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Environmental and Vibration Tests for Electronic Systems

B. Ramulu

Programmable Control Systems Lab, BHEL Corporate Research & Development, Vikasnagar, Hyderabad- 500093, India

Abstract The significance of extent of influence of ambient environment on the electronic systems depends on the field of application. Environmental tests, comprising of general and location specific tests are used as a means of getting an insight into the ability of a system to perform as per design in the target environment under influence of all parameters, capable of influencing it. The objective of environmental testing is to evaluate systems, equipment, apparatus, components, etc. in terms of determining their ability to withstand environmental conditions. Environmental testing is usually done during both prototype and production stages. This paper provides an insight into the relevance of environmental tests as applicable to electronic systems.

Keywords Environmental tests, Functional tests, Equipment under test (EUT), Electronic Systems, Ambient Conditions, Operational Voltage.

Introduction

Electronic systems including appliances/devices/prototype modules/ components etc. consist of mechanical, electrical and electronic parts and combinations thereof. Various technical issues must be considered in order to develop a product suitable to a particular environment and to test its ability to withstand those conditions. As part of the design, it is desirable that environmental testing for electronic systems is carried out as per some accepted standards like IEC60068-2-1, IEC60068-2-2, etc. Environmental testing will indirectly determine the life-span of the equipment under test. Prior to testing, a relevant and detailed test programme is to be prepared for the Equipment under test (EUT). If the system is series-manufactured, the EUT shall be taken from the current production cycle. There is no pre-defined test sequence. All the tests required for the system shall be performed on one EUT [1].

1. Visual Test

Visual Test is done to inspect conformity with the manufacturers drawing and specifications. Visual inspection is done before commencement of type approval and shall be repeated as required subsequent to each stage of the test to detect visible damage to the EUT. The test is deemed to have been passed if the equipment under test meets the requirements of GL (Germanischer Lloyd) rules for classification, construction and regulations and does not show evidence of any physical damage [1,3].

2. Performance Test

Before starting the Performance Test, power supply to the EUT is switched off and the system is allowed to reach its equilibrium state under ambient conditions. This test is sufficiently extensive to verify compliance with the manufacturer's equipment specifications. The tests are performed at the rated operational voltage (Ue). When the EUT is required to comply with an acceptable performance standard, applicability of specifications mentioned in the standard are to be ascertained prior to testing. Performance testing is necessary for checking the following:

- The system operation is in accordance with the specified requirements.

- Self-monitoring features are in place.
- Specified protections against access to the memory.
- Effect of erroneous use of control elements in computer systems.

3. Powersupply Failure Test

This test indicates the extent to which EUT can withstand the effect of power supply failure and restoration of power supply after a trip. Some of the typical tests are as follows:

- Within a period of five minutes, three interruptions are introduced on EUT.
- Half a second pause between switching off and switching on.

The tests are performed at the rated operational voltage (Ue). The time durations may be altered as per requirement of EUT.

4. Powersupply Variations Test

This test indicates the extent to which EUT can withstand the effects of variation in power supply.

Table 1: Voltage & Frequency Deviations

S. No.	Voltage deviation stationary (duration >15 min)	Frequency deviation stationary (duration > 15 min)
1	+6%	+5%
2	+6%	-5%
3	-10%	-5%
4	-10%	+5%
	Voltage deviation transient (duration 1.5s)	Frequency deviation transient (duration 5s)
5	+20%	+10%
6	-20%	-10%

Before introduction of power supply variations, EUT is allowed to reach its equilibrium state. The deviations shall be calculated from nominal value of voltage and frequency as per the Table 1.

The voltage and frequency deviations must be applied for a minimum of 15 minutes. The transient deviations should be superimposed on the nominal voltage and frequency. The tests are performed at the rated operational voltage (Ue). For equipment which requires booting, an additional power supply interruption during booting is to be performed. Verification of equipment behaviour upon loss and restoration of power supply. Possible corruption of programme or data held in the programmable system needs to be carried out [2].

5. Cold Test

This test indicates the extent to which EUT can withstand influence of low temperature. Refer to Table 2 for cold tests.

Test A: For products installed inside ship.

Test B: For products installed in cold areas or open deck.

Table 2: Conditions for Tests A &B

Test A

Temperature	5˚C ± 3˚C
Test duration A	2h

Test B

Temperature		-25˚C ±3˚C
Test duration B		2h

The functional tests are performed at the rated operational voltage (Ue).

