DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND
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IN REPLY REFER TO

NAVSEAINST 8020.19
Ser N716/985
13 Sep 00

NAVSEA INSTRUCTION 8020.19

From: Commander, Naval Sea Systems Command

Subj: ELECTROSTATIC DISCHARGE SAFETY PROGRAM FOR ORDNANCE

Ref: (a) OPNAVINST 8020.14
(b) MIL-STD-882
(c) MIL-STD-464
(d) NAVSEAINST 8020.17

Encl: (1) ESD Certification Requirements For Ordnance
(2) ESD Test Requirements For Ordnance

1. Purpose. To establish policies and procedures for the implementation of an Electrostatic Discharge (ESD) Safety Program supporting reference (a) for Navy and Marine Corps ordnance systems. To standardize implementation of reference (b) with respect to hazards from electrostatic discharges. To provide detailed ordnance ESD testing and certification requirements consistent with reference (c).

2. Background. Many modern weapons contain electrically initiated devices (EIDs) or energetic materials that are ESD sensitive. Two trends in the design of ordnance systems are potentially increasing the risk from ESD. The use of non-metallic housings, chambers and containers may reduce the inherent shielding of the energetic contents. The other trend is the addition of metallic ingredients to the energetic materials. Weapons undergo various phases of handling such as crating, uncrating, wrapping in protective plastics, removal from barrier bags, assembling, and transferring. These processes may result in the development of an electrostatic charge on the handler, transfer equipment, shipping containers, munitions or any other ungrounded object. The clothing worn by handling personnel, if made from a synthetic fiber, is especially hazardous. Operating helicopters also develop a significant electrostatic charge. The charge may be discharged to a potentially ESD sensitive point or exposed lead of an EID, or energetic material upon contact between the handler or associated equipment and the munitions.

If the charge is of sufficient magnitude, so that the energy dissipated exceeds the initiation threshold for the EID or energetic material, an accidental initiation of the device will occur. The accidental initiation may result in either a serious hazard or dud the device. If an electronic component is overloaded by excessive voltage, parametric or gross changes may occur that are detrimental to electronic functions such as signal processing, timing, arming and firing.

3. Definitions

a. Electrostatic Discharge (ESD). The transfer of electrostatic charge between bodies at different electrostatic potentials.

b. Ordnance. Military systems such as combat weapons of all kinds with the ammunition and equipment required for their use. Ordnance includes all the things that make up a ship's or aircraft's armament; guns, ammunition, and all equipment needed to control, operate, and support the weapons.

c. Electrically Initiated Device (EID). Any component having an explosive, pyrotechnic, or a mechanical output resulting from an explosive or pyrotechnic action, and electrothermal devices having a dynamic mechanical, thermal, or electromagnetic output. Examples include bridgewire electroexplosive devices (EEDs), conductive composition electric primers, semiconductor bridge electroexplosive devices (EEDs), laser initiators, exploding foil initiators, slapper detonators, electronic safe and arm devices, burn wires, and fusible links.

d. Salient. A projecting conductor that is attached by the test personnel to a point on the test item. The salient directs the electrostatic discharges where desired.

4. Scope

a. The ESD safety program for ordnance establishes and implements ESD safety standards, criteria, instructions, regulations and restrictions for the Navy and Marine Corps in accordance with the organization and responsibilities assigned by references (a) and (d).

b. This instruction applies to both new and modified Navy and Marine Corps conventional ordnance and delivery systems for nuclear weapons.

c. This instruction implements and is part of the Weapon Systems Safety and Explosives Safety Programs established by reference (a).

d. The ESD certification process for ordnance defined in this instruction applies to operations and equipment utilized from assembly/stockpile to safe separation of the weapon from the launch platform, including transporting, storing, testing, handling, loading and downloading. The ESD certification process does not include ESD vulnerability during manufacture, rework or demilitarization unless otherwise directed by the Naval Ordnance Safety and Security Activity (NAVORDSAFSECACT).

5. Policy. Reference (d) requires ESD safety certification of ordnance. The following apply:

a. Ordnance shall be designed to preclude unintentional functioning or degradation from exposure to ESD levels described in enclosure (2).

b. Prior to Approval for Low Rate Initial Production (LRIP) or Production Approval (PA), for service use, all ordnance and materiel shall be evaluated by the NAVORDSAFSECACT Ordnance Safety and Security Director (N7) and certified for ESD. The ESD certification process for ordnance is described in enclosure (1). No ordnance or materiel shall be deployed or released for service use until it is ESD certified. The Commander of the Systems Command or PEO responsible for development and deployment of the ordnance and materiel has the authority to grant a WAIVER to this requirement on the basis that an overriding fleet requirement exists. The Weapon System Explosives Safety Review Board (WSESRB) and the Commanding Officer, NAVORDSAFSECACT must be advised of and concur with such a WAIVER before deployment, including deployment considered limited or provisional in nature.

c. Support effort for obtaining ESD certification of ordnance shall be planned, budgeted, and funded as an integral part of the

overall planning for all Navy and Marine Corps ordnance under consideration or development for procurement.

6. Responsibilities

a. The Commander, Naval Sea Systems Command shall administer the ESD safety program within the Navy and Marine Corps and ensure that engineering and test facilities are available to verify ordnance compliance with enclosure (2).

(1) Commanding Officer, NAVORDSAFSECACT is responsible for implementing the NAVSEA ESD safety program and for program administrative duties. Under the Commanding Officer's direction, the Ordnance Safety and Security Director (N7):

(a) Develops and establishes ESD criteria to ensure ordnance is certified in accordance with the requirements of enclosure (1).

