1.0 GENERAL

1.1 PURPOSE

This document specifies the Environmental test requirements for electrical and electronic components used on TATA Motors vehicles. Herein, the device or component under test shall be referred to as the Device Under Test (DUT).

Deviations from the requirements of standard are allowed, only if agreed and documented between the supplier and TATA Motors, ERC.

Final Environmental test approval would be granted based on satisfactory vehicle compliance.

1.1.1 SUPPLIER'S RESPONSIBILITY

The approved supplier is responsible for ensuring that the requirements of this specification are met. All applicable test data (procedures, reports, etc.) are to be provided to TATA Motors Ltd, ERC. ERC personnel shall have the rights of observing any or all of the tests performed by/for the supplier.

Since, additional Environmental tests may prove necessity according to application; TATA Motors, reserves the right to specify additional details or revise this document during product development.

The test plan definition is responsibility of the approved supplier in agreement with TATA Motors. The test plan shall have at least the request information listed in the section 1.6 of this document.

The approved supplier and TATA Motors are responsible to work in the resolution of the any failure of the equipment during the test vehicle.

The approved supplier is responsible to provide the test report including the information listed in the section 1.8 and the specific information listed in each test of this standard to TATA Motors.

The approved supplier is responsible to provide all the information about of any change in the equipment in order to meet the requirements of this standard to TATA motors.

1.1.2 INFORMATION REQUIRED FROM SUPPLIER

The following information is to be indicated on the drawings and in the product specification (if one exists) particular to each item covered:

Operating Voltage range
Functional region of performance as specified in section 2.5 of this document.
Any deviations from this document must be indicated on the drawings and in the product specification.

1.2 SCOPE

This standard specifies environmental test conditions and requirements for electrical and/or electronic components/systems or modules in TATA vehicles.

When referring to this standard in component-specific Technical Supply Specifications, drawings and Performance Specifications shall apply and be supplemented with the appropriate specifications in consultation with the TML,ERC.

1.3 MATERIAL AND CONSTRUCTION:

The electrical and/or electronic components/systems or modules shall meet all the dimensional and material requirements specified in the drawing. Once approved, any change in the material and/or construction will be allowed only with prior approval from TATA MOTORS.

1.4 NORMATIVE REFERENCES:

Std. No.	Version	Title
ISO 16750-1	2006	Road vehicle – Environmental conditions and testing for electrical and electronic equipment – Part 1: General
ISO 16750-2	2006	Road vehicle – Environmental conditions and testing for electrical and electronic equipment – Part 2: Electrical loads
ISO 16750-3	2003	Road vehicle – Environmental conditions and testing for electrical and electronic equipment – Part 3: Mechanical loads
ISO 16750-4	2006	Road vehicle – Environmental conditions and testing for electrical and electronic equipment – Part 4: Climatic loads
ISO 20653	2001	Road vehicle – Degrees of protection (IP –code) – protection against foreign objects, water and contact – electrical equipment
IEC 60068-2-1	2007	Environmental testing – Part 2: Tests. Tests A: Cold
IEC 60068-2-2	2007	Environmental testing – Part 2: Tests. Tests B: Dry heat
IEC 60068-2-6	1995	Environmental testing – Part 2: Tests. Test Fc: Sinusoidal vibration
IEC 60068-2-14	1984	Environmental testing – Part 2: Tests. Test Na, Nb, Nc: Change of temperature
IEC 60068-2-30	2005	Environmental testing – Part 2: Tests. Test Db: Damp heat cycle test (12 hrs + 12 hrs cycle)
IEC 60068-2-32	1975	Environmental testing – Part 2: Tests. Test Ed: Free fall
IEC 60068-2-38	1974	Environmental testing – Part 2: Tests. Test Z/AD: composite temperature/humidity cyclic test
IEC 60068-2-64	1993	Environmental testing – Part 2: Test methods : Vibration, broad-band random(digital control) and guidance
IEC 60068-2-78	2001	Environmental testing – Part 2: Tests. Tests Cab: Damp heat; steady state
TS75010	2006	Dust Test for electrical and electronic items
TS 75009	2005	Water Spray Test
TS 75005	2005	Corrosion Resistance Test
JASO D-001	1994	General rules for environmental testing methods for automotive electronic equipment
ISO3795	1989	Determination of burning behavior of interior materials

Table 1: Normative References

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1.5 TEST CONDITIONS:

1.5.1 CLIMATIC TEST CONDITIONS

Unless indicated otherwise in the specific test plan, the climatic conditions are defined in Table 2.

Room Temperature	≈	Typically, 25 to 30 °C
Humidity	≈	20 to 60 % relative humidity (RH)

Table 2: Climatic test conditions

1.5.2 TEST VOLTAGE

Unless indicated otherwise in the specific test plan, the test voltage is defined in Table 3.

Nominal System Voltage (V)	Value
12 V system	13.5 ± 0.2 Volt DC
24 V system	27.0 ± 0.4 Volt DC

Table 3: Test voltage

1.5.3 TOLERANCES

Unless otherwise stated, the accuracy of instruments is to be within the following:

Voltage, Current	± 0.1 Volt DC
Time Interval	± 2.0 %
Temperature	± 3.0 °C (upto +150 °C)
Temperature	± 5.0°C above +150 °C
Relative Humidity	± 5.0 % RH
Resistance, Capacitance, Inductance	± 2.0 %

Table 4: Tolerances

The varying characteristics of electronics and electromechanical parts shall be considered where appropriate. Where doubts exist, coordination is required with the validation engineer or the appropriate specialist department for testing.

1.6 ENVIRONMENTAL TEST PLAN:

Prior to testing, an approved test plan is to be signed by the appropriate supplier, validation engineer and TATA Motors, ERC. This document typically includes:

- The DUT information (Model, Serial number, hardware and software version…)
- Number of samples to be tested.
- Pin out and short systems information.
- Test to be performed with the specific options and test levels
- Precise test setup including load box definitions.

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- Failure criteria (to determine functional status and monitoring)
- Critical timing and/or operating parameters that may affect the testing of the DUT

1.7 TEST SAMPLES:
A minimum of 2 samples shall be used for each testing. In case of wide variation of the performance between the 2 samples, a third one shall be used to confirm the results. Please refer the annexure 1 for typical sampling and test sequence fir the equipments to be fitted in the vehicle

1.8 TEST REPORT FORMAT:
On completion of the test, an Environmental test report conforming to the requirements of this specification shall be prepared and submitted for review and approval at the completion of Environmental testing to the TATA Motors. The test report shall include at least the following information:

a. Location of Test Services: Provide detail of the geographic location of the test facility
b. Description of Test Equipment: List of test equipment used to perform the tests including auxiliary equipments. Provide latest calibration dates where applicable.
c. Description of the DUT and Reference Number: Description of the DUT, and reference number, Hardware and software version.
d. Generic Test Setup Description: Provide a description of the test setup used for performing each test. The description shall include the following:
   i. Dimensioned diagrams and/or photos to illustrate the general test setup and critical aspects of each test including power supply and grounding locations, and load box details.
   ii. Diagrams and/or photos illustrating how control and monitor signals are brought in and out of the test chamber to support a typical component test.
   iii. Environmental test data (which documents test results and any deviations from the approved test plan).
   iv. More specific data to include in the test report are specified for every test in the present standard.
   v. Measurement uncertainty of the test lab.
   vi. Environmental test plan reference number and version.

1.9 TESTING FOR ACCEPTANCE:
TATA Motors has right to conduct any or all of the above tests and reject consignment, if they fail to meet the requirements of this standard.

1.10 MONITORING REQUIREMENTS:
If during a test, anomalies or failures are noted, these must be immediately reported to TML, ERC.

It is the responsibility of the supplier's development engineer to fully investigate any failures or anomalies. It is also the responsibility of the development engineer to generate a development test report which fully explains the root cause or any failure or anomaly and details the actions to be taken to correct the failure or anomaly.

Signals that need to be observed shall be clearly known and documented before the test.

1.11 MARKING:

Development samples and production parts must be marked with an adhesive label (refer Figure 1 and Figure 2, respectively). In the case of small components, tags with the adhesive label are to be attached. All of the required data must be marked with the following:

1.11.1 LABEL REQUIREMENTS FOR DEVELOPMENT SAMPLE:

a) Manufacturer's name
b) Component serial number
c) Hardware/software/integration level numbers.
d) Date of manufacture and Batch identification
e) "Development sample" statement
f) Part description and sample level
g) TML part number

TML Part Number Bar Code	Pane for any legal marking required	Manufacturer's Name Serial Number Hardware version software version
		Date of Manufacture dd/mm/yy Batch Identification
Supplier logo		"Development Sample" Sample Level (A/B/C) Part Description

Figure 1: Adhesive Label - Development sample

1.11.2 LABEL REQUIREMENTS FOR PRODUCTION PARTS:

a) Supplier logo
b) TML part number
c) Bar code (if applicable)
d) Hand of drive (if applicable)
e) Legal markings as required (e.g. 'e' mark)
f) Manufacturer's name
g) Component serial number
h) Hardware/software/integration level numbers
i) Date of manufacture and Batch identification
j) Part Description

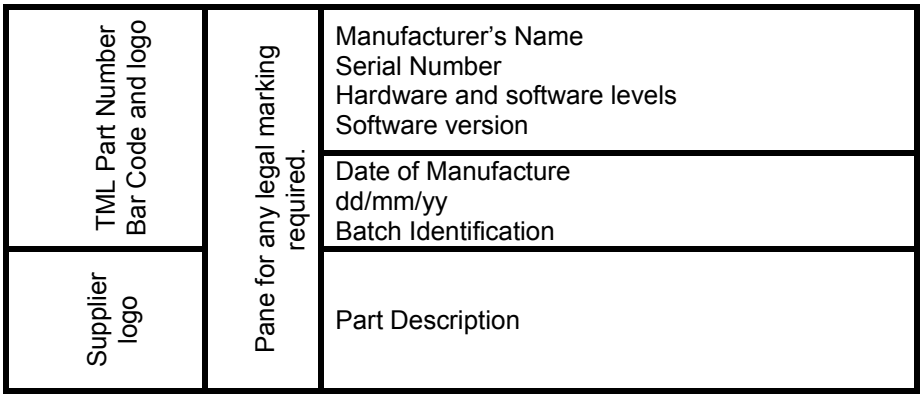

Figure 2: Label requirements-Production parts

1.11 PACKAGING:
As agreed between TATA Motors and supplier.

2.0 TEST DESIGN AND REQUIREMENTS:

2.1 OPERATING MODES:

For Environmental testing, following operating modes shall be distinguished:

2.1.1 OPERATING MODE 1

The DUT is not electrically operated.

Operating Mode 1.1	No lines are connected to the DUT.
Operating Mode 1.2	All lines are connected according to vehicle installation, but no voltage is applied.

2.1.2 OPERATING MODE 2

The DUT is electrically operated with the supply voltage Vb (battery voltage) as in a cut-off vehicle (engine OFF). All system components (e.g. sensors, actuators) and lines are connected to the DUT.

Operating Mode 2.1	System/component functions are not activated (e.g. sleep mode).
Operating Mode 2.2	Systems/components with function and activation in normal operating mode.

2.1.3 OPERATING MODE 3

The DUT is operated with the supply voltage Va (engine/alternator running).
All system components (e.g. sensors, actuators) and lines are connected to the DUT.

Operating Mode 3.1 System/component functions are not activated.

Operating Mode 3.2 Systems/components with function and activation in normal operating mode (represented by an engine speed of 2500 RPM).

2.2 TEMPERATURE RANGE:

Installation area of vehicle	A vehicle interior passenger component						B Engine compartment					C vehicle exterior body								D Cavity		E Boot
	A1	A2	A3	A4	A4 a	A4 b	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5	C6	C7	C8	D1	D2	E
	Without Particular Requirement	Direct Solar Radiation	With Exposure to Heat radiation	Passenger component Door	Attached to passenger component side	Attached to door cavity side	attached to body	attached to make manifold	on\in the engine	on\in the Transmission \ retarder	on\in the radiator	on to body	Under body / wheel housing	Unsprung masses (Wheel/Axle)	Other areas (e. trims)	Engine compartment bonnet	boot lid	Tail Gate	Between A and C Pillars	cavities open to exterior	cavities open to exterior	Boot\Luggage compartment space
NORMAL OPERATING RANGE																						
Normal Operation	(-) 40 to + 85 deg C	(-) 40 to +105 deg C	(-) 40 to + 90 deg C	(-) 40 to + 85 deg C	(-) 40 to + 85 deg C	(-) 40 to + 85 deg C	(-) 40 to +105 deg C	(-) 40 to +105 deg C	(-) 40 to + 140 deg C	(-) 40 to + 140 deg C	(-) 40 to + 120 deg C	(-) 40 to + 85 deg C	(-) 40 to + 85 deg C	(-) 40 to + 85 deg C	(-) 40 to + 85 deg C	(-) 40 to + 85 deg C	(-) 40 to + 85 deg C	(-) 40 to + 85 deg C	(-) 40 to + 85 deg C	(-) 40 to + 85 deg C	(-) 40 to + 85 deg C	(-) 40 to + 85 deg C
NON-DESTRUCTIVE ELECTRICAL RANGE																						
Re spray oven storing temperature	-	-	-	-	-	-	-	-	-	-	-	+ 130 deg C for 1 hr & + 110 deg C for 1 hr	+ 130 deg C for 30 min	+ 130 deg C for 30 min	+ 130 deg C for 30 min	+ 130 deg C for 30 min	+ 130 deg C for 30 min	+ 130 deg C for 30 min	+ 130 deg C for 30 min	+ 110 deg C for 30 min	+ 110 deg C for 30 min	-
Hot engine OFF	-	-	-	-	-	-	+ 120 deg C	+ 120 deg C	+ 150 deg C	+ 150 deg C	-	-	-	-	-	-	-	-	-	-	-	+ 90 deg C

Table 5: Temperature range

PREPARED BY	CHECKED BY	APPROVED BY	ISSUE NO.	DATE
Vijay Waghmare	Aniand V Preesty T J	M. R. Shinde GM ERC-Interior Testing	5	17.10.2014

The following applies to all areas:

- Functional and dimensional stability shall not be impaired.
- In the event of higher temperature loading related to installation (radiated heat) the value shall be documented in the drawing.

2.3 ENVIRONMENTAL TESTS:

Installation, orientation and situation, as well as electrical and mechanical connections, are to be taken into account during the environmental tests in accordance with the installation circumstances in the vehicle.

Tests carried out during volume production as per Table 6 are to be planned and documented at regular intervals. The following applies to approval:
The test specimen must pass all the required individual tests, irrespective order of the tests.
If not specified otherwise, the following generally applies when assessing electrical functions:
The assembly functions are satisfactory before, during and after exposure to the source of interference, as specified.
Electrical/mechanical operation in accordance with the function of test specimen.

Installation Area / Test	Passenger compart-ment	Engine compart-ment (attached to body)	Engine compart-ment (engine/Transmission)	Engine compartment (Decoupled intake manifold)	Vehicle Exterior body	Cavities open to interior/ exterior	Boot	Special installation
Visual examination test	A to F							
Functional Performance test	A to F							
Robustness of terminations test	A to F							
Conductor tensile strength	A to F							
Forces on connector	A to F							
High & Low temperature Storage	A	B1	B3,B4	B2,B5	C	D	E	F
Low Temperature Endurance Test	A	B1	B3,B4	B2,B5	C	D	E	F
High Temperature	A	B to D1					-	F

Endurance Test								
Powered Thermal Cycle Test	A	B1	B3,B4	B2,B5	C	D1	-	F
Resistance to thermal shock test	A to F							
Splash water thermal shock	A	B1	B3,B4	B2,B5	C	C5-C7	-	F
Thermal shock - Hot water jet	A to F							
Water spray test	A to F							
Drip Test	A to F							
Dust test	A to F							
Corrosion resistance test	A to F							
Fluid resistance test	A to F							
Environmental and humidity test	A to F							
UV Test	A to F							
Vibration test	A to F							
Sine vibrations	A to F							
Random vibrations	A to F							
Dew formation test	A to F							
Low air pressure test	A to F							
Flowing Mixed Gas Corrosion Test	A to F							
Mechanical Shock Test	A to F							
Free Fall Test	A to F							
Service Life-85/85 High	A to F							

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temperature-High Humidity Endurance	
Endurance test	A to F
Visual Tear down Analysis Test	A to F
Fitment & Functional Check on vehicle	A to F

Table 6: Environmental tests

2.4 TEST SETUP:

The test preparation process must follow the requirements of work instruction: General when the agreed test has been set up and debugged, but before carrying out any testing, the Test Engineer must invite the Development Engineer to be present for test commissioning. During commissioning the engineers must jointly agree:

- The DUTs are the correct devices to test and have the correct software installed,
- The DUTs are operating correctly and are fit for testing,
- The correct test parameters are being used,
- The DUT is in the correct functional state for testing,
- The necessary monitoring is in place and correctly operating,
- The evaluation criteria are being correctly applied,
- All variations of the specified test are correctly carried out and are carried out in the correct order,
- On any issues relevant to the specific test (see individual test sections for this information).
- TATA Test Documents shall be referenced for each test. Variations and additions shall be indicated in specific test plan.