Other information to note:

- An insulation resistance measurement should be taken.
- Equipment not operating during conditioning and testing (except for functional test).
- Functional test during the last hour at the test temperature.
- Insulation resistance measurement and the functional test after recovery.

6. Dry Heat Test

This test indicates the extent to which EUT can withstand the effect of dry heat. Refer to Table 3 for test details.
Test C- For products without increased heat stress.
Test D- For products with increased heat stress or on the open deck.

Table 3: Conditions for Tests C & D

Test C

Temperature	70˚C±2˚C
Relative humidity at test temperature	≤50%
Test duration after the EUT has reached the test temperature	16h

Test D

Temperature	55˚C±2˚C
Relative humidity at test temperature	≤50%
Test duration	16h

The functional tests are performed at the rated operational voltage (Ue).
Other information to note:

- The EUT should be placed in the test chamber at room temperature and kept in energised condition throughout the test.
- During the final hour of the test, functional tests should be performed.
- For equipment specified for increased temperature the dry heat test is to be conducted.

7. VIBRATION TEST

This test indicates the extent to which EUT can withstand the effect of external vibration conditions. Refer to Table 4 for tests details.
SWEEP SINE TEST: EUT is energised and subjected to vibration in three mutually perpendicular planes, sweeping shall be continuous. Resonance should be run at the actual test level specified. Endurance test shall be carried out for at least 90 minutes at all resonance frequencies.
WIDE BAND RANDOM TEST: The procedure is similar to above, but endurance test shall be carried out for atleast 2.5 hour in each of the three planes.

Table 4: Conditions for Vibration Test

	Displacement	**Acceleration**
2 Hz up to 13.2 Hz	±1.0mm	
13.2Hz up to 100 Hz		0.7g
Sweep rate	Max 1 octave/minute	

The functional tests are performed at the rated operational voltage (Ue).
The EUT shall be fastened to the test board by means of its own fastening devices. The equipment shall be mounted in its normal position, and in accordance with the manufacturer's instructions. When sweep test is to be carried out instead of the discrete frequency test, a number of resonant frequencies close to each other, for a duration of 120 min are used. Sweep over a restricted frequency range between 0.8 and 1.2 times of the critical frequency can be used.

8. Insulation Resistance Test

This test indicates the extent of insulation resistance at the electrical connections of the EUT.
This test is done before and subsequent to the following tests: Cold, Damp Heat, Salt mist and high voltage with the following considerations:

Table 5: Insulation Resistance Test

Rated operational voltage (Ue) AC/DC	Test voltage (DC)	Minimum insulation resistance	
≤ 65 V	2 * (Ue), min 24 V	10	1
> 65 V	500 V	100	10

Test is performed on all connections with:

- All connections w.r.t frame potential.
- Connections against each other.
- Between all phases and earth, and whereappropriate, between the phases.

Note: Certain components e.g. for EMC, protection may be required to be disconnected.

9. Pressure Test

This test indicates the extent to which the components of electronic equipment can withstand pressures when exposed to pneumatic / hydraulic conditions.

- Pressure and tightness tests are to be performed at room temperature.
- For Burst pressure, the specimen is to be subjected to a continuously raised pressure up to test pressure.

Test conditions: Pressure: ±20% Duration: 15 minutes as given in Table 6 below.

Table 6: Pressure Test

	Pressure Test	Tightness test of closure	Burst pressure test
Test Pressure	1.5X nominal pressure	Nominal pressure	4X Nominal / Maximum allowable working pressure
Test medium	Water/ Water-oil emulsion	Water / Water-oil emulsion	Water /Water-oil emulsion
Test duration	2 min	2 min	2 min

During the test, the equipment under test is connected and switched on.

10. High Voltage Test

This test indicates the capabilities of dielectric to withstand high voltagesat the electrical connections of EUT.

- Pre-conditioning of EUT is done.
- Test to be carried out at a frequency of 50-60Hz with AC test voltage as given below in table 7.

Table 7: High Voltage Test

Related voltage UN (V)	Test voltage (V) AC
Up to 65	2*UN + 500
66 to 250	1500
251 to 500	2000
501 to 690	2500
Test duration	1 minute per test

- Separate circuits are to be tested against each other and all circuits connected with each other tested against earth.
- Printed circuits with electronic components may be removed during the test.
- Period of application oftest voltage: 1 minute.

11. Electromagnetic Field Test

This test indicates the extent to which EUT can withstand the influence of electromagnetic fields.
Test is to be performed with the following test chamber conditions given in Table 8.