(b) Establishes and maintains procedures for Navy ESD Certification. Promulgates these procedures to Systems Commanders and Project Managers for ordnance under their design cognizance

(c) Reviews Requests for ESD Certification and certifies ordnance ESD sensitivity

(d) Maintains a permanent file of ESD Certification for all Navy and Marine Corps authorized ordnance

(e) Updates the ordnance ESD test requirements contained in enclosure (2)

(f) Maintains a record of waivers granted by System Commanders or PEOs

(g) Represents the Navy and Marine Corps in ESD matters on committees, boards, panels and programs with other services and foreign nations

(h) Reviews reports of accidents, incidents and problems associated with ship and shore operations that relate to ESD, and approves the corrective action

(i) Responds to ship and shore ESD safety inquiries

(2) Cognizant Acquisition Managers shall:

(a) Ensure that provisions for ESD safety are included in applicable ordnance program documents (i.e., Operational Requirement Documents (ORD), etc.).

(b) Provide funding and hardware required to obtain ESD Certification of ordnance.

(c) Submit copies of ordnance ESD Certification Requests to NAVORDSAFSECACT.

(d) Modify existing ordnance to reduce or eliminate ESD sensitivity.

(e) Ensure that ESD recertification is requested whenever changes are proposed to ordnance.

b. Systems Commanders are responsible for implementing the ordnance ESD requirements of Weapon System Safety and Explosives Safety Programs within their cognizant materiel support areas.

(1) Program Managers under the direction of a Systems Commander shall:

(a) Assure that required ESD protective features are incorporated in cognizant ordnance systems designs, facilities, ship and aircraft installations.

(b) Ensure that requests for Low Rate Initial Production (LRIP) or Production Approval (PA) of ordnance under their design cognizance are not made until an ESD Certification has been granted by NAVORDSAFSECACT (N71), or that a WAIVER (based on an over-riding fleet requirement) has been documented for the ordnance.

(c) Modify existing ordnance to reduce or eliminate ESD hazards.

(d) Provide copies of all ESD Certification Requests with supporting analysis and test data to Ordnance Safety and Security Director (N7).

(e) Ensure that ESD recertification is requested whenever changes are proposed to ordnance which might affect its susceptibility to ESD.

c. Program Managers not under the direction of a Systems Command are responsible for appropriately implementing the aspects of the ordnance ESD Safety Program delineated in paragraphs 6.a(2) and 6.b. ESD Certification as required by paragraph 5b shall be requested from NAVORDSAFSECACT (N71). The Program Manager shall provide supporting test data or formal electrical engineering analysis with the ESD Certification Request.

d. The Commander, Naval Surface Warfare Center, Indian Head Division, Electronics System Development Division is the ordnance ESD technical agent for the Navy and Marine Corps and shall provide engineering support and ESD test facilities per reference (a).

7. Action

a. The Commanding Officer, NAVORDSAFSECACT shall carry out the ESD responsibilities of the Commander, Naval Sea Systems Command, as described above.

b. All other agencies shall establish organizations, procedures and coordination necessary to carry out their responsibilities as provided in this instruction. They shall follow the technical guidance of the NAVORDSAFSECACT with respect to the preclusion of ESD hazards to ordnance.

c. Commanders and Navy Program Managers not under the direction of a Systems Command shall inform the NAVORDSAFSECACT of their Point(s) of Contact for ESD matters, appropriate pertinent Command Directives and/or instructions.

d. The Commander, Naval Surface Warfare Center, Indian Head Division shall make ESD certification recommendations to NAVORDSAFSECACT (N71).

G. P. NANOS, JR.

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ELECTROSTATIC DISCHARGE CERTIFICATION REQUIREMENTS

1. NAVSURFWARCENDIV Indian Head is tasked under this instruction to review ordnance items for ESD safety and make ESD certification recommendations to NAVORDSAFSECACT. The ESD certification program and process described in this instruction standardizes and establishes formal procedures to attain ESD safety certification. All ordnance items developed or procured prior to this instruction with indeterminate or unknown ESD safety status regardless of background shall not be exempted from certified requirements. A requirement for additional test or analysis will be determined and provided to the requesting activity.

2. The cognizant systems command program office shall provide or direct submission of the following information to NAVSURFWARCENDIV Indian Head for review and certification processing:

a. Requestor identification: The name, address, phone number and agency.

b. Ordnance item and major subcomponent identification: The MK, MOD, NALC/DODIC, model, part number and manufacturer as applicable.

c. ESD test information: ESD information is critical to evaluating ordnance for ESD vulnerability. ESD test reports or any information on ESD is by far the most important item on this list. A good ESD report states where, when and how the ESD testing was performed. The report must give the configuration of the test item and the Mil Spec or test requirement document used. ESD testing shall be conducted with live EIDs as a minimum. The ESD sensitivity of all the energetic components of a system must be addressed. For systems being modified, historical ESD test results and reports are sometimes incorporated in documents such as environmental test or qualification reports. ESD tests at the 25 kV level were sometimes performed on the explosive subcomponents instead of testing the all up round. Sometimes an analysis was done in lieu of testing. To be useful, historical information must be applicable to the current configuration.

d. Ordnance technical data package shall contain the following:

(1) Item drawing(s) that contain the type and thickness of material of construction of the major subcomponents, particularly the outside surfaces. The drawings shall identify any electrical layout of the item.

(2) Packaging drawings that identify the type and thickness of material of construction. Packaging shall include launcher drawings if the launcher is involved in handling the item.

(3) Chart of energetic and hazardous materials that lists the type and quantity of all explosives, propellants, squibs, initiators, detonators etc. and whether they are percussion or electrically initiated.

(4) Functional narrative of how the item is transported, loaded, deployed, operated etc. The narrative shall state whether the item will be vertically replenished and in what configuration.

3. The ordnance item will be certified at one of the following five levels:

a. Not sensitive to ESD

b. Sensitive to helicopter ESD only

c. Sensitive to human borne ESD only

d. Sensitive to all ESD

e. ESD requirement does not apply

4. NAVSURFWARCENDIV Indian Head shall maintain record of the certification and provide copies to the program office, Navy Safety Centers, Weapons Stations, and to users of the ordnance upon request.