2.5 REGION OF PERFORMANCE:

When a DUT is subjected to a stimulus, the required operation of a specific function(s) is determined by the criticality of that function.

Functional Performance Region for Electrical and Electronic systems is hierarchical.

- ❖ Region I is the highest and Region V is the minimum.
  - i.e. if the response required is Region II, then Region I is also acceptable due to the hierarchy.
  - Similarly, if the response required is Region IV then Region I, Region II or Region III is also acceptable.

This element describes the region of performance of the DUT during and after the test.
The minimum functional status shall be given in each test. An additional test requirement may be agreed between supplier and vehicle manufacturer.

Region	Description

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Region I	All functions of a device/system perform as designed during and after exposure to disturbance.
Region II	All functions of a device/system perform as designed during exposure. However, one or more of them can go beyond specified tolerance. All functions return automatically to within normal limits after exposure is removed. Memory functions related to the vehicle statutory data shall remain in region I.
Region III	One or more functions do not perform as designed during exposure but returns automatically to normal operation after exposure is removed. NVS Memory functions shall remain in region I (DUT- micro controller reset can be allowed, but the memory function shall have no abnormality. Current application data can be lost but is reloaded from last valid shutdown, ie, no data corruption allowed). Malfunctioning is not permissible.
Region IV	One or more functions of a device/system do not perform as designed during exposure and does not return to normal operation until exposure is removed and the device system is reset by simple “operator/use” action.
Region V	One or more functions of a device/system do not perform as designed during and after exposure and cannot be returned to proper operation without repairing or replacing the device/system.

Table 7: Region of performance

2.6 REVALIDATION:
To assure that EMC requirements are continually met, some aspects of Environmental testing shall be required if there are any mechanical, circuit or PCB design changes (e.g. die shrinks, new PCB layout). This is to be discussed with TATA Motors, ERC.

3.0 TEST REQUIREMENTS:

3.1 TESTS AND THEIR GENERAL CONDITIONS OF TESTING

3.1.1 INTIAL PERFORMANCE TEST:

Purpose:

This test is done in order to check the functionalities of the Electrical/electronic component based on the design specification and drawing. This test is mainly conducted to ensure whether the DUT is meeting the functionalities which the input documents are claiming for.

The parametric test provides a complete assessment of the DUT health and evaluates the functional characteristics of DUTs in accordance with
Functional Test Specification (supplier to provide specification)
□□□□□□Drawing

Test description:
System should operate as per the required function given in functional list or in drawing.
The functions test shall be done between successive tests (see test flow plan).
Parametric test at:

Temperature (°C)	Power Supply (V)	
System	12 V	24 V
Room temperature	8 V, 13.5 V, 16 V	16 V, 27 V, 32 V

Precondition the DUT at test temperature.
Minimum dwell time before starting the electrical tests at each temperature is 1 hour

Acceptance Criteria:
Respective functions should operate after the corresponding input signal.
The electrical tests are satisfied, if all test parameters are within the established tolerances.
All functionalities should be met as in the drawing/functional list.

3.1.2 TRI-VOLTAGE TRI-TEMPERATURE FUNCTIONAL/PARAMETRIC TEST

Purpose:
The Functional/Parametric test shall be performed at three different ambient temperatures (low, room and high) and three different power supply operational voltages (low, nominal and high) as specified in the validation test. The temperature shall be stabilized for at least 0.5 hours prior to the Functional/Parametric Test.

The power supply shall be capable of supplying sufficient current to avoid current limiting under high in-rush conditions.

All Functional/Parametric tests must be conducted with actual vehicle loads or simulated loads. The simulated loads require the approval of TML, ERC Pune.

Test conditions:
Operating temperature: Based on installation area (e. g. - 40°C to + 85°C)
As per approved drawing [1]

Parametric test at:

Temperature (°C)	Power Supply (V)	
	12 V	24 V
+85	8 V, 13.5 V, 16 V	16 V, 27 V, 32 V
RT	8 V, 13.5 V, 16 V	16 V, 27 V, 32 V
(-)40	8 V, 13.5 V, 16 V	16 V, 27 V, 32 V

Precondition the DUT at test temperature.
Minimum dwell time before starting the electrical tests at each temperature is 1 hr

([1] Note: Temperature range and operating voltage will be based on installation area and functional group

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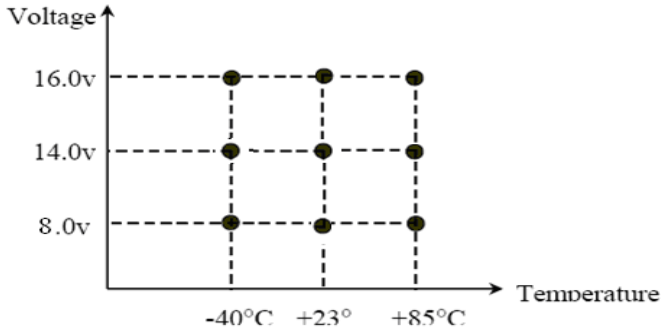

Figure 3: Definition of parametric temperature-voltage points

Test procedure:
The DUT were parametrically tested at the nine temperature-voltage points defined in Figure 3 prior to and post environmental exposure.
Performance of the DUT is measured against limits established in the Performance & Verification Document done by the supplier and also to be implemented within the manufacturing test system software.

Acceptance criteria:
- As mentioned on the part approved drawing.
- The test is satisfied, if no an allowed electrical reaction of the DUT's appeared during the test, and the relevant parameters lie within the specified limits after the test.
- During pre and post environmental functional tests, all DUT tested were within defined limits established in the Performance & Verification Document.

Test report Requirements:
- Results of the functional testing carried out.
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

3.1.3 FINAL PERFORMANCE TEST
The final performance test is identical to the initial performance test.

3.1.4 GENERAL CHARACTERISTIC TESTS

3.1.4.1 VISUAL EXAMINATION:

Before testing, the component must comply in all respects with the drawing and be free of visible faults such as scratches, spots of adhesive, deformed sub components, etc. The inspection is to be carried out under normal lighting conditions, at a distance of not greater than 0.5 m for the following:

A. Drawing requirements
- All dimensions within tolerances
- Material specification

B. Housing and cover

- Visible cracking or weakened points
- Discolouration
- Warpage
- Melting

C. Connectors

- Plastic cracks
- Bent/Damaged pins
- Excessively loose
- Warpage
- Discolouration
- Damaged connector body features

D. Minor external cosmetic damages – Housing. Cover and connectors

- Scratching/Scuffing of surfaces
- Dented corners
- Visible hairline cracks

E. Labels

- Fading of the label
- Discolouration
- Text on the label smudges
- Text on label becomes illegible
- Label no longer adheres to housing (adhesive weakens)
- Label melts

Acceptance criteria:

- After testing, the part must continue to comply with the visual and mechanical requirements of the component drawing.
- It should not be possible to detect loosening of mechanical parts, all adhesive joints must appear correct to visual inspection and sealing elements must be correctly shaped and seated in their original positions.
- Deformation of parts that can adversely affect the performance of the component is not permitted.
- No damage, cracks, molding defects in finish. Component shall be free from warpages and sharp edges.

3.1.4.2 ROBUSTNESS OF TERMINATIONS, MOUNTING FASTENERS, ETC.:

Test Conditions:
The terminal should withstand a push/pull force of 90 N and bending force of 10 N and torsional force of 0.3 Nm.
DUT shall meet the mounting fastener torque requirements.

Acceptance criteria:

- No damage or anomalies on visual inspection after the test.
- DUT shall meet functional parametric requirements after the test.
- Deformation of parts that can adversely affect the performance of the component is not permitted.

3.1.4.3 CONDUCTOR TENSILE STRENGTH (APPLICABLE FOR CONNECTORS AND PIGTAILS)

Test conditions: The component should withstand a tensile force of 100 N on each pre-wired bunch of conductors in the direction in which they leave the component and at 90° to this.

Acceptance criteria:
No damage or anomalies on visual inspection after the test.
DUT shall meet functional parametric requirements after the test.
All the items should be operational.

3.1.4.4 FORCES ON CONNECTOR:

Inspection:
Before starting the environmental test the DUT have to pass the initial performance tests and may not show any mechanical damage on the visual inspection.

Test conditions:
Reference document: IEC 512: Part 8
Pressure at the connector: (110 ± 5) N for 1 minute (for mating and retention of connector)
Tensile force per connector/cable: (100 ± 5) N for 1 minute
Test temperature: Room Temperature
Operating mode: 1.1

Acceptance criteria:
- No damage or anomalies on visual inspection after the test.
- DUT shall meet functional parametric requirements after the test.
- The DUT may not show any mechanical damage like crack or deformation. A displacement of the plug in the housing or a loosening of the connection plug to housing is not allowed.

3.2 ENVIRONMENTAL TESTS REQUIREMENTS

3.2.1 HIGH & LOW TEMPERATURE STORAGE

Reference Document: IEC 60068-2-1, A standard.

Purpose:
The purpose of this test is to verify that a component or system can withstand the effects of extremely low temperatures encountered in vehicles or in storage.

Test Parameters:

Minimum Temperature (T_{min})	(-) 40 ± 3 Degree C for 48 hours
Room Temperature	1 hour in operating condition (Operating mode 3.2)
Maximum Temperature (T_{max})	(+) 90 ± 3 °C for 48 hours
Total Test Duration	97 hours
Number of Test Cycle ('N' Cycle)	1
Temperature Reference Point	Ambient temperature (Chamber temperature)
Operation/Monitoring Mode	As per operating mode 1.1 of cl. 2.1.1 of this document
Operating temperature range	Refer table 5 for temperature range

Table 8: Test parameters – High and low temperature storage

Initial Evaluation of Test:
Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test Procedure:

a. At the beginning of the test the DUT shall be at the ambient temperature of the laboratory.
b. Place the DUT in a temperature chamber at room temperature.
c. Subject the DUT to NCycle according to the test cycle profile given above.

Acceptance criteria:

- No damage or anomalies on visual inspection after the test.
- DUT shall meet functional parametric requirements after the test.
- No critical housing deformations

Test report Requirements:

- Results of the functional testing carried out before and after testing.
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

3.2.2 LOW TEMPERATURE ENDURANCE

Reference Document: IEC 60068-2-1, A standard.

Purpose:
The purpose of this test is to verify that a component or system operates correctly at low temperatures encountered during vehicle cold weather operation.

Test conditions: Testing shall be in accordance with this document and IEC 60068-2-1 standard.

Test Parameters:
The sample shall be subjected to the following conditions.

Test Duration at T_{min}	168 hours
Minimum Temperature (T_{min})	Minus(-) 40 ± 3 °C
Temperature Reference Point	Ambient temperature (Chamber temperature)
Operation/Monitoring Mode	As per operating mode 3.2 of cl. 2.1.3 of this document
Voltages	
12 V System	13.5 V ± 0.1
24 V System	27 V ± 0.1
Operating temperature range	Refer table 5 for temperature range

Table 9: Test parameters –Low temperature endurance

Initial Evaluation of Test:
Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test Procedure:

a) Place the DUTs (DUT temperature is room temperature) in the temperature chamber at room temperature.
b) The temperature within the chamber shall then be adjusted to the temperature T_{min}.
c) Maintain and operate the DUTs at temperature T_{min} for 168 hours. The duration shall be measured form the time when the temperature T_{min} is reached.
d) At the end of this period, the DUT shall remain in the chamber and the temperature shall be gradually raised to a value lying within the limits of the standard atmospheric conditions for measurement and testing.
e) Remove the DUTs from the chamber.
f) The DUTs shall then remain under standard atmospheric conditions for recovery for a minimum of 1hr.
g) Carry out visual check and functional parametric test.

Acceptance criteria:

- No damage or anomalies on visual inspection after the test.
- DUT shall meet functional parametric requirements after the test.
- No critical housing deformations
- Less than 0.1% CAN error frames allowed for full test duration (for CAN version).

Test report Requirements:

- Results of the functional testing carried out before and after testing.
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

3.2.3 HIGH TEMPERATURE ENDURANCE

Reference Document: IEC 68-2-2Bb standard.

Purpose:
The purpose of this test is to verify that a component or system can withstand the effects of high temperatures, encountered in vehicles or in storage.

Test conditions: Testing shall be in accordance with this document and IEC 68-2-2Bb

Test Parameters:
The sample shall be subjected to the following conditions.

Test Duration at T_{max}	168 hours
Maximum Temperature (T_{max})	+105 ± 3 °C
Temperature Reference Point	Ambient temperature (Chamber temperature)
Operation/Monitoring Mode	As per operating mode 3.2 of cl. 2.1.3 of this document
Test Voltage	
12 V System	13.5 V ± 0.1
24 V System	27 V ± 0.1
Operating temperature range	Refer table 5 for temperature range

Table 10: Test parameters –High temperature endurance

Initial Evaluation of Test:
Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test Procedure:

a. Place the DUTs (DUT temperature is room temperature) in the temperature chamber at room temperature.
b. The temperature within the chamber shall then be adjusted to the temperature T_{max}.
c. Maintain and operate the DUTs at temperature T_{max} for 168 hours. The duration shall be measured form the time when the temperature T_{max} is reached.
d. At the end of this period, the DUT shall remain in the chamber and the temperature shall be gradually lowered to a value lying within the limits of the standard atmospheric conditions for measurement and testing.
e. Remove the DUTs from the chamber.
f. The DUTs shall then remain under standard atmospheric conditions for recovery for a minimum of 1hr.
g. Carry out visual check and functional parametric test.

Acceptance criteria:

- No damage or anomalies on visual inspection after the test.
- DUT shall meet functional parametric requirements after the test.
- Less than 0.1% CAN error frames allowed for full test duration (for CAN version).
- No critical housing deformations

Test report Requirements:

- Results of the functional testing carried out before and after testing
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

3.2.4 POWERED THERMAL CYCLE (PTC)

Reference document: IEC 68-2-14Nb specification.

Purpose: The purpose of this test is to verify that the component or system is able to operate in the changing temperature conditions encountered in a vehicle environment. Typical failures experienced are due to different coefficients of expansion of materials, bad solder joints, die bond separation, and temperature-related problems attributable to circuit design or weak components.

Test Condition: Testing shall be in accordance with this document and IEC 68-2-14Nb specification.

Test Parameters:

Total Test Duration	300 hrs
Test Cycle Duration	3 hrs
Number of Test Cycle ('N' Cycle)	100
Temperature Cycle Definition	Figure 4
Minimum Temperature (T_{min})	(-) 40 °C
Maximum Temperature (T_{max})	(+) 85 °C

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Temperature Reference Point	Ambient temperature (chamber temperature)
Operation/Monitoring Mode	As per operating mode 3.2 of cl. 2.1.3 of this document
Rate of Temperature Change (TChange)	≥ 4 °C / min (average over a period of not more than 3 °C / min)
Test Voltage	
12 V System	13.5 V ± 0.1
24 V System	27 V ± 0.1
Operating temperature range	Refer table 5 for temperature range

Table 11: Test parameters –Powered Thermal Cycle test (PTC)

Initial Evaluation of Test:
Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test Procedure:

a. The DUT to be located in a test fixture, orientated to replicate that of the operational environment. The fixture should also ensure that each DUT reached the specified temperatures during testing when placed in the environmental chamber.
b. The DUT is to be undergo temperature cycle between (-)40°C and (+) 85°C for a period of 300 hrs (100 cycles), as detailed in figure 4.
c. The stated temperature is to be the chamber air temperature, as measured at a distance of 25 mm from the DUT case.
d. The DUT is to be functionally operated as defined in figure 4 during the environmental exposure. Signals and output loads were derived from the performance requirement and are typical of driving conditions seen in the vehicle.
e. On completion of the Powered Thermal Cycle test, the environmental test chamber shall be returned to ambient room temperature (typically, 25 to 30°C).