Table 8: Electromagnetic Field Test

Parameter	Range
Frequency	80MHz to 2GHz
Sweep rate	$\leq 1.5 * 10^{-3}$ dec/s (1%/ 3s)
Field strength	10 V/m
Modulation	AM 80% at 1000 Hz sinewave
Polarization	Vertically and horizontally

During the test the equipment under test is operated at its rated operational voltage (Ue). The functional tests should be performed on the EUT. If the wiring to and from the EUT is not specified, unshielded parallel conductors shall be used. To simulate electromagnetic fields radiated by different transmitters, the test is to be confined to the appliances exposed to direct radiation by transmitters at their place of installation.

12. Salt Mist Test

The EUT shall be examined to verify that deterioration or corrosion (if any) is superficial in nature due to exposure to salt mist. Four spraying periods with a storage of 7 days after each spraying. Initial measurement of insulation resistance and initial functional test is taken. Functional test on the 7th day of each storage period is noted. Insulation resistance measurement and performance tests 4 to 6 after recovery is to be done.

13. Damp Heat Test

This test indicates the extent to which EUT can withstand the influence of damp heat.

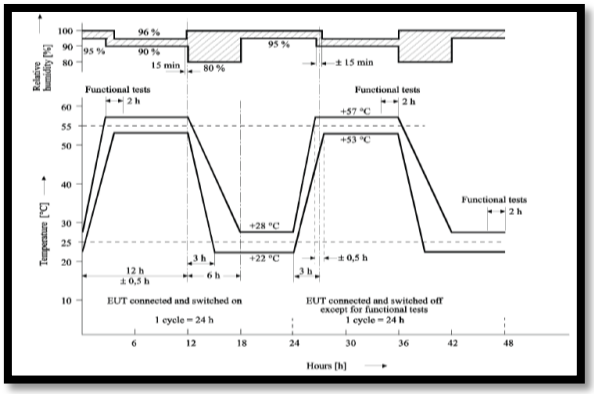

Figure 1: Damp heat test cycle showing temperature & humidity condition.

Air flow velocity across the humidity sensor should be 1.5-2m/s. Only distilled water should be used for humidifying. Insulation resistance test must be carried out before test and EUT must be visually inspected. Equipment operating during the complete first cycle is switched off during the second cycle except for functional test. Functional test is done during the first 2 hours of the first cycle at the test temperature and during the last 2 hours of the second cycle at the test temperature. Duration of the second cycle can be extended due to convenient handling of the functional test.

Table 9: Damp Heat Test

Tests	Class A-Static	Class B-Cyclic
Additional preconditioning	Pre-heat EUT to chamber temp to avoid water droplets formation	Before exposing to high humidity, keep EUT at ambient conditions.
Temp-humidity condition	40°C and 93%	According to Fig. 1
Recovery	After conditioning keep the EUT at ambient conditions (for 1-2 hrs.)	
Performance Test	To be performed within the first 2 hours.	Performed at upper test temp within the first 2 hours of the first test cycle and the last 2 hours of the second test cycle.
Tolerance	Temp: ± 2°C.	

14. Electrostatic Discharge Test

This test indicates the extent to which EUT can withstand the influence of electrostatic discharges. Test to be performed as per conditions given in Table 10 below.

Table 10: Electrostatic Discharge Test

	Contact discharge	**Air discharge**
Test voltage	6kV	8kV
Test duration per test point	Minimum 10 individual discharges per polarity	Minimum 10 individual discharges per polarity
Time between individual discharges	Minimum 1 second	Minimum 1 second
Wave form parameters		

Electrostatic discharge will be performed at all points and surfaces of the EUT which an operator may come in contact with during operation. The test is to be confined to the points and surfaces that may need to be physically accessed by the operator.

15. Flame Retardant Test

This test is done to estimate the capability of the EUT to withstand flame induced damages. This test is to be performed on the EUT or enclosure of the EUT by applying needle-flame test method.

Flame application: 5 times 15s each; Interval between each application-15s or 1 time 30s.

Other observations:

- The burnt out or damaged part of the specimen should not exceed bymore than 60 mm in length.
- In the event of a flame or incandescence being present, it shall extinguish itself within 30s of the removal of the needle flame.
- Any dripping material shall extinguish itself in such a way as not to ignite a wrapping tissue. The drip height is 200 mm ± 5 mm.

Additional tests maybe specified in the relevant test programmes as per requirement. Such tests may comprise: Ice test, High Temperature test, Temperature Shock test, High/Low Pressure test, Mechanical Shock test, Wind Pressure test, Sealing test, Soldering test, Mould growth test, Storage test, Radiation test, Explosion safety test, Air pollution test, Sensitivity test, Acceleration test etc.

16. Case Study

This section outlines an illustrative example of a few tests performed on processor based electronic modules using the WEISS Environmental Stress Screening Climatic Test Chamber. The following figures (Fig.2 to Fig.5) show Test Chamber, measuring equipment, test connections and program screens, photographs of which have been taken during the tests. The modules subjected to testing are Machine Signal Interface module and Thyristor Signal Interface module.

Equipment Used:

1. WEISS ESS climatic test chamber; 2. Tektronix make Storage Oscilloscope; 3. Fluke make Multimeter.

Figure 2: Test Chamber

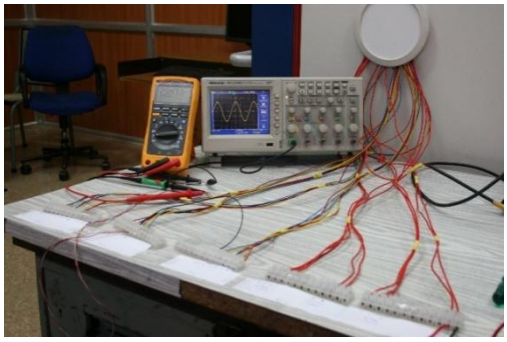

Figure 3: Connections & Measuring Equipment

Figure 4: Program Screen-1

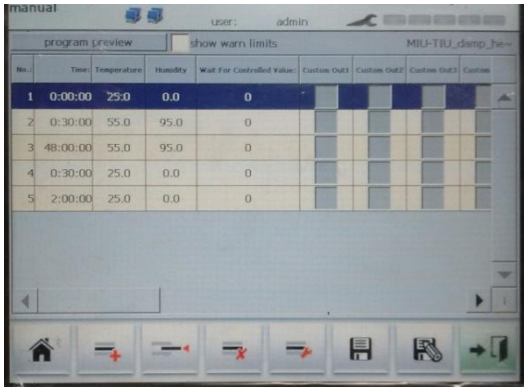

Figure 5: Program Screen-2

Tests Performed

1. Cold Test: This test has been performed as per IEC 60068-2-1.Temperature has been brought down from +25 ºC to 0 ºC at a rate of 1 ºC / minute and maintained at 0 ºC temperature for 48 hrs.

EUTs were kept in power ON condition throughout the test. Measurements have been taken before, during and after the tests.

2. Dry Heat Test: This test has been performed as per IEC 60068-2-2. Temperature was raised from +25 ºC to +55 ºC @ 1 ºC / minute and kept at 55 ºC for 48 hrs duration. In the next step, the temperature was raised from +55 ºC to +60 ºC @ 1 ºC / minute and kept for 24 hrs duration at 60 ºC. Temperature was brought down from +60 ºC to +25 ºC @ 1 ºC / minute.

EUTs were kept in power ON condition throughout the test. Measurements have been taken before, during and after the tests.

3. Damp Heat Test: This test has been performed as per IEC 60068-2-30. Temperature was raised from +25 ºC to +55 ºC @ 1 ºC / minute. Relative Humidity was maintained at 95% for a period of 48hrs. The temperature was brought down from +55 ºC to +25 ºC @ 1 ºC / minute.

EUTs were kept in power ON condition throughout. Measurements have been taken before, during and after the tests.

After completion of the Cold, Dry heat and Damp Heat tests, EUTs were found to have met the performance satisfactorily.

Conclusion

An overview of various environmental tests to be performed on electronic systems has been presented in this paper. Brief details of some of the frequently used environmental tests have been presented in this paper. The tests detailed in the paper are useful in evaluating, and testing the performance of the electronic components, modules, system, equipment, etc.

A case study performed on some of the currently being used electronic modules has been presented. The results of the testing conducted on the modules mentioned in the case study have been found to be satisfactory.

References

[1]. G. Lloyd, 2012, Guidelines for the Performance Of Type Approvals, Rules for Classification and Construction of Additional Rules and Guidelines.

[2]. Environmental Test Specification for Electrical, Electronic and Programmable Equipment and Systems, DNVGL, 2015.

[3]. Requirements Concerning Electrical and Electronic Installations, International Association of Classification Societies.