5. Contact Code 660 or 660E, at NAVSURFWARCEN Indian Head Division on DSN 354-4466 or Commercial (301) 744-4466, e-mail nialja@.ih.navy.mil if you have any questions.

ESD TEST REQUIREMENTS FOR ORDNANCE

1. PURPOSE. To establish a laboratory safety and operability test simulating personnel (human) and helicopter generated ESD conditions. The ordnance item must withstand electrostatic discharges (lightning environment is addressed separately from ESD). Electrostatic charges develop and discharge during preparation procedures, assembly, handling, maintenance, transportation and deployment of an ordnance system. Electrostatic charges on helicopters (and on weapon systems being transported or deployed by the helicopters) develop during flight and may discharge during vertical replenishment and/or landing operations. Operating helicopters on the ground or hovering with a tether generate electrostatic charges. The test evaluates the item design ESD sensitivity.

2. Description

2.1 General. All bare and packaged ordnance items are to be subjected to positive and negative discharges of electrostatic energy at selected exterior points. All ordnance shall be tested bare, with the personnel-borne ESD level at the lowest component level that will be handled by personnel during storage, transportation and use. The personnel-borne ESD test simulates the maximum electrostatic discharge from the human body and is performed at two different test conditions representative of such discharges. (see Table 1, Enclosure 2) Ordnance exposed to helicopter-borne ESD will be ESD tested both packaged and bare. The helicopter-borne ESD test simulates the maximum expected electrostatic discharge from helicopters flying, hovering or operating on the ground.

2.1.1 Personnel-borne ESD (bare). This test shall be conducted on bare devices to evaluate their safety and operability.

2.1.2 Helicopter-borne (packaged). This test shall be conducted on devices in their standard packaged configuration (unit or bulk packaging), shipping container or launch tube, to evaluate their safety and operability.

2.1.3 Helicopter-borne ESD (bare). This test shall be conducted on bare devices to evaluate only their safety.

2.2 Selection of Test Points. Test points shall be selected by identifying the points on the surface of the ordnance item under test determined by analysis to be the most susceptible to ESD. Ordnance items shall be tested for susceptibility to direct penetration of discharge currents or to excitation of the structure and subsequent internal distribution of the electrical energy from the discharge.

2.2.1 Bare Devices. Ordnance shall be tested and/or evaluated in worst-case conditions. All expected electrostatically relevant handling configurations, both with and without caps, covers and protective devices shall be evaluated. The test points on a device shall be selected with special attention and consideration given to connectors, pins, apertures, slots, joints and other discontinuities that may transfer electrical energy by contact or radiation.

2.2.2 Packaged Devices. Ordnance shall be in their shipping containers in their normal shipping configurations (for example, intact solder-seal lids or metal foil tapes or wraps). When selecting test points on a container, special attention shall be given to joints and other discontinuities that may transfer electrical energy by contact, induction or radiation.

2.2.3 Electrically Initiated Devices: EIDs will be tested for personnel-borne ESD as noted in 2.2. Testing at the component level can be used in place of all up round testing, however the ESD sensitivity of any other energetic components must still be evaluated. EIDs will be positively and negatively tested in all combinations of pin to pin, pin to case, shorted pin to case etc.

2.3 Environmental Conditions. The test shall be conducted on devices at an ambient temperature of +23°C±10°C (+73°F±18°F). Relative humidity of the ambient atmosphere shall be no greater than 50 percent. The device shall be preconditioned at +23°C±10°C (+73°F± 18°F), relative humidity no greater than 50 percent for no less than 24 hours prior to this test.

2.4 Device Configuration. The ordnance item shall be completely assembled except that the main explosive or propulsive charge(s), if determined by previous testing and/or analysis to be insensitive or inaccessible to ESD, may be omitted to facilitate testing. Electrical equivalency of the ordnance item shall be otherwise preserved if energetic elements are removed before proceeding with the ESD certification tests. The omission or removal of main explosive or propellant charges must be documented and the technical justification provided. All ESD testing will utilize live EIDs. All EEDs must contain their energetic components.

2.5 Test Documentation. Test plans, equipment, conditions, results, and analyses shall be documented in a formal report. To assure a proper record, the following major items of the test effort shall be documented for any test performed.

2.5.1 Test Plan. The planned test effort shall include a listing of specific tests, by test number and title (and specific procedure variations and options, if applicable), test sequence if used, the inspections, measurements and data gathering to be performed, and the data analysis method to be used, if applicable. Any modification, deviation or waiver in the test procedures of this standard shall be documented in the test plan. Test plans shall specify any requirements and procedures required to verify device operation. The test plan shall also specify:

a. The number (see Section 5.3) and configuration of devices for each discharge; the location of discharge points; the number of times each device may be subjected to discharge; the type of electrode to be used (see Section 4.4); the discharge gap or description of the mechanism utilized to move the electrode toward the test item (see Section 4.5); and the test sequence (see Section 5.2).

b. The performance requirements, pre-test data (for example, electrically initiated device (EID) bridge resistance and thermal time constants) and parameters for determining proper evaluation of the device during and after test, including how cumulative damage, if any is to be assessed.

2.5.2 Test Item Record. Each test article shall be identified and described by a test item record. The record shall include pre-test performance, performance during the test, and post-test performance as described below.

2.5.2.1 Pre-test Performance. Prior to conducting any of the tests, the performance level of the test item shall be established under standard ambient conditions unless test circumstances totally preclude this. A record shall be made of all data to determine compliance with required performance and, when applicable, to provide a reference level or criteria for checking desired performance of the test item during or at the conclusion of the test. If several tests are to be performed in sequence and the cumulative effect of use conditions is desired, then the measurement of performance level prior to each individual test may be deleted and only the pre-sequence measurement performed. The pre-test performance check may be made after installation of the item under test if installation conditions necessitate it.

2.5.2.2 Performance During Test. When operation of the test item is required during the test, a record shall be kept of the data for comparison with pre-test or post-test performance as required. The conditions during the performance check shall be those specified in the individual test.

2.5.2.3 Post-test Performance. When operation of the test item is required at the conclusion of the test, a record shall be kept of the data for comparison with pre-test performance or during-test performance, whichever is required in each individual test for determining conformance with the criteria for passing the test.

2.5.3 Test Equipment/Instrumentation. Test equipment and Instrumentation used to quantitatively control, monitor or measure test parameters shall:

a. Have a measurement error less than one-fourth the tolerance for the variable to be measured.

b. Conform to laboratory standards whose calibration is traceable to the U. S. National Institute of Standards and Technology.

c. Be calibrated at least every 12 months and be used during the in calibration period.

2.5.4 Test Conditions. The conditions of test as described in Section 2.3 shall be recorded during testing.

2.5.5 Test Results. Report all test results in accordance with section 2.5.6. Any deviations or waivers on the original test plan or the procedures of the standard shall be documented, along with the technical reasons for the changes.

2.5.6 Test Reports. Test reports will contain the following information:

a. Date(s)of test

b. Test location/facility

c. Test personnel

d. Test conditions recorded in section 2.5.4

e. Test equipment/instrumentation, type/model, serial number. (including Paragraph 2.5.3 items)

f. Configuration of test item, MK, Mod, NALC/DODIC, model, drawing, part number, revision, as applicable. The description should include any deletions or variations of the test item from the final configuration of the ordnance. (see Section 2.4)

g. Test item record (See Section 2.5.2)

h. Photograph or sketch of test configuration

i. All test results, data, and ESD waveforms (See Section 2.5.5)

j. Analysis of test results and data

k. Conclusion on the ESD sensitivity of the item

3. CRITERIA FOR PASSING THE ESD TESTS

3.1 Device Condition After Personnel-borne ESD (bare) and Helicopter-borne ESD Packaged Tests. At the completion of these tests, the ordnance shall be safe for transportation, storage, handling and use, as well as operable.

3.1.1 Safe for Use. The ordnance shall maintain its safety features in a condition which will not create a hazard for personnel or cause any subsequent action which will compromise the safety conditions required during handling, transportation, storage and use. Ordnance use includes installation, firing or release of the ordnance.

3.1.2 Operable. When the ordnance is provided its required inputs, it shall perform to completion of its function and sequence producing all required outputs within the operating period or at the specified time. Determination of operability may require firing the ordnance using a procedure adapted to the type of device being tested and/or its associated system.

3.2 Ordnance Condition after Helicopter-borne ESD (bare) Test. At the completion of this test, the device shall be safe for transportation, storage, handling and use. The ordnance does not have to be operable unless otherwise specified.

3.3 Decision Basis. Breakdown, inspection, other appropriate tests and engineering judgment shall form the basis for the decision that devices have passed or failed the test.

4. EQUIPMENT

4.1 Test Apparatus. The functional electrical schematic for the ESD test apparatus is shown in Figure 1.

4.1.1 Energy Delivery Capability. The energy delivery capability of the test apparatus shall be verified and recorded on a daily basis during testing. If a salient is used on the

test item, it shall be considered part of the discharge circuit. (See paragraph 4.5)

4.1.1.1 Personnel-borne ESD Test. The energy delivered to each of the calibration test loads given in Table 1 shall be between 0.18 percent and 0.22 percent (when using a 500 ohm series resistance) or between 0.018 percent and 0.022 percent (when using a 5000 ohm series resistance) of the energy stored on capacitor "C" (see figure 1). Section 7.3.2.1 provides a description of the threat to devices or their subsystems caused by an electrostatic discharge from a human body. Section 7.4 provides a description of the required instrumentation and a procedure for measuring the energy delivered by the test apparatus used to simulate the threat. Calibration test waveforms should fall within the bounds specified in Figures 2 through 5, as applicable.

4.1.1.2 Helicopter-borne ESD Test. The energy delivered to the calibration test load given in Table 1 shall be between 80 percent and 100 percent of the energy stored on capacitor "C" (see figure 1).

TABLE 1 Test Parameters

DISCHARGE PROCEDURE	VOLTAGE ON C kilovolts	CAPACITOR C picofarads	RESISTANCE R ohms	DISCHARGE INDUCTANCE microhenrys	CALIBRATION TEST LOAD ohms
Personnel	+25+/-5%	500+/-5%	5000+/-5%	<5	1+/-5%
Personnel	-25+/-5%	500+/-5%	5000+/-5%	<5	1+/-5%
Personnel	+25+/-5%	500+/-5%	500+/-5%	<5	1+/-5%
Personnel	-25+/-5%	500+/-5%	500+/-5%	<5	1+/-5%
Helicopter	+300+/-5%	1000+/-10%	1 max*	<20	100+/-5%
Helicopter	-300+/-5%	1000+/-10%	1 max*	<20	100+/-5%

*Total distributed discharge circuit DC resistance.

4.2 Circuit Component Characteristics

4.2.1 Power Supply. The power supply shall provide both positive and negative test voltages with respect to ground.

4.2.2 Isolation Circuitry. Isolator (see figure 1) shall isolate the test item from the charging circuit during charging of capacitor "C" and shall isolate the power supply from the discharge circuit during discharge to the test item.

4.2.3 Series Resistance. The series resistance "R" shall be non-inductive. For the helicopter-borne ESD test, R represents the allowable total discharge circuit DC resistance, excluding the test item (see figure 1).

4.2.4 Capacitor. Capacitor "C" shall be chosen to minimize inductance, leakage and equivalent series resistance (ESR).

4.2.5. Oscilloscope. To properly record test waveforms, an oscilloscope is required having at least a DC to 100 MHz frequency response.

4.2.6 Test Parameters. The voltage, capacitance, resistance, discharge circuit inductance, and calibration test load for each test procedure, including the inductance of the capacitor and wiring to the probes shall be in accordance with the values in Table 1. Inductance shall be measured at a minimum 1 k Hz frequency.

4.3 Electrode Characteristics. The test electrode shall be metal and have a size and shape that minimize corona. The electrode surface shall be maintained smooth, clean and shiny to insure high electrical conductivity and uniformity of discharge.

4.4 Electrode Control. A mechanism shall be provided to cause the test electrode either to discharge to the test item through a previously specified fixed gap (see Section 2.5.1a) or to move toward the test item at the speed at which it was calibrated. The electrode may be snubbed to prevent hitting the test item. Where it is desired to insure that the discharge is directed to a particular point on the test item or to assure contact by the electrode without mechanical shock, an electrically conductive salient may be attached to the test item. In this case, it shall be established that the salient can withstand the discharge arc and that the surface of the test item with salient omitted can also withstand a direct discharge arc. The salient shall be

included in energy delivery calibration tests (see Section 4.1.1).

4.5 Safety considerations. Proper safety interlocks, switches, grounds and procedures shall be used to protect test personnel from electrical and explosive hazards. A grounding rod with insulated handle (or equivalent) shall be provided to short circuit the test electrode to test-circuit ground while test personnel are setting up for the next discharge.

5. PROCEDURE

5.1 Test. Perform the personnel-borne ESD tests and the helicopter-borne ESD tests in accordance with the test plan. Test details, for example, configurations, order of trials, inspection and number of trials, shall be at the discretion of the test designer and shall be documented in the test plan.

5.2 Test sequence. Items shall be tested as follows:

5.2.1. The test item shall be positioned such that the test electrode can discharge to the first designated test point on the item.

5.2.2 Capacitor "C" shall be charged to the chosen voltage and polarity. After "C" is fully charged and has been isolated from the power supply, the test electrode is allowed to discharge to the test point.

5.2.3 The capacitor discharge energy shall be applied sequentially to each of the designated test points. The capacitor shall be fully recharged for each point.

5.2.4 The test sequence shall be stopped if the test item at any time gives an indication of failure to pass the test, or at the discretion of the test activity. After removal of residual electrical energy from the test apparatus and the test item, the test item shall be inspected for compliance with Section 3. Otherwise, sequential application of capacitor discharge energy to all selected test item points shall be continued.

5.2.5 The above sequence shall be repeated with opposite polarity voltage.

5.2.6 Steps a through e shall be performed for the remaining test items.

5.3 Number of test items. A minimum of 20 items shall be tested to the personnel-borne ESD threat. A minimum of 10 items shall be tested to the helicopter-borne ESD threat. Tests may be conducted by using different ordnance items or on the same ordnance item with a different set of EIDs and electronic/electrical subsystems.

5.4 Compliance. The test item meets the pass/fail criteria specified in Section 3.

6. SUPPLEMENTAL INTERMEDIATE VOLTAGE ESD TESTING

6.1 Supplemental Testing. Conduct ESD testing on at least one sample at intermediate voltages between zero and 300 kilovolts should be conducted to identify voltage breakdown paths which may not be observed at the voltages given in Table 1. The minimum parameters for additional tests are provided in Table 2. The two ESD discharge voltages in Table 1 are based on the maximum levels, not the most likely levels.

TABLE 2. Suggested Supplemental Test Parameters.

Discharge Procedure	Voltage on C kilovolts	Capacitor C picofarads	Resistance R (ohms)	Discharge Inductance microhenrys	Calibration Test Load ohms
Helicopter	+50±5%	1000±10%	1 max *	< 20	100±5%
Helicopter	-50±5%	1000±10%	1 max *	< 20	100±5%
Helicopter	+100±5%	1000±10%	1 max *	< 20	100±5%
Helicopter	-100±5%	1000±10%	1 max *	< 20	100±5%
Helicopter	+150±5%	1000±10%	1 max *	< 20	100±5%
Helicopter	-150±5%	1000±10%	1 max *	< 20	100±5%
Helicopter	+200±5%	1000±10%	1 max *	< 20	100±5%
Helicopter	-200±5%	1000±10%	1 max *	< 20	100±5%
Helicopter	+250±5%	1000±10%	1 max *	< 20	100±5%
Helicopter	-250±5%	1000±10%	1 max *	< 20	100±5%

*Total distributed discharge circuit DC resistance.

6.2 Testing of an Armed Device. Device development testing or operational conditions may require that an armed device be handled. For these cases, it is recommended that the personnel-borne ESD test be conducted on armed devices to establish if they are sensitive to electrostatic discharges up to 25 kilovolts. The results of this test will also be helpful in establishing procedures for disposing of the device or rendering it safe by Explosive Ordnance Disposal Personnel.

7. RELATED INFORMATION

7.1 Relation to Other Environmental Tests. Electrostatic discharge tests should be conducted either singly or as part of a sequence after other environmental tests have been completed on the device. It is suggested that items also be evaluated for susceptibility to electrostatic discharge after they have been attached to their associated weapons, if practical. Items subjected to environmental tests which might alter the electrical properties of the item (such as immersion or salt spray) should not be used for ESD testing.

7.2 Number of Tests per Device. The number of electrostatic discharges to a particular device, bare or packaged, has not been specified and is at the discretion of the test activity. The determination of the permissible number of discharges should be based in part on whether cumulative damage should be counted in assessing whether the device meets the passing criteria of Section 3.

7.3 Electrostatic Environment.

7.3.1 Personnel-borne. The physiological characteristics that affect the electrostatic hazard vary over a wide range. The degree of the hazard also depends on the type of clothing worn and the relative humidity of the ambient air. The upper bound hazard may be represented by charging a low-loss, low-inductance 500-picofarad capacitor to 25 kilovolts and discharging it through a 500 ohm resistor with not more than 5 microhenrys of total circuit inductance.

7.3.2 Helicopter-borne. Helicopters and other hovering aircraft become electrostatically charged by ion emission from the engines and by the triboelectric charge separation on airfoils. Helicopter ESD characteristics vary over a wide range, but a typical upper bound may be represented by a 1000-picofarad capacitor charged to 300 kilovolts.

7.4 Waveform Characterization of the Personnel-borne ESD threat. The heavy curves in Figures 2 and 3 represent typical 25 kilovolt pulses for the 500ohm and 5000ohm series resistances respectively. Rise times are approximately 15 nanoseconds (10 percent to 90 percent of peak value). The range of waveforms for equipment used to simulate the personnel-borne ESD threat should fall within the bounds of the curves given in those figures. Figures 4 and 5 represent typical boundaries for voltage waveforms as measured on a storage scope using the calibration circuit presented in Figure 6. The 1-ohm resistor should be coaxial in order to ensure the proper frequency response. If possible, the probe should be touching the resistor contact when the discharge is triggered. This will produce the most consistent waveforms. Waveforms should be characterized before and after testing and included in the test report.

7.5 Bibliography.

7.5.1 Technical Report 62-72, *Helicopter Static-Electricity Measurements,* by James M. Seibert, US Army Transportation Research Center, June 1962.

7.5.2. Technical Report 69-90, *Investigation of CH-54A Electrostatic Charging and of Active Electrostatic Discharge Capabilities,* by M. C. Becher, US Army Aviation Material Laboratories, January 1970.

7.5.3 Technical Report TR-2207, *Evaluation of Dynasciences Model D-04E Active Electrostatic Discharge System Mounted on the CH-46A Helicopter,* by Charles L. Berkey, Naval Weapons Laboratory, September 1968.

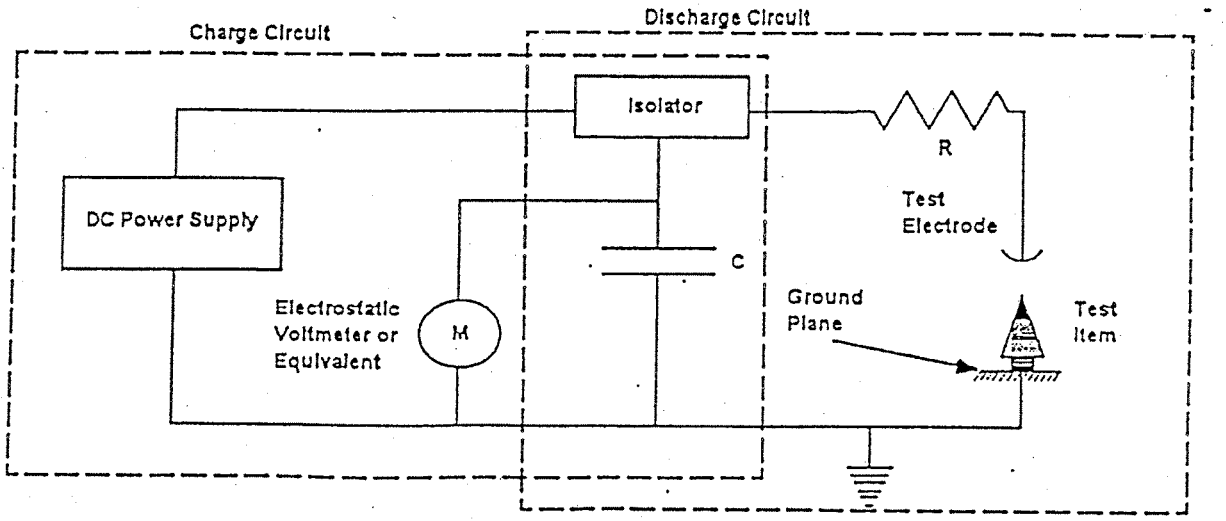
7.5.4 *Electromagnetic Criteria for US Army Missile Systems: EMC, EMR, EM, EMP, ESD, and Lightning, by* Charles D. Ponds, Colsa, Inc., February 10-87.

7.5.5 UK Ministry of Aviation - Explosives Research and Development Establishment Report No. 18/R/62, *Measurement of Human Capacitance and Resistance in Relation to Electrostatic Hazards with Primary Explosives,* 17 August 1 c-62.

7.5.6 NATO STANAG 4235, *Electrostatic Environmental Conditions Affecting the Design of Materiel for Use by NATO Forces.*

7.5.7 NATO STANAG 4239, *Electrostatic Discharge Testing of Munitions Containing Electroexplosive Devices.*

7.5.8 NATO AOP 24, *Assessment and Testing of Munitions Containing Electroexplosive Devices to the Requirements of STANAG 4239*



Note: Helicopter borne ESD may require a multiple capacitor system.

FIGURE 1 Functional Electrical Schematic for Electrostatic Discharge Apparatus.

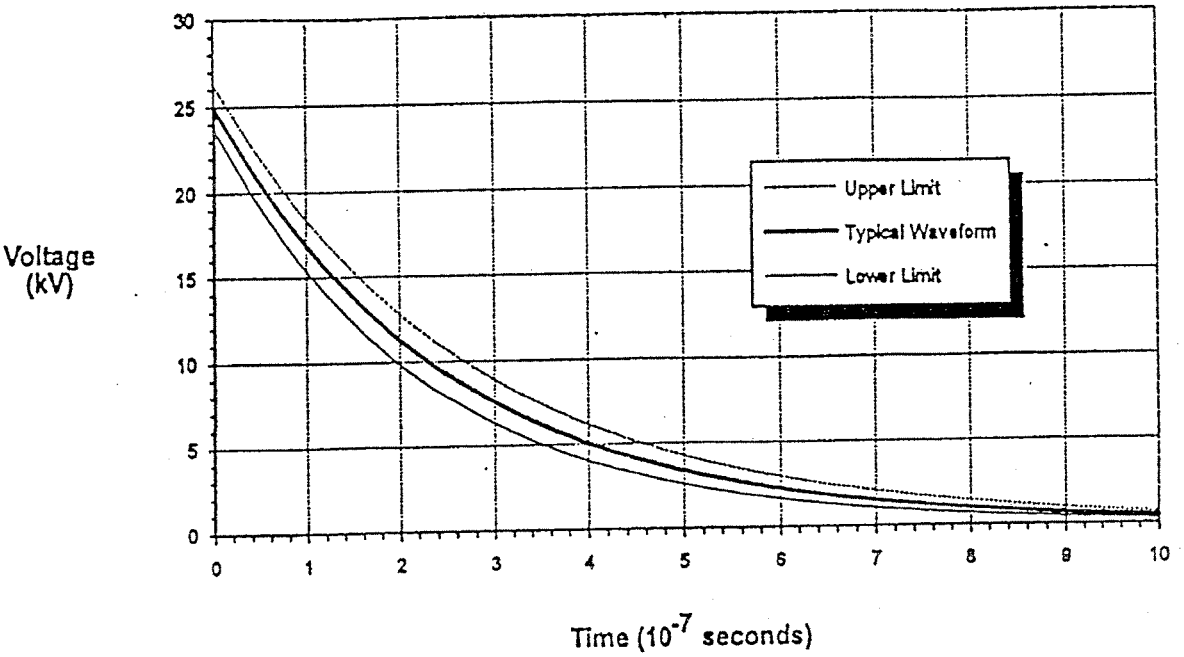


FIGURE 2. ESD Waveform (500-ohm series resistance).

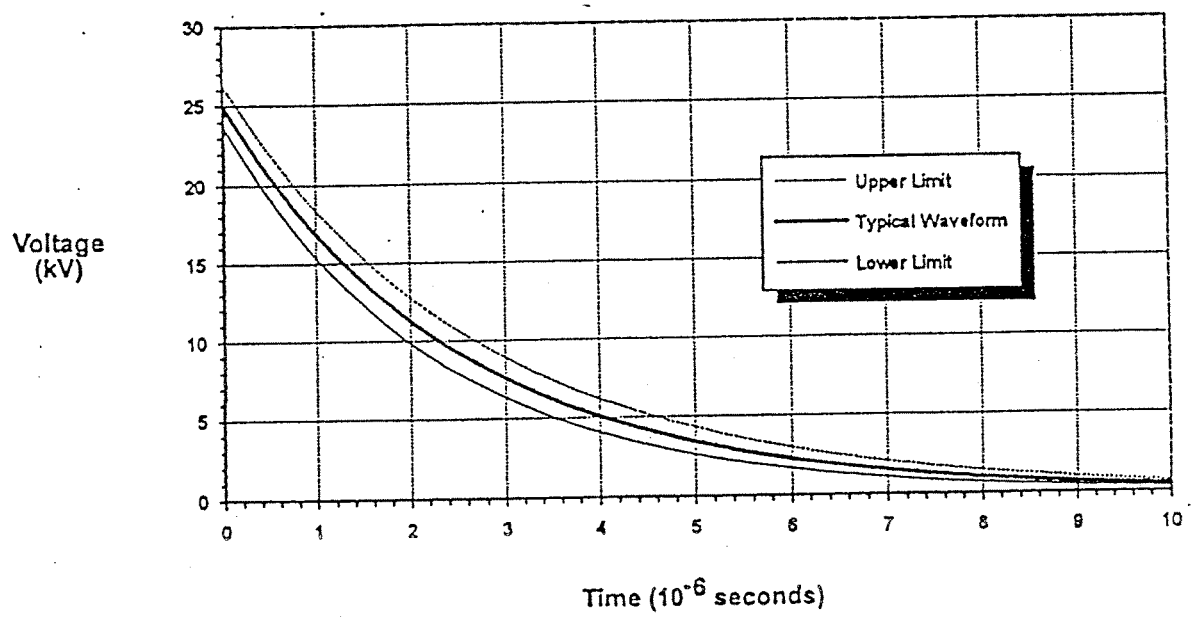


FIGURE 3. ESD Waveform 5000-ohm series resistance .

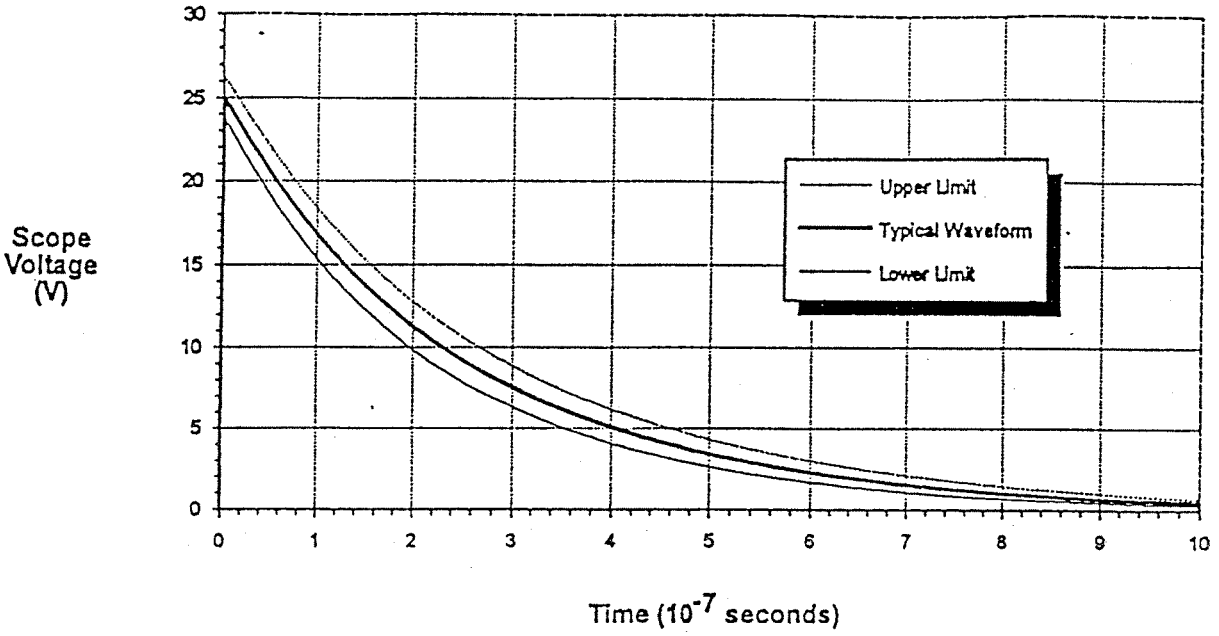


FIGURE 4. ESD Waveform on Oscilloscope (500-ohm series resistance).

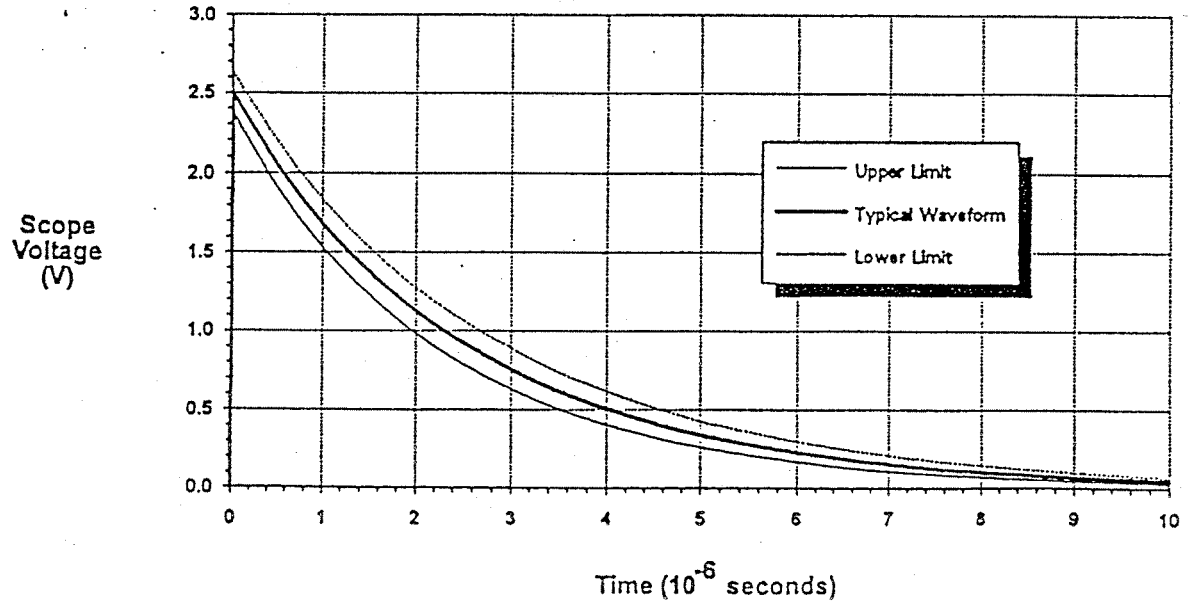


FIGURE 5. ESD Waveform on Oscilloscope (5000-ohm series resistance).

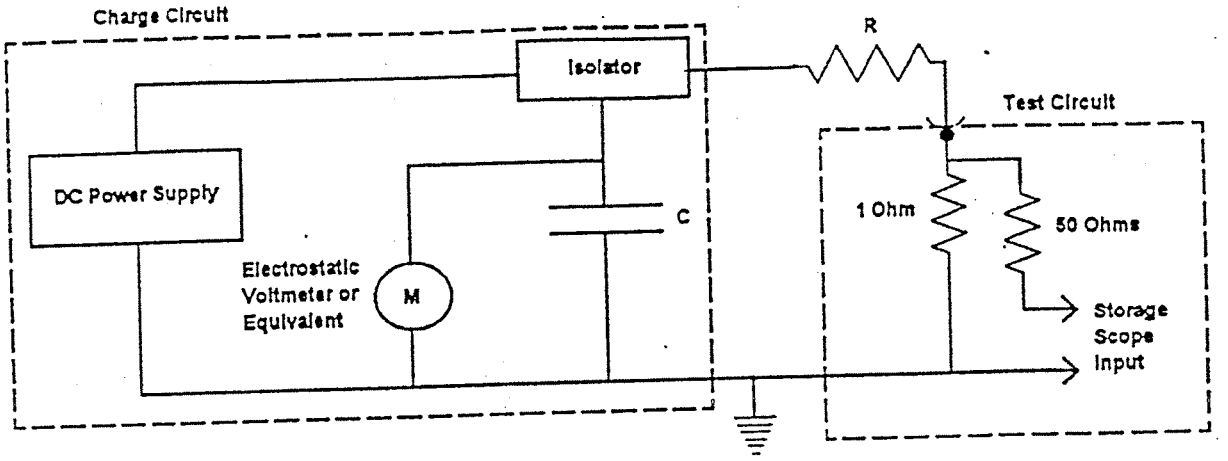


FIGURE 6. Personnel-borne ESD Waveform Calibration Circuit.