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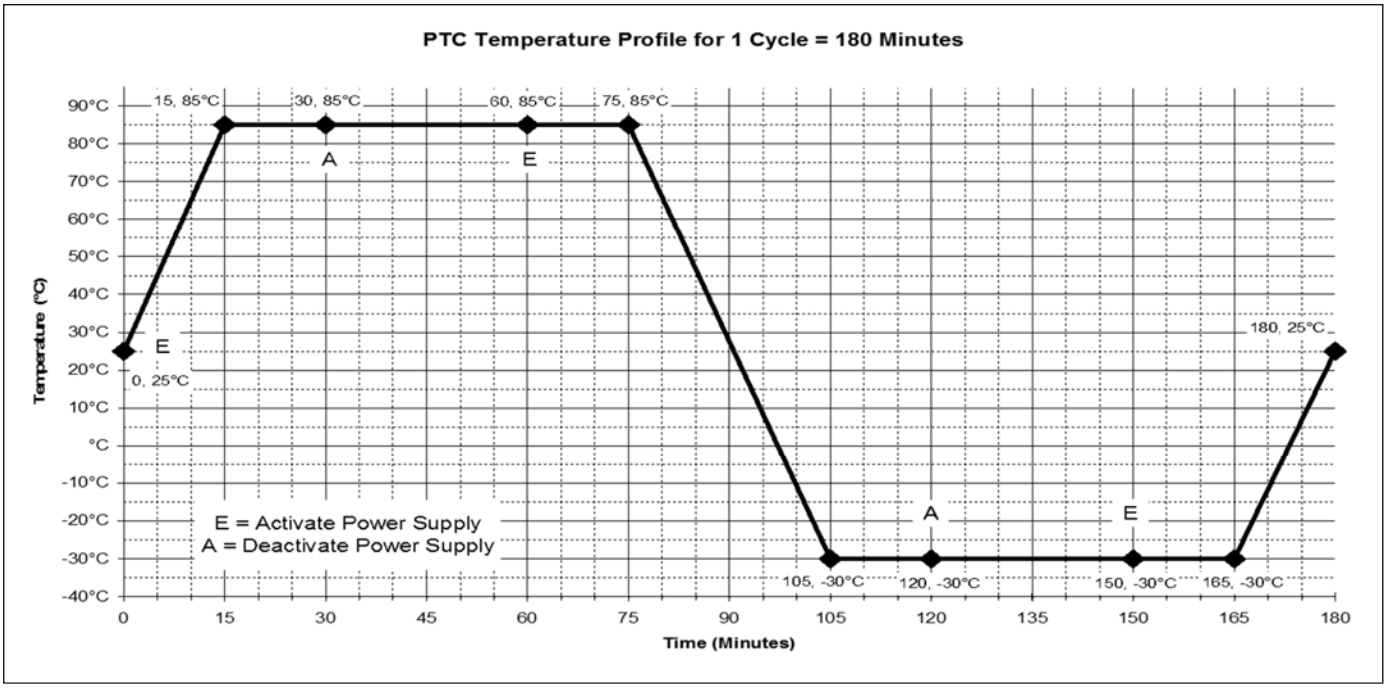

Figure 4: Power temperature profile

Acceptance criteria:

- No damage or anomalies on visual inspection after the test.
- DUT shall meet functional parametric requirements after the test.
- Less than 0.1% CAN error frames allowed for full test duration (for CAN version).
- No critical housing deformations

Test report Requirements:

- Results of the functional testing carried out before and after testing
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

3.2.5 THERMAL SHOCK TEST (AIR to AIR)

Reference Document: IEC 68-2-14, Na standard.
Purpose:
The purpose of this test is to verify that the component or system is able to operate in the changing temperature conditions encountered in a vehicle environment. Typical failures experienced are due to different coefficients of

expansion of materials, bad solder joints, die bond separation, and temperature-related problems attributable to circuit design or weak components. This test is not a life test. [2]

Test condition: Testing shall be in accordance with this document and IEC 68-2-14, Na standard.

Test description:

Temperature at start of test	Room Temperature
Upper Temperature (T_{max})	(+)85°C
Lower Temperature (T_{min})	(-)40°C
Operation mode	As per operating mode 1.1 of cl. 2.1.1 of this document
Storage time at upper temperature (T_{max})	45 minutes
Transfer time	≤ 10 seconds
Storage time at lower temperature (T_{min})	45 minutes
Number of cycles('N' cycle) Standard requirement	100 cycles
Increased requirement	300 cycles
Recovery time	1 hour
DUT Operating temperature range	As per Table 5

Table 12: Test parameters –Thermal shock test (air to air) (3)

Initial Evaluation of Test:
Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test Procedure:

a) At the beginning of the test the DUT shall be at the ambient temperature of the laboratory.
b) Place the DUTs in a dual zone thermal shock chamber with mating connectors and adjust the temperature of zones to T_{min} and T_{max}.
c) Maintain the DUTs at temperature T_{min} for 45 minutes.
d) Transfer the DUTs from the T_{min} zone to the T_{max} zone within 10 seconds.
e) Maintain the DUTs at temperature T_{max} for 45 minutes.
f) Transfer the DUTs from the T_{max} zone to the T_{min} zone within 10 seconds.
g) Repeat the thermal cycles (steps b through f) for a total number of 'N' Cycle.
h) The DUTs shall then remain for the 1 hour under standard atmospheric conditions for the attainment of temperature stability.

Acceptance criteria:

- No damage or anomalies on visual inspection after the test.
- DUT shall meet functional parametric requirements after the test.

([2] Note: 50 % of the DUT are tested without housing if the devices utilize PCB technology. DUT without housing (opened) shall not be subjected to any further testing.

([3] Note: Longer storage times are required for large or heavy DUT (Specification according to Performance Specifications, e.g. 60 min / 90).

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- Less than 0.1% CAN error frames allowed for full test duration (for CAN version).
- No critical housing deformations.
- No anomalies in visual tear down analysis.
- Full functionality of electrical and mechanical junctions.

Test report Requirements:

- Results of the functional testing carried out before and after testing
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

3.2.6 THERMAL SHOCK WITH SPLASH WATER

Reference Document: ISO 16750-3 standard.

Purpose:
This test simulates a thermal shock induced by cold water and is applicable to components in the splash areas of the vehicle. The purpose is to simulate cold water splashing over a hot system/component, as can happen when a vehicle is driven on wet roads in winter. Failure modes are mechanical cracking of materials or seal failures caused by differential thermal expansion coefficients. An additional failure mode, not addressed in section 9.3.6.1, is a loss of water tightness and the intrusion of water into the system/component.

Applicable installation areas are

- Engine Compartment: B
- Vehicle Exterior Body: C

Test conditions: Testing shall be in accordance with this document and ISO 16750-4 standard.

Test Parameters:

Temperature at start of test	Room Temperature
Water specification	De-ionized water with 3 % by weight of fine Arizona dust (As per ISO 12103- 1:1997xiii). The mixture shall remain well mixed throughout the test.
Exposure time at T_{max}	t_1 = 30 minutes (Refer Figure 5)
Electrical operation	t_2 = 15 minutes (Refer Figure 5)
Splashing period	t_3 = 3 seconds (Refer Figure 5)
Operation mode	As per operating mode 3.2 of cl. 2.1.3 of this document
Splashing impact force	0.2 to 0.4 N (on the test sample)
Orientation of the DUT	As in the vehicle.
Number of cycles('N' cycle)	100
Splash water temperature (T_s)	0 to + 4 °C
Test cabinet temperature	Max temperature for normal operating temp range
DUT Operating temperature range	As per Table 5

Table 13: Test parameters –Thermal shock with splash water test

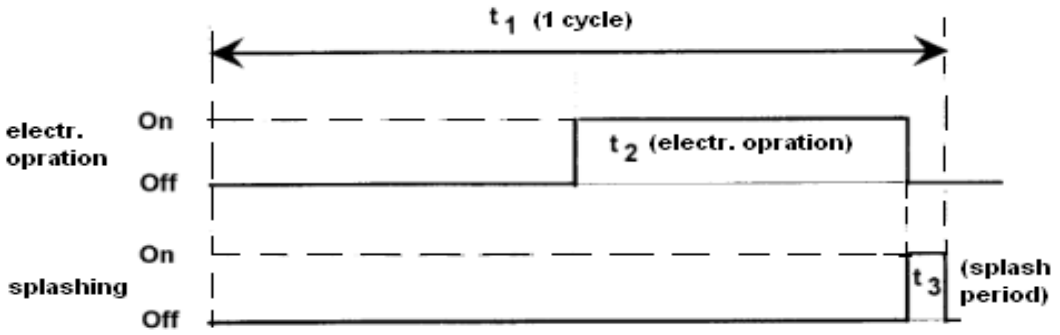

Figure 5: Thermal shock with splash water

Initial Evaluation of Test:
Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test Procedure:

a. Heat the sample in a hot air oven at Tmax (upper temperature) for time t_1.
b. Operate the sample as per normal vehicle operation for time t_2.
c. Then use a jet to splash the sample with cold water for time t_3.
d. The splash coverage should represent the splash direction (s) that is likely to occur in the vehicle but the splash width should always be greater than the sample width.

Acceptance criteria [4]:

- DUT shall meet functional parametric requirements after the test.
- Less than 0.1% CAN error frames allowed for full test duration (for CAN version).
- No critical housing deformations.
- No anomalies in visual tear down analysis.
- Full functionality of electrical and mechanical junctions.

Test report Requirements:

- Results of the functional testing carried out before and after testing
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

[4]Note: Test samples which are permanently connected at ignition state I (e.g. ABS sensors) shall be operated at the splashing period t3 in accordance with their normal function in the vehicle.

3.2.7 HOT WATER JET TEST

Reference Document: NA

Purpose:
The purpose of this test is to simulate the jetting of water onto electrical/electronic components, which are situated in exposed locations, when the car is jet-washed. The test is to be carried out with commercially available steam blasting (hot water) equipment.

Applicable components:
Engine Compartment
Vehicle Exterior Body

Test conditions: Testing shall be in accordance with this document.
Test Parameters:

Number of cycles('N' cycle)	30 cycles
Water temperature	(+)80 °C
Water pressure	100 ± 3 Bar
Water discharge angle	35° ± 5°
Distance of jet nozzle	80 to 100mm from test sample
Spray time	10 s for each accessible spatial direction (when installed in the vehicle), followed by a 10 s break

Table 14: Test parameters –Thermal shock with Hot water jet

Initial Evaluation of Test:
Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.
Test Procedure:

1. Heat the sample in a hot air oven at T_{max} (upper temperature) for time t_1.
2. Operate the sample as per normal vehicle operation for time t_2.
3. Then use a jet to splash the sample with cold water for time t_3.
4. The splash coverage should represent the splash direction (s) that is likely to occur in the vehicle but the splash width should always be greater than the sample width.

Acceptance criteria:

- DUT shall meet functional parametric requirements after the test.
- Less than 0.1% CAN error frames allowed for full test duration (for CAN version).
- No critical housing deformations.
- No anomalies in visual tear down analysis.
- Full functionality of electrical and mechanical junctions.
- No water is to have penetrated the sample and the enclosure rating shall be IPX9K.

Test report Requirements:

- Results of the functional testing carried out before and after testing
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed photographs of the damage must be provided.

- Details of test setup including photographs and parameters.

3.2.8 WATER SPRAY TEST:

Purpose:
The resistance of the DUT against penetration of spray water is tested.

Test Conditions: According to T. Spec. 75009 (IS 9000 part 16).

Test Parameters:

Test Duration (t_1) a. Engine compartment items b. cab mounted items	 8 hours 4 hours
Number of Test Cycle ('N' Cycles)	1
DUT Temperature (T_{DUT})	RT
Test Equipment	Water jet nozzle 6.3 mm diameter acc. ISO 20653 std.
Distance between Nozzle and DUT	2.5 m to 3 m
Rotation Speed Turn Table	2 rpm
DUT Test Position	In-vehicle mounting orientation
Operation/Monitoring Mode	As per operating mode 1.2 of cl. 2.1.1 of this document
Water Temperature (T_{Water})	T_{DUT} ± 5 °C
No of nozzles	8
Water Flow Rate	12.5 l/min ± 5%
Water Pressure at spray nozzle	Approx. 200 kPa

Table 15: Test parameters –Water spray test

Initial Evaluation of Test:
Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test Procedure:
a. Connect original connectors to the DUT unless still connected from the preceding dust test.
b. Do not open the DUT before the following functional/parametric test.
c. Adjust the flow rate of the high-velocity water according the parameter given above.
d. Each DUT shall be attached to the spray chamber turntable in-vehicle mounting orientation.
e. Subject each DUT to the high-velocity water while rotate the DUT.

Level of Acceptance[(5)] :
- At the end of the test, the seals of the DUT must not be impaired in their function.
- No water shall have entered at sealed point e.g. at boots, seals, gaskets etc.
- No water passing through component shall have approached any electrical loads or connections.
- The DUT should meet requirements of performance test after the test.

[(5)]Note: The fitment position of the DUT must be defined in the drawing. Ventilation via the plug is not permitted.

Test report Requirements:

- Results of the functional testing carried out before and after testing
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

3.2.9 IMMERSION IN WATER

Reference Documents: ISO 16750-4

Purpose:
The purpose of this test is to simulate the immersion of electrical/electronic components in water, which are located in the wade area, e.g. ABS sensors.
The test sample is to be warmed to the upper stress temperature T_O as per Table 2 and held at this temperature for one hour. Then the test sample is completely immersed in 0°C, 5% salt-water solution.

Test parameters:

Temperature at start of test	Room Temperature
Water specification	De-ionized water with 3 % by weight of fine Arizona dust (As per ISO 12103- 1:1997xiii). The mixture shall remain well mixed throughout the test.
Holding time t_h at T_{max}	1 hr or until DUT temperature stabilization is reached
Changeover time	≤ □5 seconds from hot chamber to fully immersed
Immersion period	5 minutes
Operation mode	As per operating mode 3.2 of cl. 2.1.3 of this document
Electrical operation	Full electrical operation throughout the test
Orientation of the DUT	As mounted in the vehicle.
Number of cycles('N' cycle)	20
water temperature (T_s)	0 to +4 °C
Test cabinet temperature	Max temperature for normal operating temp range
DUT Operating temperature range	As per Table 5

Table 16: Test parameters – Immersion in water

Initial Evaluation of Test:
Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test Procedure:

1. Operate the DUT in a hot air oven at T_{max} for the specified holding time (t_h).
2. With the device still operating, submerge it for 5 min in an ice water tank
3. With water tank depth of more than or equal to 10 mm.

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Acceptance criteria:

- DUT shall meet functional parametric requirements after the test.
- Less than 0.1% CAN error frames allowed for full test duration (for CAN version).
- No critical housing deformations.
- No anomalies in visual tear down analysis.
- Full functionality of electrical and mechanical junctions.
- No water is to have penetrated the sample and the enclosure rating shall be IPX9K.

Test report Requirements:

- Results of the functional testing carried out before and after testing
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

3.2.10 DRIP TEST

3.2.10.1 VERTICAL DRIP TEST

Reference Documents: ISO/WD 20653 standard.

Purpose:
The Purpose of this test is to simulate the water dripping condition on Electrical/Electronic component, are located in the engine compartment as well as passenger compartment. Example ECU, Display modules.

Test parameters:

Test equipment or test conditions	Drip apparatus figure 6 enclosure on a turntable speed approx. 1rev/min
Water flow rate	(1,0 +0,5) mm/min (precipitation height)
Water pressure	0
Water temperature	Water temperature shall be maintained 5 degree less than the equipment temperature to prevent from formation of condensed water.
Exposure time	15 minutes
Operating mode	As per operating mode 1.2 of cl. 2.1.1 of this document
Orientation of DUT	As per vehicle mounting condition.

Table 17: Test parameters – Vertical drip test

Initial Evaluation of Test:
Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

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Test Procedure:

1. The test set up shell be made with a equipment that produces a uniform flow of water drops over the whole area of the DUT as shown in the figure 6.
2. The turntable on which the DUT is placed shall have a rotation speed of 1 r/min. And the placement of DUT shall be to the center axis of turntable eccentricity (distance between turntable axis and the DUT axis) shell be within 100 mm approximately.
3. The DUT is placed in its normal operating position under drip box, the base of which is larger than that of the DUT.
4. An DUT normally fixed to the body or frame, shall be fixed in normal position of use to a wooden board having dimension which are equal to those of that surface of the DUT this in contact with the body or frame when the DUT is mounted as in vehicle mounting condition.

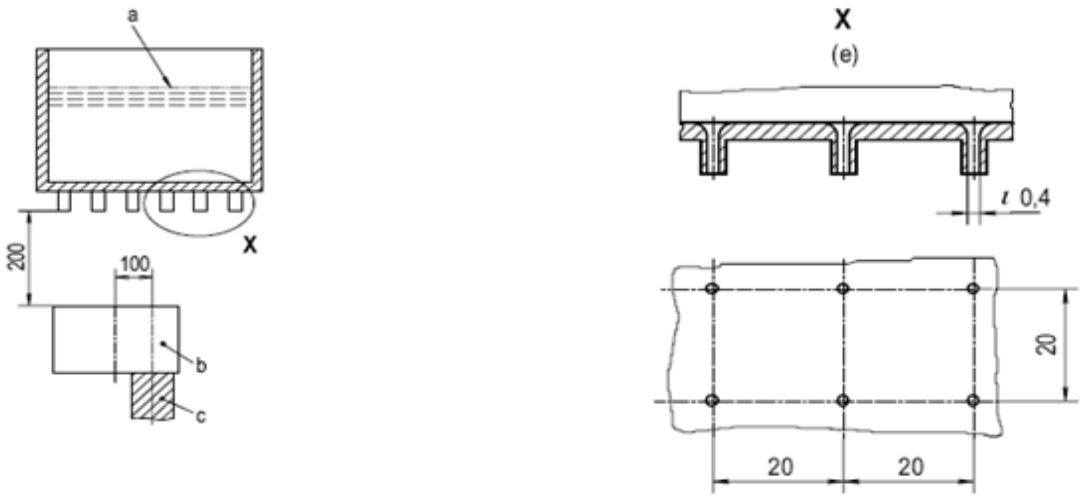
Note: when the base of the drip box is smaller than that of the enclose/device under test the latter may be divided into several section, the area of each section being large enough to be covered by the dripping water. The test is continued until the whole area of the DUT has been sprinkled for the specified time.

Acceptance criteria:

After testing in accordance with the appropriate requirements of the test the enclosure shall be inspected for ingress of water and check for the following.

- DUT shall meet functional parametric requirements after the test.
- Less than 0.1% CAN error frames allowed for full test duration (for CAN version).
- No critical housing deformations.
- No anomalies in visual tear down analysis.
- Full functionality of electrical and mechanical junctions.
- No water is to have penetrated the sample.

Dimensions in millimeters



a) degree of protection against ingress of water 1

Key:

a adjustable water level
b equipment under test
c turntable
d holder
e hole pattern (sectional drawing)

f t = Diameter

Figure 6 – Drip apparatus

3.2.10.2 DRIP TEST ENCLOSURE INCLINED AT 15°

Reference Documents: ISO/WD 20653 standard.

Purpose:
This test is done in order to investigate the function of the Electrical/Electronic component subjected to dripping of water. This test is mainly conducted to check the susceptibility of the electronic components against dripping of water due to rain which causes the water to flow inside the engine compartment and drip on the electrical/electronic components.

Test parameters:

Test equipment or test conditions	Drip apparatus figure 7 enclosure in 4 fixed positions, inclined at 15°
Water flow rate	(3.0 +0.5) mm/min (precipitation height)
Water pressure	0

Water temperature	Difference to the temperature of the equipment under test no more than 5°C for water temperature which are more than 5°C lower, measures shall be agreed the users of the standard to prevent the formation of condensed water.
Exposure time	2.5 min for each of the four positions
Operating mode	As per operating mode 1.2 of cl. 2.1.1 of this document
Orientation of DUT	As per vehicle mounting condition.

Table 18: Test parameters –Inclined drip test

Initial Evaluation of Test:

Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test Procedure:

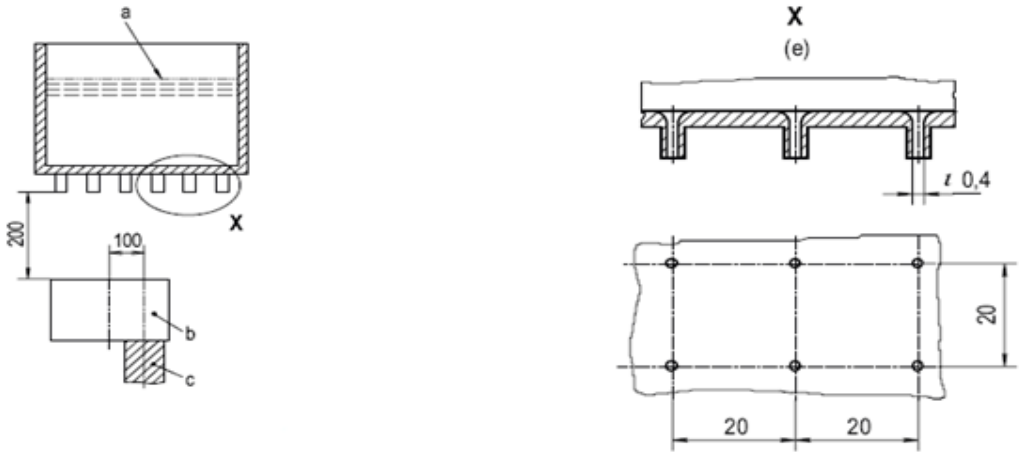
1. The dripping device is the same as specified in 3.2.10.1 but adjusted to provide the water flow rate specified
2. The table on which the enclosure is placed does not turn. DUT is placed does not turn as in the first case.
3. The DUT is tested for 2, 5 min in of four positions of tilt.
4. These positions are 15° on either side of the vertical in two mutually perpendicular planes as shown in figure 7.

Acceptance criteria:

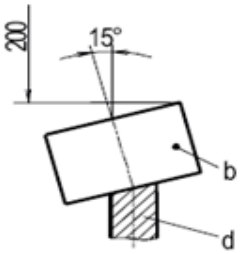
After testing in accordance with the appropriate requirements of the test the enclosure shall be inspected for ingress of water.

- DUT shall meet functional parametric requirements after the test.
- Less than 0.1% CAN error frames allowed for full test duration (for CAN version).
- No critical housing deformations.
- No anomalies in visual tear down analysis.
- Full functionality of electrical and mechanical junctions
- No water is to have penetrated the sample and the enclosure rating shall be IPX9K.

Dimensions in millimeters



a) degree of protection against ingress of water 1



b) degree of protection against ingress of water 2

Key:

a adjustable water level
b equipment under test
c turntable
d holder
e hole pattern (sectional drawing)

f t = Diameter

Figure 7 – Drip apparatus for Inclined drip test

3.2.11 LOW AIR PRESSURE TEST (ALTITUDE TEST)

Purpose:
To determine if the DUT is able to meet specification requirements when subjected to reduced atmospheric pressure. The test simulates pressure and temperature conditions due to operating at 4800 m and being shipped in an un-

pressurized aircraft at 10 400 m. This test is intended for electrical and electronic devices that are sealed or that have components that are affected by pressure changes.

If the electrical and electronic device has pressure sensitive technology, its performance may be affected. Marginal heat dissipating electrical and electronic devices may overheat during Test 1.

Test Conditions: Test according to IEC 60068-2-13 standard.

3.2.11.1 LOW AIR PRESSURE TEST IN POWERED MODE

Test parameters:

Temperature at start of test	Room Temperature
Low Pressure (P_{low})	55 kPa
Maximum Rate of Pressure Change (P_{change})	10 kPa/min
Holding time at Low Pressure (t_1)	16 hr
Temperature Reference Point	Chamber temperature
DUT Test Position	Not relevant
Operation/Monitoring Mode	As per operating mode 3.2(every 30 min) of cl. 2.1.3 of this document 30 min

Table 19: Test parameters – Low air pressure test in powered mode

Initial Evaluation of Test:
Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test procedure:

a. Place the DUT in a suitable chamber
b. Reduce the pressure to flow at a rate of change.
c. Maintain the test conditions for a period of t_1 and operate the DUT according to the operation monitoring mode given above.
d. Upon completion of the test, return the DUT to standard atmospheric conditions.

Acceptance Criteria:

a. The DUT shall pass the Functional Check during Test 1.
b. The DUT shall pass the Functional performance Test after Test 2.

Test report Requirements:

- Results of the functional (or ri-temperature / tri-voltage) testing carried out before and after testing.
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

3.2.11.2 LOW AIR PRESSURE TEST IN UNPOWERED MODE

Test parameters:

Temperature at start of test	Room Temperature
Low Pressure (P_{low})	25 kPa
Maximum Rate of Pressure Change (P_{change})	10 kPa /min
Holding time at Low Pressure (t_2)	16 hr
Temperature Reference Point	Chamber temperature
DUT Test Position	Not relevant
Operation/Monitoring Mode	As per operating mode 1.1 of cl. 2.1.3 of this document

Table 20: Test parameters – Low air pressure test in unpowered mode

Initial Evaluation of Test:
Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test procedure:
a. Place the DUT in a suitable chamber
b. Reduce the pressure to Plow at a rate of Pchange.
c. Maintain the test conditions for a period of t_2.
d. Upon completion of the test, return the DUT to standard atmospheric conditions.
e. A Functional/Parametric Test shall be performed at the end of test.

Acceptance Criteria:
- The DUT shall pass the Functional Check during Test 1.
- The DUT shall pass the Functional performance Test after Test 2.

Test report Requirements:
- Results of the functional testing carried out before and after testing
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

3.2.12 DUST TEST

Purpose:
The resistance of the DUT against penetration of dust is tested.

Test condition: As per TS75010 (IS 9000 part 12) standard.

Test Parameters:

Total Test Duration Engine compartment Passenger compartment	 8 hours 2 hours
Test Temperature (T)	40 ± 3 °C
Relative Humidity (RH)	25 to 75 %
Test Equipment size	1 cubic meter
Dust Type	ISO 12103-A2 acc. to ISO 12103-1 (fine test dust)
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position	In-vehicle mounting orientation
Operation/Monitoring Mode	As per operating mode 1.2 of cl. 2.1.3 of this document
Number of Test Cycles ('N' Cycles)	20
Test Cycle Duration, Dust Settling Time (t_2)	15 min
Air/Dust Mixture Circulation Time (t_1)	5 seconds

Table 21: Test parameters – Dust test

Initial Evaluation of Test:
Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test Procedure:

a. Connect original connectors to the DUTs.
b. At room temperature RT, place the DUT in a dust chamber oriented to represent the in-vehicle mounting orientation.
c. Circulate the air/dust mixture for the time t_1, followed by a settling period of time t_2. Repeat this cycle for 'N' no. of Cycles).
d. Following the test, remove the DUTs from the chamber and remove accumulated dust by brushing, wiping or shaking, care being taken to avoid introduction of additional dust into the DUTs. Under no circumstances shall dust be removed by either air blast or vacuum cleaning.
e. Transfer the DUTs directly to the following water protection or humidity test (as indicated by the test flow plan). Do not open the DUTs or disconnect the connectors before the following water protection or humidity test.

Acceptance criteria:

- At the end of the test, the seals of the DUT must not be impaired in their function.
- No dust shall have entered at sealed point e.g. at boots, seals, gaskets etc.
- No dust passing through component shall have approached any electrical loads or connections.
- The DUT should meet requirements of performance test after the test.

Test report Requirements:

- Results of the functional testing carried out before and after testing
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

3.2.13 CORROSION RESISTANCE TEST

Purpose:
The corrosion resistance of the DUT against salt spray fog and salt water is tested. Furthermore, the leak tightness of the DUT is tested by switching it on.

Test condition: As per TS 75005 (IS 9000 part 11) specification.

Test Parameters: The sample shall be subjected to the following conditions:

Total Test Duration	150 hours
Test Cycle Duration	24 hr
Number of Test Cycle (NCycle)	6
Test Cycle	One cycle consists of 24 hr. exposure to salt spray fog followed by 1 hr. without salt spray fog (see Figure 8). Temperature during the time when there is no salt spray fog.
Test Temperature (T)	(35 ± 2) °C
Salt Solution	NaCl concentration: (5 ± 1)% pH, value at RT: 6.5 to 7.2 (acc. IEC 60068-2-11)
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position	In-vehicle mounting orientation
Operation/Monitoring Mode	Initial the operating mode 2.1 of clause 2.1.2 of this document. Between the fourth to sixth hours of the test cycle Operating Mode 3.2 of clause 2.1.2 of this document.

Table 22: Test parameters – Corrosion resistance test

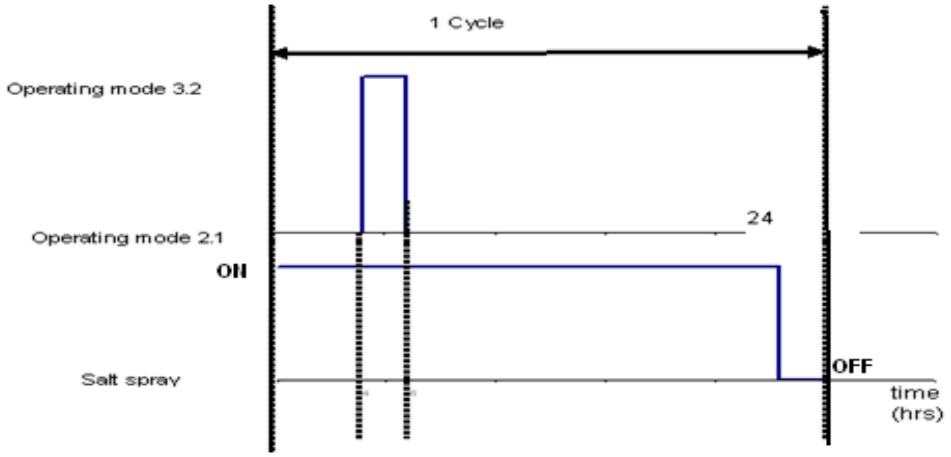


Figure 8 – Test cycle for salt spray fog test and electrical operation

Initial evaluation of test:
Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test procedure: *(Refer Figure 8 for test cycles)*

a. All surfaces shall be clean and free from oils, greases or other protective materials not part of the design.
b. Place the DUT in a salt spray chamber at temperature T in their in-vehicle mounting orientation (reference the definition of axis as per drawing). The samples shall not be in contact with each other or with other metal parts, and shall be so arranged as to exclude any influence of one part upon another.
c. Spray the DUT for 24 hr, and then stop spraying for a rest period of 1 hr.
d. Repeat the spray cycles (step C) for a total number of 'N' no. of cycle.
e. At the completion of the test, the samples shall be washed in running tap water for minimum 2 minutes until all residues of salt solution on the surface are removed or if this is not possible for a maximum of 5 minutes. The temperature of the water used for washing shall not exceed +35 °C. Then subject the DUT to air blast at a pressure not exceeding 200 kPa and at a distance of approximately 300 mm to remove droplets of water and dry.
f. The samples shall be stored at room temperature for 1 to 2 hr prior to performing any post-test measurements.

Acceptance criteria:

- The required corrosion protection must be achieved. If the penetration of salt water is not permissible, the following applies:
  - Region of performance I, for operating Mode 3.2.
  - Region of performance I, for operating Mode 2.1.
- There shall not be any red corrosion, white rust deposits/marks on the surface of plated parts.

Test report Requirements:

- Results of the functional testing carried out before and after testing
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

3.2.14 FLUID RESISTANCE TESTS

Purpose:
The resistance of a DUT to various chemical agents is tested.
Components and associated parts that can come into contact with the specified chemical agents shall be resistant to those agents. They shall be tested with all agents they are likely to come into contact with, except for those materials which can be shown by documentary evidence to be immune to the contaminant, which need to be tested.

Test conditions: Testing shall be in accordance with this document.

Test parameters:

Apply Temperature for Chemicals	RT
Storage Temperature (T)	See table below
Maximum Temperature (T_{max})	85 °C
Storage Time (t_1) at T	24 hr

Temperature Reference Point	Ambient temperature
DUT Test Position	Not relevant
Operation/Monitoring Mode	As per operating mode 1.2 of cl. 2.1.1 of this document

Table 23: Test parameters – Fluid resistance test

Initial evaluation of test:
Functional check and visual check shall be conducted before the test. Visual check shall be done after the test. The execution of the test shall be with the unaided emmetropic eye, with normal color perception and from a normal distance at sufficient illumination.

Application Method:

Method	Application by	Description
❶	Cotton cloth	Wet a cotton cloth (30x30) with 50 ml respective chemical agent. Wet the DUT with this cotton cloth until it is completely wet. Let redundant agent drip off the DUT.
❷	Brush	Immerse brush into the chemical agent for each new side. Brush the DUT, until it is completely wet. Let redundant agent drip off the DUT.
❸	Spray	Spray the DUT with the chemical agent until it is completely wet. Let redundant agent drip off the DUT.
❹	Immersion	Immerse the DUT completely into the chemical agent for 5 sec. Let redundant agent drip off the DUT.

Table 24: Application methods for Fluid resistance test

Test Procedure:

The sample shall be subjected to the following conditions in non-operating mode
General Fluid Temperature (if not specified): 27.5 ± 3 °C
Duration of application of fluids (if not specified): 30 minutes

Test Method:
The samples shall be accommodated within a cabinet or behind protective shields. Sealed samples shall have their harness connectors mated and fully sealed. The samples shall be tested for resistance to contaminants. A separate sample shall be used for each of the test fluids. The samples shall be tested by immersion in the fluids identified in Table 25.

Sr No	Testing fluid I chemical I oil	Specification	Fluid temp. in °C	Minimum duration of immersion	Cabin expos -ed	Cabin unexp osed	Door mounted	Trunk	Engine compa rtment	Chassis mounted
1	Alcohol base cleaner		27 ± 5		❶	❷	❷		❷	❷

2	Ammonia based		27 ± 5		❶	❷	❷		❷	❷
3	Antifreeze (50% Vol I Vol)	50 % Mono Ethylene Glycol 50 % Water	118 ± 5	60 min	❷,❸		❸		❸,❹	
4	Battery fluid with 35% of Sulphuric acid		27 ± 5						❷	❷
5	Brake / Clutch	DOT3IDOT 4	85 ± 5	60 min					❷,❹	❷
6	Coffee (10 oz cream, 2 tsp sugar)		27 ± 5		❷,❸	❸				
7	Coffee without sugar		27 ± 5		❷,❸	❸				
8	Cleaner / degreaser		27 ± 5						❷	❷
9	Cola – Coca cola, Pepsi, etc.		27 ± 5		❷,❸	❸				
10	Citric acid – lemon / orange juice		27 ± 5		❷,❸	❸				
11	Diesel Fuel	BS EN 590 1993, IS: 1460.	27 ± 5	60 min					❸,❹	
12	Electric grease connectr		27 ± 5		❷	❷	❷	❷	❷	❷
13	Engine bay		27 ± 5	60 min					❹	
14	Engine Cleaning Solvent	Gunk	27 ± 5	60 min					❸,❹	
15	Engine Oils	ASTM D-471 Oil1	100 ± 5	24 hours					❷,❹	❷
16	Engine coolant		27 ± 5						❸	
17	Ether - starting		27 ± 5						❸	

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18	Finger nail polish remover		27 ± 5		❷					
19	General purpose thinner		27 ± 5	5 min					❷,❹	
20	Gasohol		27 ± 5						❷	
21	Grease	Castrol LM	27 ± 5	60 min			❷		❷,❹	❷
22	Hair spray		27 ± 5		❷					
23	Hand cleanser		27 ± 5		❷					
24	Hand lotion		27 ± 5		❷				❷	❷
25	Insect repellent		27 ± 5		❷					
26	Kerosene	BS2869 Class	27 ± 5	60 min					❸,❹	
27	Lubricating oil		27 ± 5						❷	❷
28	Manual Gearbox I Hypoid Oil	ASTM D-471	100 ± 5	24 hours					❷,❹	❷
29	Paint		27 ± 5						❷	❷
30	Power Steering Oil	Dexron II D (SAE 90W)	85 ± 5	60 min					❷,❹	❷
31	San tan lotion		27 ± 5			❷,❶			❷	❷
32	Soap I detergent water		27 ± 5			❷,❸	❷,❸	❷,❸		
33	Sulphuric Acid	25% solution - laboratory grade	27 ± 5	1 min					❷,❹	❷
34	Underbody		27 ± 5	60 min			❷		❷,❹	
35	Unleaded Petrol	50 % Toluene 50% Tri-Methyl Pentane	27 ± 5	60 min					❸,❹	
36	Unleaded Petrol I Methanol (85% leaded petrol to 15%	42.5% Toluene 42.5% Tri-Methyl Pentane 15% Methyl	27 ± 5	60 min					❸,❹	
37	Undercoating material						❷	❷	❷	❷

PREPARED BY	CHECKED BY	APPROVED BY	ISSUE NO.	DATE
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38	White sprint	ASTM D-484 (standard Solvent)	27 ± 5			❷			❷	
39	Wash and Wax						❷		❷	
40	Acid rain					❷	❷	❷	❷	❷
41	Windshield washer solvent	Ethyl alcohol, 27ml Iso-propanol, 10ml Ethylene glycol, 3ml Water 60 ml	50 ± 5		❷,❸					❷
42	Liquid Air	Ambi-Pur				❷,❸				

Table 25: Contaminants (Availability of contaminants)

Immersion:

- Immersion is required for the items which are fitted in engine compartment and more in contact with fluids (e.g. vehicle speed sensor, crank angle sensor, switches, etc).
- On completion of the immersion the samples shall be allowed to drain at 50°C for 48 hours. They shall then be cleaned, dried and examined.
- Sealed DUT shall be allowed to return to room ambient temperature and shall then be re-checked to the functional requirements.

Acceptance criteria:

- Normally visible areas shall not have suffered any noticeable degradation or loss of clarity of markings.
- Full functionality of electrical and mechanical junctions.
- To satisfy functional performance after the test.

Test report Requirements:

- Results of the functional (or tri-temperature / tri-voltage) testing carried out before and after testing
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed photographs of the damage must be provided.
- Photographic evidence showing the state of the DUT after testing as either confirmation of no change or showing the nature of any change that has occurred.

3.2.15 ENVIRONMENT & HUMIDITY TEST:

Reference document: IEC 60068-2-38 Z/AD standard.

Purpose:
The test simulates the use of a system/component under high ambient humidity. The failure modes addressed are electrical malfunctions caused by moisture, for example from leakage current caused by a printed circuit board soaked with moisture. An additional failure mode is a "breathing effect" that transports moisture inside the housing when the air inside the DUT cools down and ambient air with high humidity is drawn into it.

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Test condition: Testing shall be in accordance with this document and IEC 60068-2-38 Z/AD standard

Test Parameters:

Total Test Duration	288 hours	
No of cycles	2	
Test Cycle Duration	144 hours	
Temperature Reference Point	Ambient temperature (chamber temperature)	
DUT Test Position	In-vehicle mounting orientation	
Operation/Monitoring Mode	3.1 /3.2, 3.2 for 10 min when the maximum temperature is reached	
Test Voltage 12 V System 24 V System	 13.5 V 27 V	
Operating temperature range	Refer table 5 for temperature range	
Environment & Humidity test cycle		
Duration	Temperature	Relative Humidity
1± 0.25 hrs	+ 85 ± 2 °C	-
16 ± 0.50 hrs	(-) 30 ± 2 °C	-
72 ± 1.00 hrs	+ 85 ± 2 °C	-
24 ± 1.00 hrs	+ 65 ± 2°C	95 % min
7 ± 0.50 hrs	(-) 30 ± 2°C	-
24 ± 1.00 hrs	+ 65 ± 2 °C	95 % min

Table 26: Test parameters – Environment and humidity test cycle

Initial Evaluation of Test:
Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test procedure:

a. Test to be done in circulating air oven or refrigerated cabinet. DUT in installed condition shall be tested to the following cycle (in powered mode). Each cycle consists of temperature of humidity cycle as mentioned in table 26.
b. After the completion of cycle, the component shall rest at ambient temperature for 24 hours.

Acceptance criteria:

- To meet the requirements of functional performance after the test.
- Less than 0.1% CAN error frames allowed for full test duration (for CAN version).
- There should be no change in contact path.
- Full functionality of electrical and mechanical junctions
- No anomalies in visual tear down analysis. No visual deterioration or degradation should occur.

Test report Requirements:

- Results of the functional testing carried out before and after testing
- Results of external and internal analysis before and after testing.

- If any external and/or internal damage is observed photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

3.2.16 DAMP HEAT, STEADY STATE TEST

Reference Document: ISO 16750-4:2006 standard.

Purpose:
The purpose of this test is to determine the effect of high humidity at a constant temperature, without condensation on the sample.

Test Condition: The test shall be performed in accordance with IEC 60068-2-78 standard.

Test Parameters:

Total Test Duration	21 days
Maximum Temperature (T_{max})	(40 ± 2) °C
Relative Humidity (RH1)	95 % ± 3%
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position	In-vehicle mounting orientation
Operation/Monitoring Mode	As per operating mode 3.2 of cl. 2.1.3 of this document

Initial Evaluation of Test:
Before starting the environment test the DUTs shall pass the preceding functional/parametric tests and may not show any mechanical damage on the visual inspection.

Test Procedure:

a. Place the DUT in a climatic chamber at temperature (25 ± 2) °C and relative humidity (95 ± 3) RH.
b. Perform the test by adjusting climatic chamber (+) 40 °C at 95 % RH for 21 days.
c. On completion of the test, DUT shall be removed from the chamber and shall be kept under standard atmospheric conditions for testing for a period of 24 hr before the specified post-functional/parametric tests shall be done.

Acceptance criteria:
- The test sample must be fully capable of functioning during and after the test.
- The sample shall display no visible deleterious effects such as cracking, warping, swelling or softening. No critical housing deformations.

Test Report Requirements:
- Results of the functional (or tri-temperature / tri-voltage) testing carried out before and after testing.
- Results of external and internal analysis before and after testing shall be published in the reports.
- If any external and/or internal damage is observed, photographs of the damage must be provided.
- Details of test setup including photograph and parameters.

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3.2.17 U-V LIGHT CONDENSATION TEST
Reference Document: ASTM G 154 (Formerly ASTM G 53) standard.

Purpose:
This is applicable only for items exposed to sunlight.

Test conditions:
Testing shall be in accordance with this document and ASTM G 154 standard.

Test parameters:

Lamp: UVB lamp no. QFS 40
Cycle of U-V : Exposure time and temperature: 4 hour / 60 °C
Condensation time and temperature : 4 hour / 50 °C
Total exposure time: 200 Hours
No of Cycles : 25 cycles
Operating mode: 1.1

Acceptance criteria:
At the end of test, there should not be visual discoloration or deformation or deterioration of the sample to be observed.

Test report Requirements:
- Results of the functional testing carried out before and after testing
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

3.2.18 DEW FORMATION TEST

Reference document: JASO D 001-94 specification.

Test Purpose:
The dewing test is to test for the effect of condensation on printed circuit boards. The dewing test is applicable only to electronic components containing printed circuit boards. It is not required if the component is hermetically sealed.

Test Conditions: Testing shall be in accordance with this document and JASO D 001-94 specification.

Test parameters:

Total Test Duration	Approx. 3 h
Number of cycle	1
Transfer Time (T_3)	As fast as possible (max. 5 min)
Time until electrical Test Start (T_5)	As fast as possible (max. 5 min)
Electrical Operation Time	10 min
Temperature Reference Point	Chamber temperature
DUT Test Position	In-vehicle mounting orientation

Operation/Monitoring	As per operation 1.2 (off) / 3.2 mentioned in cl. 2.0 of this document
Chamber 1: Low constant temperature chamber	
Room Temperature (RT)	RT
Minimum Temperature (T_{min})	(-) 20 ± 2 °C
Holding Time (T_2)	2 ± 0.5 hours (DUT shall be tempered through)
Rate of Temperature Change (T_{Change})	2 K/min (-->T_1 ~13 minutes minimum)
Chamber 2: Constant temperature and humidity chamber	
Maximum Temperature T_{max}	45 ± 3°C
Relative Humidity (RH1)	95 ± 5 %RH
Holding Time (T_4)	10 min

Table 27: Test parameters – Dew formation test

Initial Evaluation of Test:
Before starting the environment test the DUTs shall pass the preceding functional/parametric tests and may not show any mechanical damage on the visual inspection.

Test Procedure:

a. All test chamber parameters and the result must be recorded.
b. The whole test performance needs to be recorded (especially humidity, temperature and function).
c. Subject the DUT to one cycle per the graph above with respect of following procedure.
d. Move the DUT from chamber 1 to Chamber 2, as fast as possible.
e. After storage in chamber 2, move the DUT to laboratory environment as fast as possible and operate the DUT with the operation mode given above for the time T_6 as soon as possible. Do not remove humidity from the DUT before and during operation.
f. In the event that a nonconformance occurs, the nonconformance shall be noted, and the DUT shall be “dried out” under standard lab conditions for a minimum of 24 hours, and then re-tested for parametric test.

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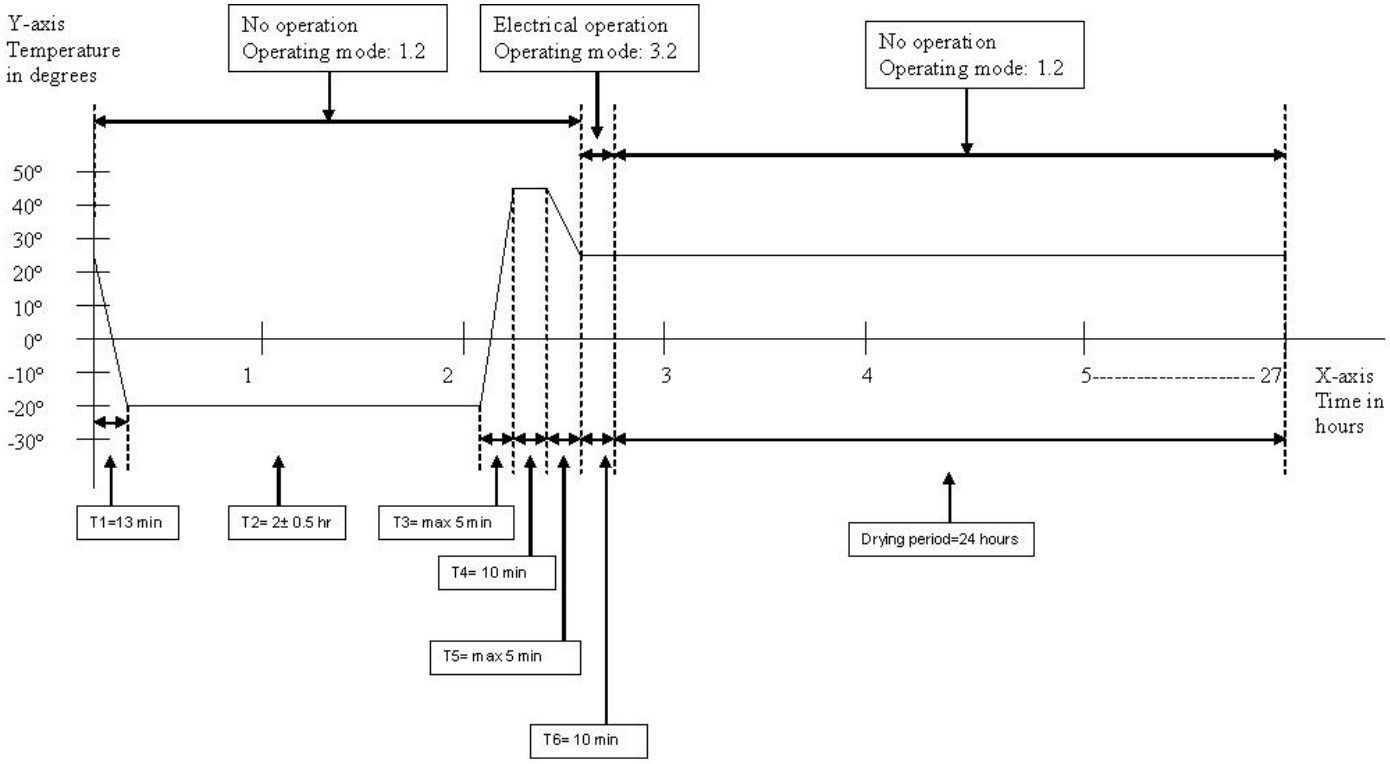

Figure 9: Test cycle for Dew formation test and electrical operation

Acceptance criteria:

- The DUT shall pass the Room Temperature Functional/Parametric tests following the 24 hour drying period. Non-conformances noted during the 5 min., 30 minute and 2 hour Parametric tests shall be included the test documentation.
- No damage or anomalies on visual inspection after the test. The PCB shall be examined for electrochemical migration. Other changes of the PCB shall be likewise recorded (e.g. corrosion, defects in the solder resist).

Test report Requirements:

- Results of the functional testing carried out before and after testing
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

3.2.19 FLOWING MIXED GAS CORROSION TEST [6]

Reference document: IEC 60068-2-60 standard.

Purpose: This test simulates the use of components in the presence of corrosive gases, for example in polluted atmospheres. One potential failure mode is electrical malfunction caused by non-conductive corrosion products on the surface of electrical contacts such as switch contacts or connectors. Another potential failure mode is the penetration of protective (e.g. paint) coatings leading to corrosion of the material underneath.

Test conditions: Testing shall be in accordance with this standard and IEC 60068-2-60.

Test Parameters:

Gas concentrations: Method 4
Operating Mode: 1.1
Test duration: 21 days

Parameters	Method 4
H_2S (10-9 vol/vol)	10 ± 5
NO_2 (10-9 vol/vol)	200 ± 20
Cl_2 (10-9 vol/vol)	10 ± 5
SO_2 (10-9 vol/vol)	200 ± 20
Temperature °C	25 ± 1
RH%	75 ± 3
Volume changes per hour	3 to 10
1) H2S = 1 µg/m^3 to 0.71 mm^3/m^3; 2) NO2 = 1 µg/m^3 = 0.53 m^3/m^3 3) Cl2 = 1 µg/m^3 = 0.34 mm^3/m^3; 4) SO2 = 1 µg/m^3 = 0.38 mm^3/m^3	

Table 28: Flowing mixed gases concentrations

Mounting position: In vehicle-mounted attitude, mated with correct connectors

Electrical operation: The test sample shall be connected to a permanent battery feed during the entire test where this is the case in the vehicle application. No other feeds are permitted.

Initial Evaluation of Test:
Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Acceptance criteria:

- DUT shall meet requirements of performance test after the test.
- For electrical contacts, a visual inspection followed by a resistance check shall be made following completion of the test; significant corrosion is not acceptable and the contact concerned must comply with its specification.
- For protective coatings, a visual examination shall be made.

Test report Requirements:

- Results of the functional testing carried out before and after testing
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed, photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

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3.3 DYNAMIC TESTS

3.3.1 VIBRATION TEST REQUIREMENTS

- The vibration test is not a wear test. There are different vibration tests with different test severities. These are dependent upon the fitting position of the DUT.
- The DUT shall be mounted in as-installed position on the vibrator table/sliding table by means of suitable holders. Cables and hose connections as well as related add-on parts shall be properly mounted. Cables and hoses shall be supported in accordance with installation conditions without influencing the DUT.
- The specified values refer to directly mounted DUT. The acceleration measuring point is the interface between test table and DUT.
- For large and solid DUT (e.g. alternator, starter or battery) application of the mean value method according to IEC 60068-2-64 on the DUT fixing points can be agreed upon with TATA Motors, ERC. DUT orientation and test sequence shall be documented in the test report.

Inspection: Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test Description:
The DUT shall be mounted on a vibration fixture and test harnesses shall be connected.

Operating mode:
The system is operated with the test voltage of 13.5 V for 12 V system and 27 V for 24 V system, with all electrical connection made and system/equipments & controls usual operating mode. Operating mode 3.2
The DUT should be exposed to a vibration profile as per mounting.
During the vibration exposure, the DUT was temperature cycled between (–) 40 °C and plus (+) 85 °C for the duration of the vibration test as detailed (Refer Table 5 for DUT Operating temperature range)

Temperature profile:
As vibration load may occur in the vehicle at low and high temperatures, the vibration load test is performed with a temperature profile according to Section 3.2.4.
The DUT shall be functionally operated and monitored during the vibration test. The samples shall be viewed as desired and a check on the operation of the chamber at suitable intermediate intervals. Opening of the chamber shall be restricted to the minimum time and frequency necessary to carryout the above operations.

Mounting condition: If the electronic control unit (ECU) is used in the vehicle with a bracket, then all sinusoidal and random vibration tests shall be done with this bracket based on vehicle fitment.
On completion of the test, the environmental test chamber to be returned to ambient room temperature (plus 23 °C).

Test Voltage:
Test voltage: + 13.5 Volts DC for + 12 systems
Test voltage: + 27 V for + 24 V systems

LIMITS of Equipment: Unless otherwise stated, the accuracy of equipment shall be within the following:
Temperature: ± 2 °C with a resolution of at least 0.2 °C, b) Humidity: 3%RH. Refer Table 5 for DUT operating temperature range

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Acceptance criteria:

- To meet the requirements of performance test after the test. Region of performance I.
- The DUT's shall be inspected visually after the environmental test. Mechanical damage like cracks or deformations is not allowed.
- Less than 0, 1% CAN error frames allowed for full test duration (for CAN version).
- No disturbing noise may occur for any operating type.
- No anomalies in visual tear down analysis.

Test report Requirements:

- Results of the functional (or tri-temperature / tri-voltage)testing carried out before and after testing
- Results of external and internal analysis before and after testing.
- Plots of DUT acceleration.
- Logs of monitored parameters made during the test.
- If any external and/or internal damage is observed, photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

3.3.1.1 SINE VIBRATIONS - Engine mounted equipments

Reference document: IEC 60068-2-6 standard.

Purpose:
The vibrations occurring on an internal combustion engine are composed of the two following types:

- Excitation with sinusoidal vibrations resulting from piston movement
- Excitation with wide band random vibrations resulting from all other movements

Test Condition: Testing shall be done in accordance with this document and IEC 60068-2-6 standard.

Test Parameters:

Test Cycle Duration	22 hours for each plane of the DUT
Number of Test Cycle ('N' Cycle)	1 cycle each axis
Maximum Temperature (T_{max})	85 °C
Minimum Temperature (T_{min})	(-) 40 °C
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position/Orientation	As mounted in vehicle
Operation/Monitoring Mode	As per operation mode 3.1 / 3.2 (see sine vibration profile) mentioned in column 2.0 of this document
Sweep rate	1 octave per minute
Voltages	
12 V - System	13.5 V ± 0.1
24 V - System	27 V ± 0.1

Table 29: Test condition – Sine vibrations, Engine mounted equipments

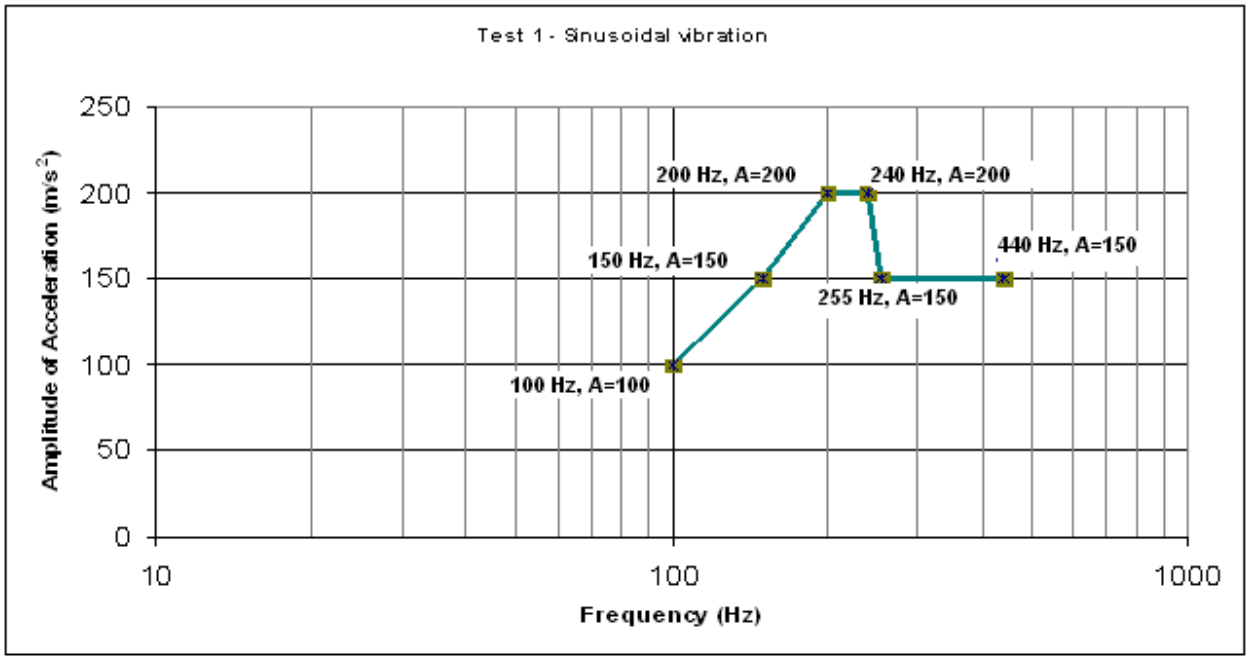

Figure 10: SINE VIBRATIONS - Engine mounted passenger car equipments

Frequency (Hz)	Amplitude of acceleration (m/s²)
100	100
150	150
200	200
240	200
255	150
440	150

Table 30: Amplitude parameters – Sine vibrations, Engine mounted equipments

3.3.1.2 RANDOM VIBRATIONS – Engine mounted equipments

Reference document: IEC 60068-2-64 standard.

Purpose:
The equipment should withstand the random noise from all other vibration sources of an engine, e.g. closing of valves.

Inspection: Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test Condition: Perform the test according to IEC 60068-2-64 standard.

Test Parameters: *(Refer Table 31, 32 and Figure 11 for test conditions)*

Test Cycle Duration	22 hours for each plane of the DUT
Number of Test Cycle ('N' Cycle)	1 cycle each axis
Maximum Temperature (T_{max})	85 °C
Minimum Temperature (T_{min})	(-)40 °C
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position/Orientation	As mounted in vehicle
Operation/Monitoring Mode	As per operation mode 3.1 / 3.2 (see sine vibration profile) mentioned in column 2.0 of this document
RMS Acceleration	181 m/s2
Voltages	
12 V - System	13.5
24 V - System	27 V

Table 31: Test conditions – Random vibrations, Engine mounted equipments

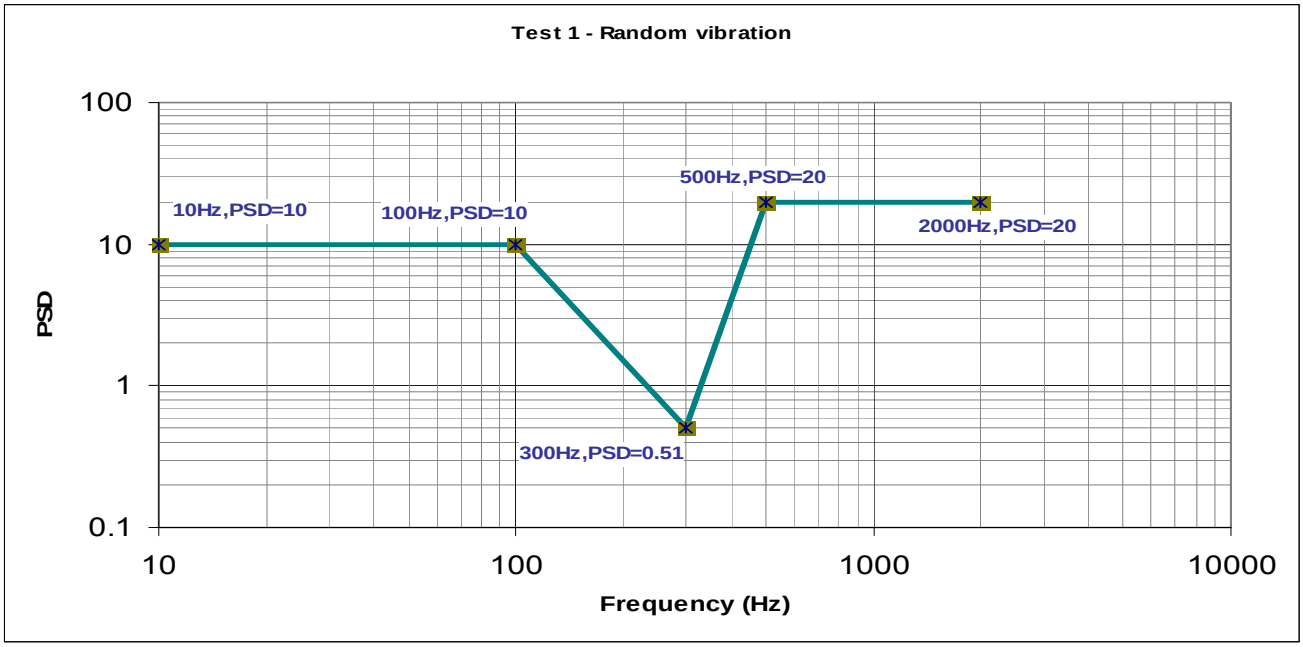

Figure 11: RANDOM VIBRATIONS – Engine mounted passenger car equipments

Frequency (Hz)	PSD ((m/s2)2/Hz)
10	10
100	10
300	0.51

500	20
2000	20

Table 32: PSD values – Random vibrations, Engine mounted equipments

3.3.1.3 SINE VIBRATIONS – Gear box or transmission mounted equipments

Reference document: IEC 60068-2-6 standard.

Purpose:
The equipment to withstand the sinusoidal vibration transmitted from unbalanced mass forces.
The transmission vibrations are composed of the two following types:

- Excitation with sinusoidal vibrations resulting from piston movement in the engine.
- Excitation with wide band random vibrations resulting from gear friction and all other movements.

NOTE: For DUT inside the transmission, higher values can be the result.

Inspection: Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test Condition: Perform the test according to IEC 60068-2-6 standard.

Test Parameters:

Test Cycle Duration	22 hours for each plane of the DUT
Number of Test Cycle ('N' Cycle)	1 cycle each axis
Maximum Temperature (T_{max})	85 °C
Minimum Temperature (T_{min})	(-)40 °C
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position/Orientation	As mounted in vehicle
Frequency sweep time	1 octave/min, logarithmic
Operation/Monitoring Mode	As per operation mode 3.1 / 3.2 (see sine vibration profile) mentioned in column 2.0 of this document
Voltage 12 V - System 24 V - System	 13.5 V 27 V

Table 33: Test Condition – Sine vibrations, Gear box and transmission mounted equipments

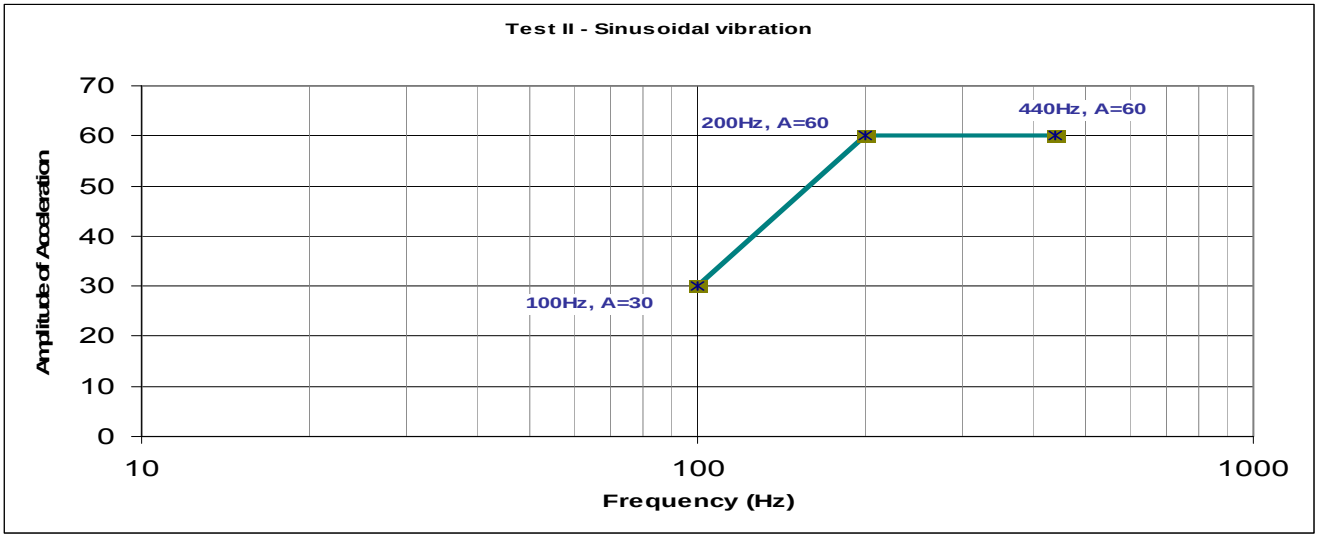

Figure 12: SINE VIBRATIONS – Gearbox or transmission mounted passenger car equipments

Frequency (Hz)	Amplitude of acceleration (m/s^2)
100	30
200	60
440	60

Table 34: Amplitude parameters – Sine vibrations, Gear box and transmission mounted equipments

3.3. 1.4 RANDOM VIBRATIONS – Gear box or transmission mounted equipments

Reference document: IEC 60068-2-64 specification.

Purpose:
The equipment should withstand the random noise from all other vibration sources of an engine and noise created by the friction of the gearwheels

Inspection: Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test Condition: Perform the test according to IEC 60068-2-64 standard.

Test parameters:

Test Cycle Duration	22 hours for each plane of the DUT
Number of Test Cycle ('N' Cycle)	1 cycle each axis
Maximum Temperature (T_{max})	85 °C
Minimum Temperature (T_{min})	(-)40 °C
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position/Orientation	As mounted in vehicle
RMS acceleration	96.6 m/s²
Operation/Monitoring Mode	3.1 / 3.2 (see random vibration profile)
Voltages	
12 V - System	13.5 V
24 V – System	27 V

Table 35: Test condition – Random vibrations, Gear box and transmission mounted equipments

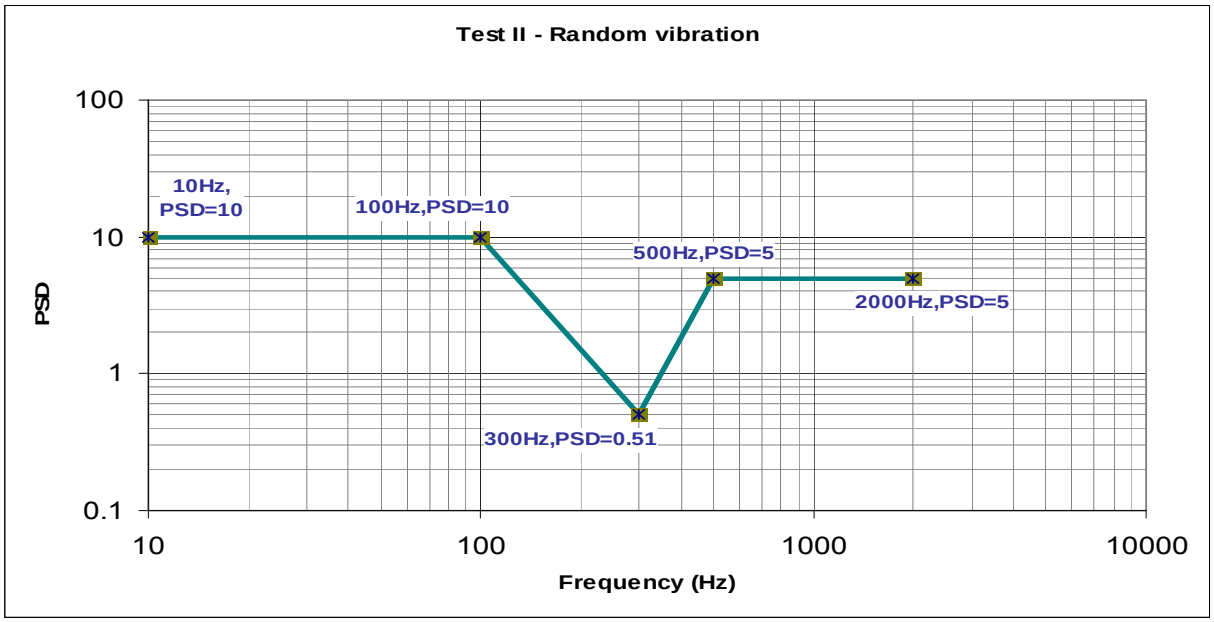

Figure 13: RANDOM VIBRATIONS – Gear box or transmission mounted passenger car equipments

Frequency (Hz)	PSD ((m/s²)²/Hz)
10	10
100	10
300	0.51

500	5
2000	5

Table 36: PSD values– Random vibrations, Gear box and transmission mounted equipments

3.3.1.5 SINE VIBRATIONS - Plenum chamber (cab) mounted equipments

Reference document: IEC 60068-2-6 specification.

Purpose: The equipment to withstand the sinusoidal vibration transmitted from unbalanced mass forces.

Inspection: Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test Condition: Perform the test according to IEC 60068-2-6 specification.

Test parameters:

Test Cycle Duration	22 hours for each plane of the DUT
Number of Test Cycle ('N' Cycle)	1 cycle each axis
Maximum Temperature (T_{max})	85 °C
Minimum Temperature (T_{min})	(-)40 °C
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position/Orientation	As mounted in vehicle
Frequency sweep time	1 octave/min, logarithmic
Operation/Monitoring Mode	As per operation mode 3.1 / 3.2 (see sine vibration profile) mentioned in column 2.0 of this document
Voltage 12 V - System 24 V - System	 13.5 V 27 V

Table 37: Test conditions– Sine vibrations, Plenum chamber mounted equipments

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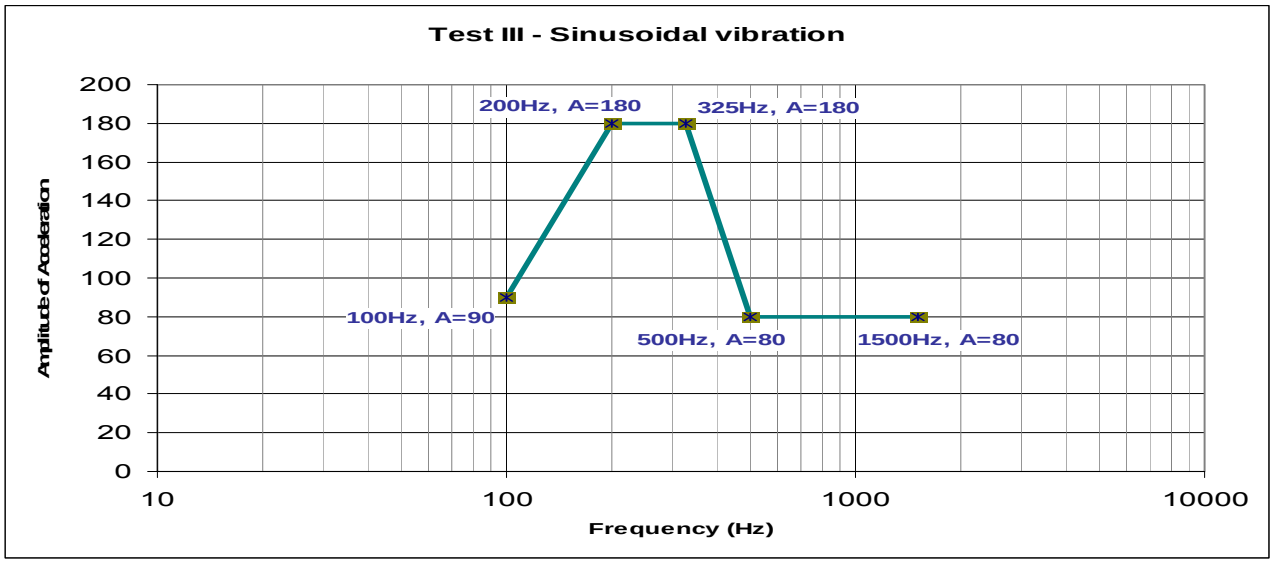

Figure 14: SINE VIBRATIONS – Plenum chamber mounted passenger car equipments

Frequency (Hz)	Amplitude of acceleration (m/s^2)
100	90
200	180
325	180
500	80
1500	80

Table 38: Amplitude values– Sine vibrations, Plenum chamber mounted equipments

3.3.1.6 RANDOM VIBRATION FOR VEHICLE BODY MOUNDTED EQUIPMENTS
Reference document: IEC 60068-2-64.

Purpose: The equipment should withstand random vibration induced by rough-road-driving.

Inspection: Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test Condition: Perform the test according to IEC 60068-2-64 specification.

Test parameters: *(Refer Table 39, 40 and Figure 15 for test conditions)*

Test Cycle Duration	8 hours for each plane of the DUT
Number of Test Cycle ('N' Cycle)	1 cycle each axis
Maximum Temperature (T_{max})	85 °C

Minimum Temperature (T_{min})	(-)40 °C
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position/Orientation	As mounted in vehicle
RMS Acceleration	27.8 m/s²
Operation/Monitoring Mode	As per operation mode 3.1 / 3.2 (see sine vibration profile) mentioned in column 2.0 of this document
Voltages	
12 V - System	13.5 V ± 0.1
24 V - System	27 V ± 0.1

Table 39: Test condition – Random vibrations, Vehicle body mounted equipments

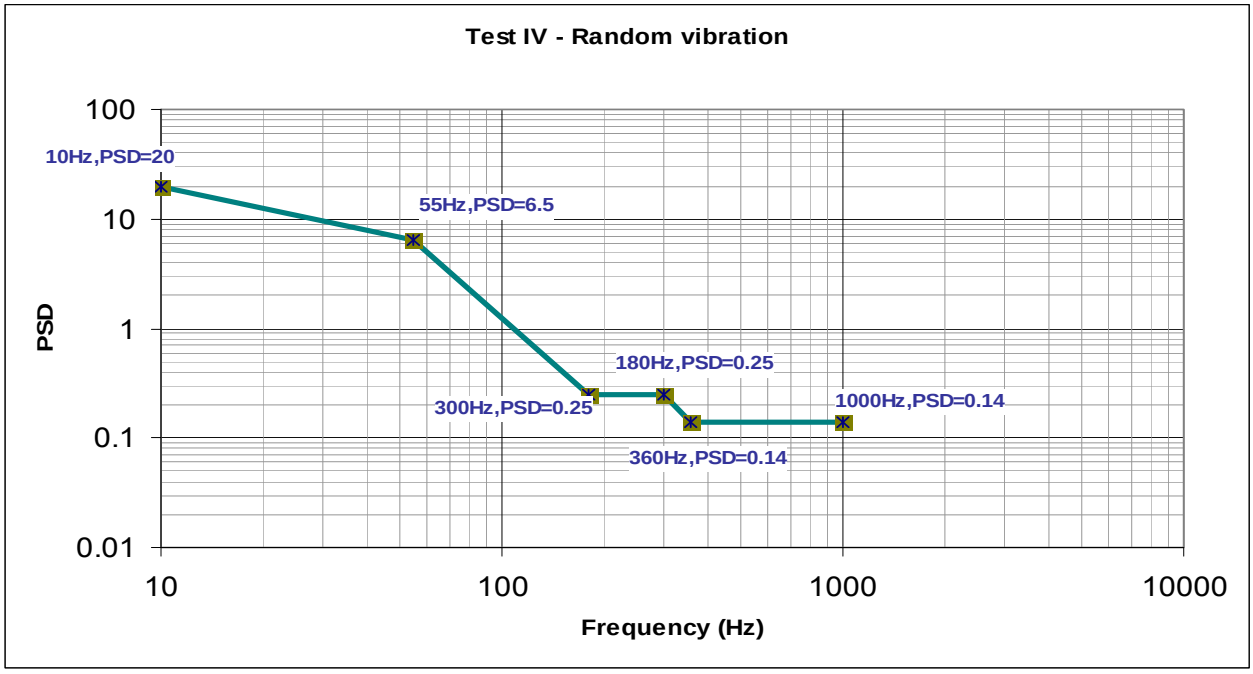

Figure 15: RANDOM VIBRATIONS – Vehicle body mounted passenger car equipments

Frequency (Hz)	PSD ((m/s²)²/Hz)
10	20
55	6.5
180	0.25
300	0.25
360	0.14
1000	0.14

Table 40: PSD values – Random vibrations, Vehicle body mounted equipments

3.3.1.7 RANDOM VIBRATIONS – Wheel or wheel suspension mounted equipments
Reference document: IEC 60068-2-64 specification.

Purpose: The equipment should withstand random vibration induced by rough-road-driving.

Test Condition: Perform the test according to IEC 60068-2-64 specification. Refer Figure 16 and Table 41 as given below

Inspection: Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test Description:
Power temperature cycle: Refer 3.2.4

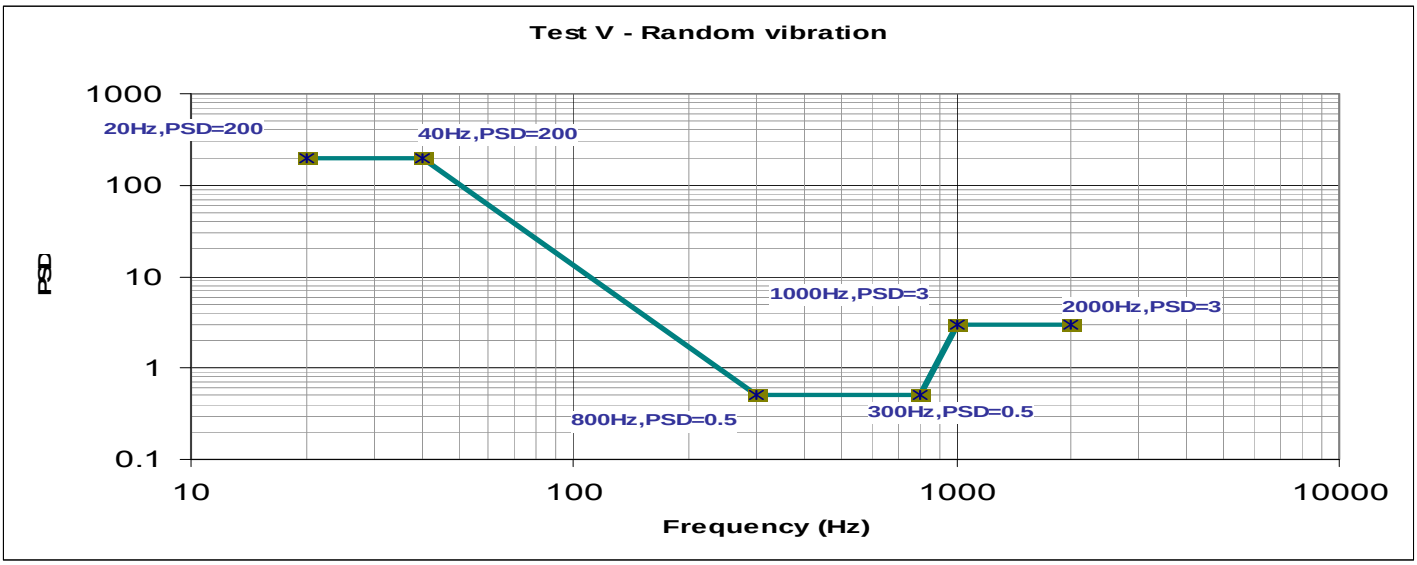

Figure 16: RANDOM VIBRATIONS – Wheel or wheel suspension mounted

Frequency (Hz)	PSD ((m/s²)²/Hz)	RMS Acceleration (m/s²)	Time per Axis (Hours)	No. of Axis	Total duration in hours
20	200	107.3 m/s²	8	3	24
40	200				
300	0.5				
800	0.5				
1000	3				
2000	3				

Table 41: PSD values – Random vibrations, wheel / wheel suspension mounted equipments

3.3.2 MECHANICAL SHOCK TEST:

3.3.2.1 Endurance shock test for systems/components in doors, hood and trunk lid/tailgate

Reference document: ISO 16750-3 standard.

Purpose: The fierce closing of doors, hood and trunk lid/tailgate is simulated.

Test Condition: Testing shall be in accordance with ISO 16750-3 standard.

Test Parameters:

Shock Form (Pulse Shapes)	Half-sinusoidal
Shock Pulse Duration (nominal)	6 ms
Acceleration	500 m/s²
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position	(check: in DUT-axis or in mounting position and/or mounting orientation")
Pulse direction	Same direction as for the DUT installed in the vehicle.
Operation/Monitoring Mode	As per operating mode 1.2 mentioned in column 2.0 of this document.

Table 42: Test condition – Mechanical shock test

The DUT to be exposed to half sine mechanical shock pulses, ten in each opposite direction of each perpendicular axis as per table given below.
The tests shall be performed on all three perpendicular axes and in both directions.

Mounting location	Number of pulses)
Driver's door	100,000
Front passenger's door / rear doors	50,000
Trunk lid / tailgate	30,000
Engine hood	3,000

Table 43: Pulses for endurance shock test

Initial Evaluation of Test:
Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test Procedure:

The mechanical support of the cable harness has to be on the vibration fixture.
A cable harness true to the original cable harness in the vehicle has to be used (same cable width like in the vehicle; no additional cables in the harness are allowed. The mechanical support of the cable harness has to be on the vibration fixture. Vibration/pulse control is on the vibration fixture. Demonstrative acoustical behavior (noise, rattling) has to be documented.

The DUT shall be fixed on the shaker in a direction to generate the effect of acceleration in the same direction as it occurs in the vehicle use. Acceleration resulting from the shock in the test shall be in the same direction as the acceleration of the shock that occurs in the vehicle.
The cable harness has to be reinforced (fixed) in a distance of (15 ± 2) cm to the connector.
Apply a half-sine shock pulse (number of shocks, direction and test temperature see tables above).

Acceptance criteria:

- To meet the requirements of performance after the test.
- No visual deterioration or degradation should occur
- There should be no change in contact path
- Full functionality of electrical and mechanical junctions
- No anomalies in visual tear down analysis.

Test report Requirements:

- Results of the functional testing carried out before and after testing
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed, photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

3.3.2.2 MECHANICAL SHOCK TEST FOR SYSTEMS/COMPONENTS ON THE BODY

Reference document: IEC 60068-2-27 specification.
Purpose: The fast driving over curbstones and deep potholes is simulated.

Test Condition: Testing shall be in accordance with IEC 60068-2-27 specification.

Test Parameters:

Shock Form (Pulse Shapes)	Half-sinusoidal
Shock Pulse Duration (nominal)	11 ms
Acceleration	500 m/s²
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position	(check: in DUT-axis or in mounting position and/or mounting orientation")
Pulse direction	Same direction as for the DUT installed in the vehicle.
Operation/Monitoring Mode	As per operating mode 3.2 mentioned in column 2.0 of this document.
Total number of shocks/axis	20 (10 positive + 10 negative)

Table 44: Test conditions – Mechanical shock test for systems/components on the body frame

The DUT to be exposed to half sine mechanical shock pulses, ten in each opposite direction of each perpendicular axis as per table given below.
The tests shall be performed on all three perpendicular axes in both directions.

Initial Evaluation of Test:
Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test Procedure:

The mechanical support of the cable harness has to be on the vibration fixture.
A cable harness true to the original cable harness in the vehicle has to be used (same cable width like in the vehicle; no additional cables in the harness are allowed. The mechanical support of the cable harness has to be on the vibration fixture. Vibration/pulse control is on the vibration fixture. Demonstrative acoustical behavior (noise, rattling) has to be documented.

The DUT shall be fixed on the shaker in a direction to generate the effect of acceleration in the same direction as it occurs in the vehicle use. Acceleration resulting from the shock in the test shall be in the same direction as the acceleration of the shock that occurs in the vehicle.
The cable harness has to be reinforced (fixed) in a distance of (15 ± 2) cm to the connector.
Apply a half-sine shock pulse (number of shocks, direction and test temperature see tables above).

Acceptance criteria:
- To meet the requirements of performance after the test.
- No visual deterioration or degradation should occur
- There should be no change in contact path
- Full functionality of electrical and mechanical junctions
- No anomalies in visual tear down analysis.

Test report Requirements:
- Results of the functional testing carried out before and after testing
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

3.3.3 FREE-FALL TEST

Reference document: IEC 68-2-32Ed specification.

Purpose:
The falling of the DUT on a concrete floor is simulated. Parts which will obviously be damaged during this test (e.g. headlights) do not have to be tested.

Test conditions: Testing shall be in accordance IEC 68-2-32 Ed specification.

Test Parameters: *(Refer Table 45, 46 and below)*

Drop Height	1 m
Drop Directions, Drop Numbers	See table below
Impact Surface	Concrete ground
Test Temperature (T)	Room temperature
Temperature Reference Point	Ambient temperature (laboratory temperature)

DUT Test Position	See drop directions and numbers below
Operation/Monitoring Mode	As per operating mode 1.1 mentioned in column 2.0 of this document.

Table 45: Test parameters – Free-fall test

DUT	Drop directions	
	1st drop	2nd drop
A	(+)U	(-)U
B	(+)V	(-)V
C	(+)W	(-)W
D	1 corner	2 corners

Table 46: Dropping directions and samples – Free fall test

Insert Drawing of DUT with axes-definition

Initial Evaluation of Test:
Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test Procedure:
The DUTs are to be dropped according the parameters given above.
Visually inspect the DUTs for any obvious damage visible to the naked eye. Any and all damage noted following each drop must be fully documented with pictures, clearly noting the axis in which the damage occurred (refer to the definition of axes section).

Acceptance criteria:
- To meet the requirements of performance after the test.
- No visual deterioration or degradation should occur.
- There should be no change in contact path.
- Full functionality of electrical and mechanical junctions
- No anomalies in visual tear down analysis.

Test report Requirements:
- Results of the functional testing carried out before and after testing
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed, photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

3.4 DURABILITY TESTS

3.4.1 SERVICE LIFE - 85/85 HIGH TEMPERATURE – HIGH HUMIDITY ENDURANCE

Reference document: ISO 16750-4, Section 5.7; IEC 60068-2-78 specification.

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Purpose:
The test simulates the use of a system/component under high ambient humidity. Failure mode is electrical malfunctions caused by moisture (e.g. leakage current caused by a printed circuit board which is soaked with moisture).

Test conditions: Testing shall be in accordance with
Test Parameters:

Total Test Duration (t_1)	1000 hr
Maximum Temperature (T_{max})	85 ± 3 °C
Relative Humidity (RH1)	85 ± 5 %
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position	In-vehicle mounting orientation (see chapter drawing)
Operation/Monitoring Mode	3.1 / 3.2, intermitted operation: 23 h op. mode 3.1 followed by 1hr op. mode 3.2
Test Voltages	
12 V System	13.5 V ± 0.1
24 V System	27 V ± 0.1
Operating temperature range	Refer table 5 for temperature range

Table 47: Test parameters – Service life test

Initial Evaluation of Test:
Functional check and visual check shall be conducted before the loading the DUT. Visual check shall be done after the loading.

Test procedure:
a. The DUT was mounted inside an environmental test chamber and the environmental test chamber to be stabilized at plus 85°C and 85% RH.
b. The DUT to be exposed to plus 85°C and 85% RH for 1000 hours.
c. The DUT to be functionally operated and monitored during the environmental exposure.
d. On completion of the High Temperature – High Humidity Endurance test, the environmental test chamber to be returned to ambient room temperature (plus 23°C) and functional tests to be performed.

Acceptance criteria:
- To meet the requirements of performance test after the test.
- Less than 0.1% CAN error frames allowed for full test duration (for CAN version).
- No critical housing deformations
- Full functionality of electrical and mechanical junctions
- No anomalies in visual tear down analysis.

Test report Requirements:
- Results of the functional testing carried out before and after testing
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

3.4.2 ENDURANCE TEST:

The endurance test shall be done with the modules connected to loads that simulate the normal operating environment. During the normal electrical operation the DUT's will be monitored by the diagnostic interface (or equivalent interface). The warning lamp will be monitored for functional errors. The test equipment checks the DUT's correct action by monitoring the warning lamp (if available) and reading out the contents of the fault-memory with the diagnostic interface. The DUT's shall be continuously supplied with an ignition supply voltage of + 13.5 V (or 27 V DC) for the duration of the test.

Inspection: The DUT's shall be visually inspected before and after the test. Before starting the environmental test the DUT's shall pass the initial performance test and may not show any mechanical damage on the visual inspection. The DUT's shall be put through the final performance test at the end of the test.

Test Conditions: Testing shall be done in accordance with this document

Test Parameters:

Total Test Duration	2000 hr
Test Cycle Duration	6 hours
Number of Test Cycle ('N' Cycle)	333.3
Temperature Cycle Definition	Figure 17
Load	As specified in the drawing (Application specific).
Minimum Temperature (T_{min})	Minus 40 °C
Maximum Temperature (T_{max})	Plus 85 °C
Temperature Reference Point	Ambient temperature (chamber temperature)
Operation/Monitoring Mode	3.2
Mounting position:	As on vehicle.
Rate of Temperature Change (TChange)	≥ 4 °C / min (average over a period of not more than 5 °C / min
Test Voltage 12 V System 24 V System	 13.5 V 27 V
Operating temperature range	Refer table 5 for temperature range

Table 48: Test parameters – Endurance test

Initial Evaluation of test:

Functional check and visual check shall be conducted before the loading of the DUT. Visual check shall be be done after the loading.

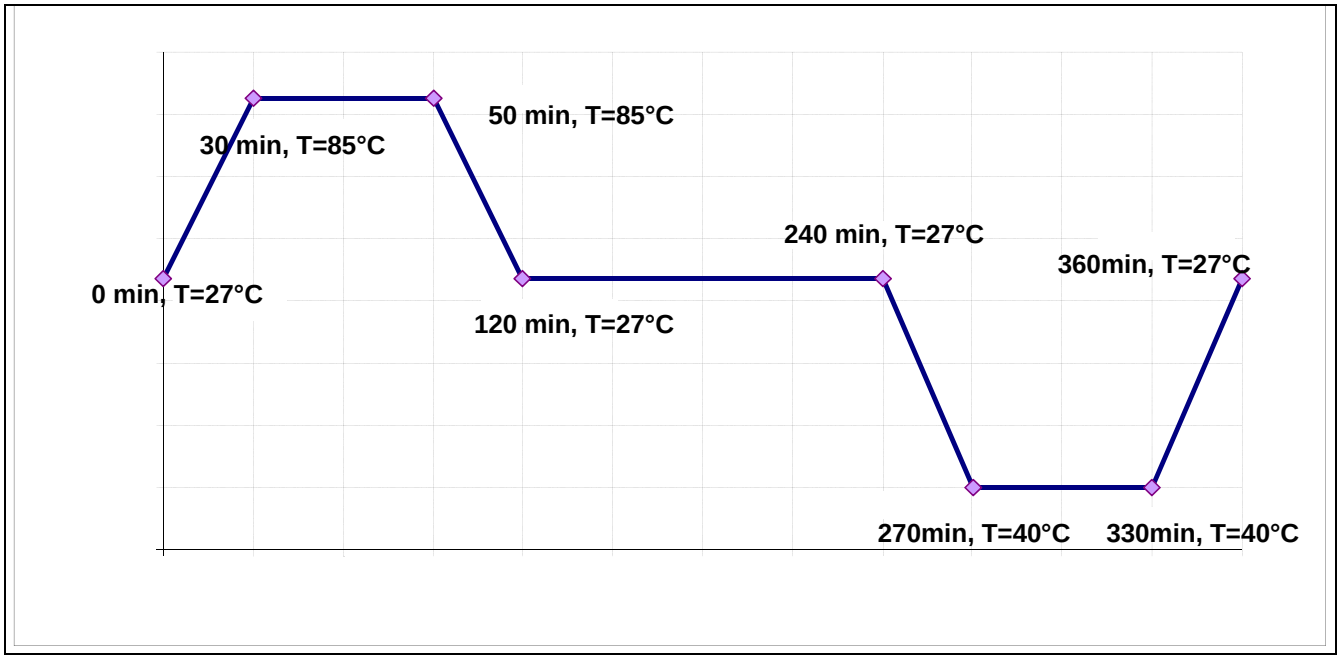

Figure 17: Endurance test temperature cycle

Acceptance criteria:

- To meet the requirements of functional performance after the test.
- Less than 0.1% CAN error frames allowed for full test duration (for CAN version).
- No critical housing deformations
- Full functionality of electrical and mechanical junctions
- No anomalies in visual tear down analysis.

Test report Requirements:

- Results of the functional testing carried out before and after testing
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

3.5 VISUAL TEAR DOWN ANALYSIS

Purpose:
The purpose of this test is to understand the effects of environmental exposure on DUT performance and reliability after a specific test.

Test Description:

a) A visual examination of the exterior of the all DUT shall be performed.
b) Device to be opened to have full visual access to the circuit board assembly.
c) DUT were closely examined for the following, from various oblique angles:
   - Solder joints on all components
   - Metallic growth/Contamination
   - Cracked or broken components
   - Adhesive interfaces (e.g. glue dots, hot melt, etc.…)
   - Compressive interfaces (e.g. heat rails, fasteners, etc.…)
   - Process anomalies (e.g. solder balls, ferrite dust, flux residue, etc.)
   - Residual deposits/marks (Red rust, white marks, discoloration etc)

The general condition of the DUT shall be recorded in a Visual Examination Report, along with any physical deviations, which may result in premature failure of the product to perform its function.

3.6 FITMENT & FUNCTIONAL CHECK ON VEHICLE:

Test conditions:
Sample shall be checked for Fitment & function in normal operating condition of the vehicle.

Acceptance Criteria:

- Sample should fit in vehicle as per design. There should not be any mismatch in the sample in mounting dimensions. There shall be no fitment or fouling problems.
- No functional /mechanical damage/failure during and after the vehicle fitment and functional check.
- The sample should function satisfactorily on vehicle and also to meet all the requirements of functional performance test.

Test report Requirements:

- Results of the functional (or tri-temperature / tri-voltage) testing carried out before and after testing.
- Results of external and internal analysis before and after testing.
- If any external and/or internal damage is observed photographs of the damage must be provided.
- Details of test setup including photographs and parameters.

3.7 FLAMMABILITY TEST:

Reference Document: ISO 3795 standard.

Purpose:

The purpose of this test is to reduce the deaths and injuries to motor vehicle occupants caused by vehicle fires, especially those originating in the interior of the vehicle from sources such as matches or cigarettes.

Test Conditions: Testing shall be in accordance with ISO 3795:1989 standard

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Test Parameters:

Pre-conditioning temperature	27 deg C
Humidity	50 %
Time allowed Conditioning	24 hours to 168 hours
Length of the sample	356mm
Width of the sample	100 mm
Thickness of the sample	13 mm
Bunsen burner tube diameter	10 mm
Bunsen burner tube height	1.5 inch
Bunsen burner flame height from the tube mouth	38 mm
Space between Bunsen burner tip and the test specimen	19 mm

Table 49: Test parameters – Flammability test

Preparation of samples for Test: *(Refer Figure 18, below)*
Sample dimensions (mm):

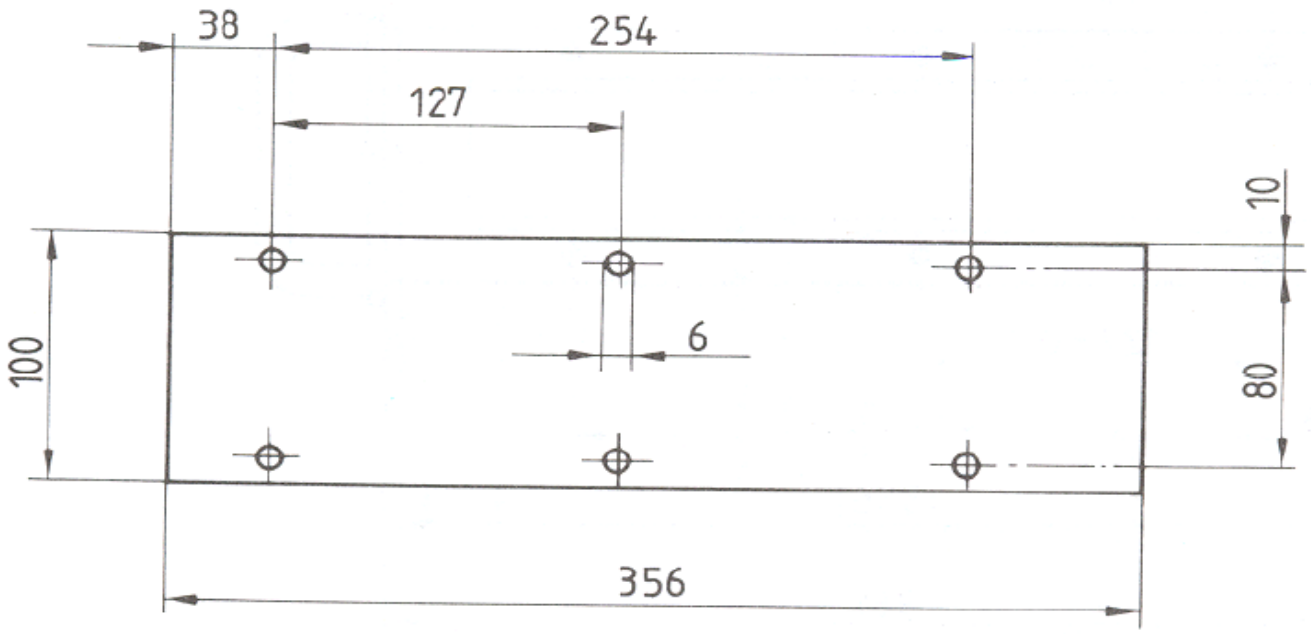

Figure 18: Flammability test sample dimensions

Test Procedure:

a. The sample is placed in the sample holder and held at a height = 161 mm from the base of the combustion chamber as shown in the Figure 19.
b. Before starting the first test, the flame shall burn at least for 60 sec for stabilization and the gas flame is adjusted to a height of 38mm or indicated through a mark in the chamber.
c. The natural gas flow to the Bunsen burner is cut off after 15 sec after the sample is exposed to the flame.
d. Observe the propagation of flame and reaching the first measuring point and the stop clock is switched ON.
e. Measure the burning time till the flame come to the last measuring point (or) measure the time if the flame extinguishes before coming to the last measuring point.
f. Measure the burnt distance up to the point were the flame extinguished, in case the flame does not reach the last measuring point.
g. In case the flame do not ignite I does not continue burning after the burner has been extinguished OR when the flame extinguishes before reaching the first measuring point so that no burning time could be measured then the burning rate is said to be 0 mm/min and specify in the report as same.
h. Measure the burnt distance by checking the decomposed part, which is destroyed on its surface or in the interior due to burning.

All dimensions are in mm

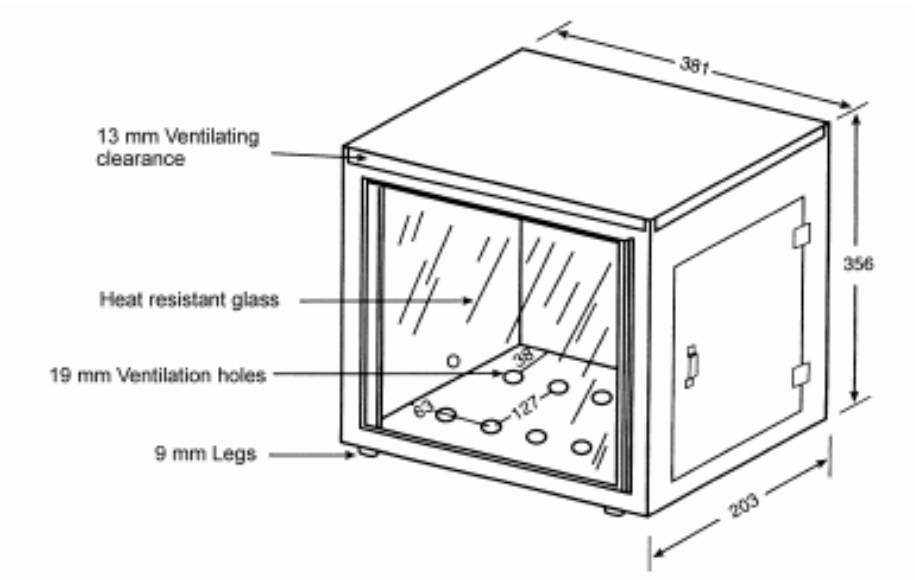

Figure 19: Flammability test – Combustion chamber

Calculation of burn rate:

Where,
B: Burn rate in (mm / min)
D: Distance traveled by the flame in (mm)
T: Time for the flame to travel D mm in (sec)

Acceptance criteria:

- If the burn rate does not exceed 100 mm / min when exposed to Bunsen flame.
- Else Burnt distance shall be within 51 mm for 60 sec. of exposed in Bunsen flame then the samples are in compliance with the requirements.

Test reports requirements:

- Specification of sample such as homogenous or composite material, type, making and color of the test sample shall be denoted in the test report.
- Dimension along with the thickness, position and number of test samples shall be covered.
- Burn distance, burning time and burning rate calculation are to be mentioned.
- Failure modes and special test condition along with necessary photographic evidences be necessary included to support the declaration.

3.7 SAFETY PRECAUTIONS:

Do's:

a. Do necessary check of electrical connections in between the DUT, Signal Generators and Monitoring system to avoid unintentional short.
b. Do check for the any electrical leakage within the test setup before start of the test.
c. Do check for the DUT enclosure fasten properly before start of the test.
d. Do proper shielding around the test setup, especially for the dynamic or structural durability tests.
e. Do necessary inspection around the test setup to avoid any material interruption.
f. Do instruction manuals at the right location of the test rig.
g. Do checking before start of test for test setup interface (both mechanical and electrical).

Don'ts:

a. Don't access the DUT manually/physically touching during the test.
e. Don't keep the power supply ON for inspecting the DUT during test.
f. Don't allow non-trained operator to control or operate the test facility.
g. Don't place any tools or loose parts around/on the test setup.

GLOSSARY:

DUT	Device under test
ERC	Engineering Research Center
IEC	International Electro-technical Commission
TS	TATA Specification
T spec	TATA Specification
JIS	Japan Industrial Standards
V	Voltage
I	Current
R	Resistance
RH	Relative Humidity
RPM	Revolution Per minute
Ω	Ohms
M	Mega
K	Kilo
N	Newton
Deg C / °C	Degree Celsius
s	Seconds
min	Minutes
hr / hrs	Hour/Hours
NaCl	Sodium Chloride
Li	Lithium
ml	Milliliter
Hz	Hertz
m/s	Meter / second
DC	Direct current
AC	Alternating current
Nm	Newton meter
RMS	Root Mean Square
PSD	Power Spectral Density
JASO	The Society of Automotive Engineers of Japan
V_a	System voltage when engine/alternator running
V_b	Battery voltage/ Supply voltage
TML	TATA Motors Ltd.
RT	Room Temperature

4.0 UPDATION DETAILS:

SR. NO.	PREPARED BY	APPROVED BY	ISSUE NO.	DATE	AMENDMENTS
1.	Viplav Waghmare	M. P. SHINDE	5	17.10.2014	Water Drip Test added on page 27 to 31. Voltage & temperature tolerance band updated.
2.	Manoj Parashar	M. P. SHINDE	4	31.12.11	Test cycle for Dew formation added on Pg 45, Section 3.2.17
3.	D. M. Chaugule	M. P. SHINDE	3	11.08.08	New Release

PREPARED BY	CHECKED BY	APPROVED BY	ISSUE NO.	DATE
Viplav Waghmare	Aniend V / Preesty T J	M. P. Shinde GM ERC-Indoor Testing	5	17.10.2014