment during a period in which a pulsed emitter would cause interference.

h. Recognition of EMI Problems: Certain avionic systems/work centers may experience the following discrepancies. These problems can easily be attributed to the effects of EMI.

(1) Communication/Navigation:

(a) TACAN loss/false lock
(b) UHF/VHF radio weak reception
(c) Omega/Loran systems, ambiguous position indications
(d) Interference between unrelated COM/NAV systems

(2) IFF/Radar:

(a) False interrogations/identifications
(b) Intermittent operation of ground-mapping radar
(c) Interference with Ground Proximity
(d) Loss of radar sensitivity

(3) Flight Controls:

(a) Uncommanded control inputs
(b) Loss of AFCS

(4) Weapons Systems:

(a) Inadvertent firing of weapons
(b) Inadvertent jettison of stores
(c) Inaccurate guidance

(5) Ancillary Systems:

(a) Incorrect fuel quantity readings
(b) Incorrect landing gear position indication

3. The key to effective action against the effects of EMI rests in the ability of the personnel involved to gather the information, identify the victims and possible sources. Noting the victim's geographical location as well as attitude, altitude, heading, or position can be critical in determining the cause of and prevention of EMI. Other items to consider are weather conditions, time of day, and other platforms in the vicinity during the interference.

4. All suspected occurrences of EMI must be reported. By alerting QA and utilizing VIDS/MAF documentation and plain-language messages for hazardous EMI reports, any trends in EMI can be identified and eliminated. Formal messages (Hazardous Material Reporting, Engineering Investigations, Explosive Mishap Reporting) can go one step further to alert manufacturers and depot maintenance of present and future design considerations.

5. The Naval Safety Center, through OPNAVINST 3750.6R (Naval Aviation Safety Program), requires that ANY known or suspected EMI problem be reported via Hazard Reports.

**J. SUMMARY:** The proper procedures for the protection of Naval aircraft and their systems from EMI damage cannot be overemphasized. Proper maintenance, corrosion detection/ prevention, and proper handling of equipment must be maintained at all times to ensure that the aircraft is always fully operational and mission capable.

**NOTE:**
**REFER TO NAMP SOP (Volume 5, Chapter 22) FOR ADDITIONAL AND SPECIFIC INFORMATION.**

## K. QUESTIONS AND ANSWER PERIOD: