Volume XXII 2019
ISSUE no.2
MBNA Publishing House Constanta 2019

Scientific Bulletin of Naval Academy

SBNA PAPER • OPEN ACCESS

Testing of immunity to electrostatic discharge of electronic devices and devices electrically initiated

To cite this article: I. Ciocioi and V. Nae, Scientific Bulletin of Naval Academy, Vol. XXII 2019, pg. 337-342.

Available online at www.anmb.ro

ISSN: 2392-8956; ISSN-L: 1454-864X

doi: 10.21279/1454-864X-19-I2-040

Testing of immunity to electrostatic discharge of electronic devices and devices electrically initiated

I Ciocioi[1] and V Nae[2]

[1] „Mircea cel Batran" Naval Academy
[2] „Admiral Murgescu" Navy Petty Officers School
ciocioi.iancu@gmail.com, valinae2002@yahoo.co.uk

Abstract. Electrostatic discharges of bodies loaded with static electricity are accompanied by the emergence of tension and transient currents, which can cause damage to electronic devices and the ignition of electrically initiated devices. In electromagnetic compatibility a great importance (from the point of view of electrostatic discharge) has the discharge of human body.

1. Electrostatic discharge

Electrostatic discharge can be defined as a transfer electrostatic change between two bodies at different electrostatic potentials by air discharge or through direct contact discharge [8].

The main form of electrization of bodies is the triboelectric effect that occurs in the case of friction of two bodies – one loads with positive load and the other with negative electrical load, according to the Triboelectric series (positive „+" – Human hands, Rabbit fur, Glass, Mica, Human hair, Naylon, Wool, Fur, Lead, Silk, Aluminum, Paper, Cotton, Steel, Wood, Amber, Sealing wax, Hard rubber, Nickel, Copper, Gold, Platinum, Sulfur, Acetate rayon, Polyester, Celluloid, Polyurethane, PVC (vinyl), Silicon, Teflon – negative „-").

In terms of electromagnetic compatibility, the standards regarding immunity testing at electrostatic discharges address three models:

- electrostatic loading of the human body (as a result of movement, manipulation of various objects, parts, etc.) and unloading it to the ground directly through the testing device/circuit (Human Body Model-HBM);
- electrostatic charging occurring in a production process and unloading through the device subjected to direct grounding (Machine Model-MM);
- electrostatic charging and unloading of the device subjected to testing at a metallic surface (Charged Device Model-CDM).

The human body is the main source of electrostatic discharge production and can be modeled by a 100 picofarad capacitor and a 1500 ohm resistor [6]. The change in the body capacity of the human operator is determined by the type of clothing, the type of the pot surface and relative humidity. The change in body resistance of the human operator is determined by factors such as humidity, oils and salt from the surface of the skin, the conductive surface of the device.

The electrostatic voltage at which the human operator is charged is based on the work carried out and is shown in table 1 [6].

Table 1.

Means of static generation	Electrostatic voltage	
	10 – 20% - Relative humidity	65 – 90% - Relative humidity
Walking across carpet	35000	1500
Walking over vinyl floor	12000	250
Worker at bench	6000	100
Vinyl envelopes for work instructions	7000	600
Common poly bag picked up from bench	20000	1200
Work chair padded with polyurethane foam	18000	1500

2. Immunity testing of electronic devices to electrostatic discharge

Electronic equipment (electronic/microelectronic device) must have a certain level of immunity to electrostatic discharge. Electronic devices/components can be destroyed or degradation by exposure to electrostatic discharge. Potentially susceptible electronic devices/components are microcircuits, discrete semiconductors, thick and thin film resistors, integrated circuits, hybrid devices and piezoelectric crystals. Susceptibility of electronic devices/components to electrostatic discharges depends upon the magnitude and shape of the electrostatic discharge pulse.

Military Standard 464 (MIL-STD-464, Electromagnetic environmental effects requirements for systems) provides general requirements for ordnance safety and electrical and electronic subsystems, when ordnance items or electronic subsystems are exposed to Personnel-borne Electrostatic Discharge [7].

The purpose of electrostatic discharges tests is to determine whether electrostatic discharges transferred to electronic equipment (electronic/microelectronic devices) by personnel contact will damage the equipment or lead to the malfunctioning and degradation of its performance.

Test result types are: normal performance, functionality and performance reduced temporarily but will return to normal, functionality and performance are reduced and will require a system reset in order to return to normal and electronic/microelectronic device failure.

The next military standards (MIL-STD), military handbook (MIL-HDBK) and Allied Environmental Conditions and Test Publication (AECTP) provides requirements and guidance for the electrostatic discharge (ESD) tests:

- MIL-STD-883, Test Method Standard Microcircuits;
- MIL-STD-331, Test method standard fuses, ignition safety devices and other related components, environmental and performance tests for;
- MIL-HDBK-263, Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts Assemblies and Equipment (excluding electrically initiated explosives devices);
- AECTP-500, Electromagnetic Environmental Effects Test and Verification;
- AECTP-250, Electrical and Electromagnetic Environmental Conditions.

Testing the immunity of electronic/microelectronics devices to electrostatic discharges can be determined according to the IEC 61000-4-2, Electromagnetic compatibility – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test.

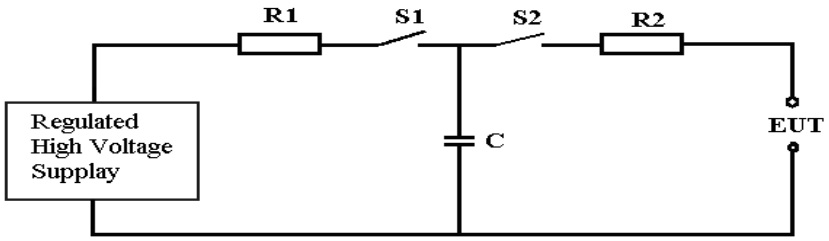
The test method and levels stipulated by AECTP-500 are similar to IEC 61000-4-2.

According to MIL-STD-883 on immunity to electrostatic discharge, electrical/microelectronic devices may be classified in the following classes and subclasses (table 2). The human body is modeled by a 100 picofarad capacitor and a 1500 ohm resistor (as in MIL-HDBK-263). The tests are presented in table 3 and test are conducted in order of severity in order to determine the level of immunity.

Table 2. Device ESD failure threshold classification (MIL-STD-883).

Class		Sensitivity range
0		< 250 V
1	1A	200 V - < 499 V
	1B	500 V - < 999 V
	1C	1000 V - < 1999 V
2		2000 V - < 3999 V
3	3A	4000 V - < 79999 V
	3B	≥ 8000 V

Network model for testing an electronic device (equipment) in terms of electrostatic discharge of the human body, is shown in Figure 1.



	MIL-STD	IEC
R_1	10^6 - 10^7 Ω	50 - 100 MΩ
R_2	1500 Ω ± 1%	330 Ω
C	100 pF ± 10%	150 pF

Figure 1.

The current impulses corresponding to the IEC 61000-2 and MIL-STD-883 standards for an 8kV voltage are shown in Figure 2 and the pulse parameters in table 3 (contact discharge).

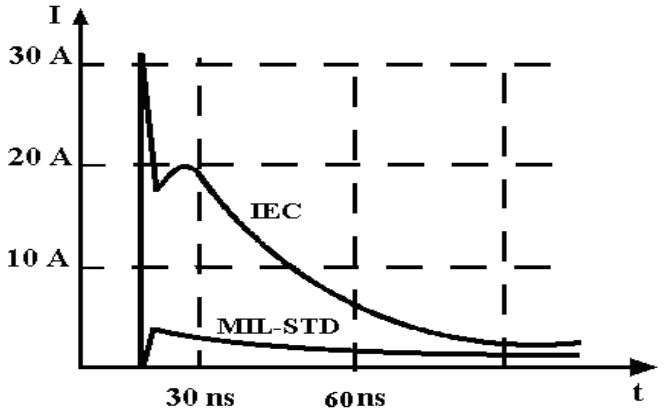


Figure 2.

It is noted that electronic equipment (electronic/microelectronic devices) tested according to IEC 61000-4-2 can be ordered aboard the ship without the need for new tests because its requirements are much higher than the MIL-STD-883 military standard.

Table 3. IEC 61000-4-2 and MIL-STD-883 Test Levels

Test Voltage [kV]	IEC 61000-4-2		MIL-STD-883	
	Peak Current [A]	Rise Time, t_c [ns]	Peak Current [A]	Rise Time, t_c [ns]
2	7,5	0,7 – 1	1,3	2 – 10
4	15	0,7 – 1	2,6	2 – 10
6	22,5	0,7 – 1	4	2 – 10
8	30	0,7 – 1	5,3	2 – 10

3. Immunity testing of electrically initiated devices to electrostatic discharges

An electrically initiated device (EID) is a unit, device, or subassembly that uses electricity to produce a pyrotechnic, thermal or mechanical initiated explosion, as well as electroexplosive devices (hot bridgewire, semiconductor bridge, carbon bridge and conductive), exploding foil initiators, laser initiators, burn wire and fusible links.

Immunity testing of electrically initiated devices (EID)/ammunition to electrostatic discharges can be carried out in accordance with:

- AECTP-500, Electromagnetic Environmental Effects Test and Verification;
- AECTP-250, Electrical and Electromagnetic Environmental Conditions.

Electrostatic discharge of personnel is considered the greatest hazard for electrical/ammunition-initiated devices. The network model for testing an electrically initiated device/ammunition from the point of view of the electrostatic discharge of the operator shall consist of the elements shown in table 4 [4].

Table 4.

Equipment	Parameters			
	Electrostatic voltage [kV]	Capacitance [pF]	Resistance [Ω]	Circuit inductance [μH]
Munitions	25 ± 5%	500 ± 5%	500 ± 5%	5 max.
Munitions	25 ± 5%	5000 ± 5%	5000 ± 5%	5 max.

Note: The voltage will be changed to positive and negative voltage.

The test applies to ammunition throughout its lifecycle:

- ammunition handled by personnel;
- ammunition subject to an electrostatic environment due to the vertical supply (take-off) procedures of the helicopter;
- ammunition that can be affected by the above environment.

Calibration of the immunity test device to electrostatic discharge of electrical/ammunition initiated devices will be carried out through the waveform table generated, both for positive polarity and for negative polarity, for Levels of 10, 15, 20 and 25 kV. The calibrated test load (50 Ω and/or attenuators, Figure 3) connects to a data acquisition system indicating the waveform in Figure 4 whose growth time is less than 15 ns. The test circuit is shown in Figure 2.

Because there are significant variations in many components from lot to lot the number of test samples used is critical in the assigning of relevance to ESD test results. For example, when the number of samples used is 10, the confidence level goes to 80% and the reliability is 85% (the items are insensitive to ESD). For 22 tested items, the confidence level goes to 90% with a reliability of 90% [3].

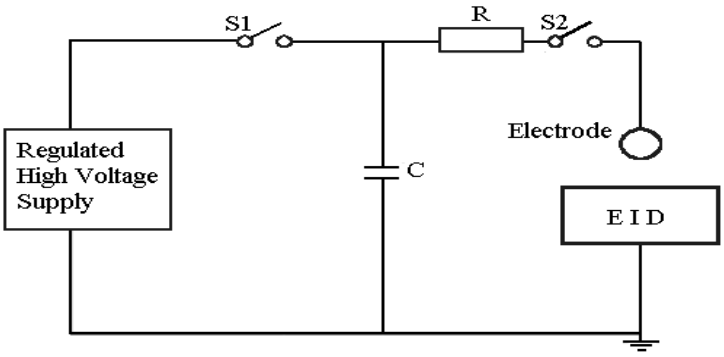


Figure 3. Personnel Generated ESD Test Circuit.

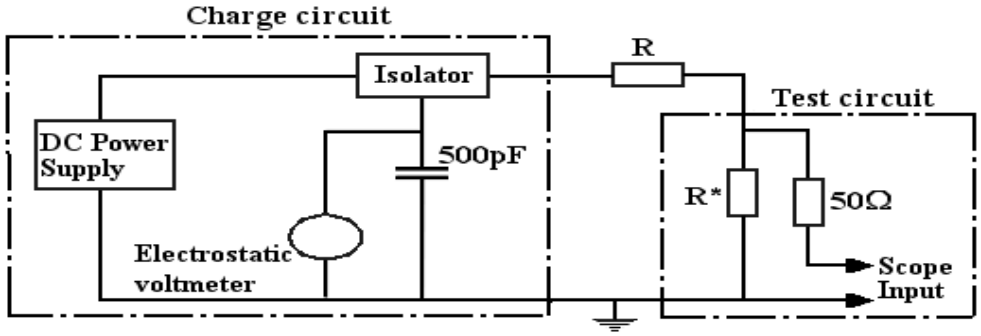


Figure 4. Personnel-borne ESD Waveform Calibration Circuit (Value of R* can be 1-2 Ω).

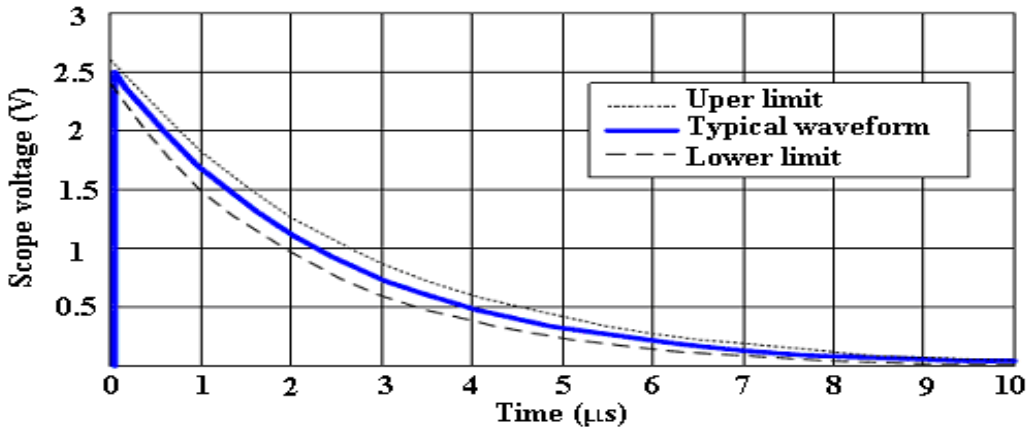


Figure 5. Typical ESD Waveform.

4. Conclusions

Immunity to electrostatic discharge: equipment tested according to IEC 61000-4-2 (SR EN 60945) may be ordered aboard the ship without further testing being required because its requirements are much higher than the military standard MIL-STD-883.

For the testing of immunity to DES a DIE it is necessary to calibrate the immunity test device to electrostatic discharge of electrical/ammunition initiated devices and this will be done by the table of the waveform generated, both for Positive polarity and for negative polarity, for levels 10, 15, 20 and 25 kV (adapted to 50W to achieve a waveform with a growth time of 10ns).

References

[1] MIL-STD-883, Test Method Standard Microcircuits.
[2] IEC 61000-4-2, Electromagnetic compatibility – Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test.
[3] AECTP-500, Electromagnetic Environmental Effects Test and Verification.
[4] AECTP-250, Electrical and Electromagnetic Environmental Conditions.
[5] Schwab, A., Compatibilitatea electromagnetică, Editura Tehnică, Bucureşti, 1996.
[6] MIL-HDBK-263B, Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts Assemblies and Equipment (excluding electricaly initiated explozive devices).
[7] *** Department of Defence, JOTP-062, Joint Ordnance Test Procedure (JOTP) - Personnel-borne ElectroStatic Discharge (PESD) and Helicopter-borne ElectroStatic Discharge (HESD), Requirements for Ordnance, Joint Munitions Safety Test (JMST) Working Group.
[8] STANAG 4235, Electrostatic Discharge Environment.