# Specification for Testing Automotive LED Modules



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# SPECIFICATION FOR TESTING AUTOMOTIVE LED MODULES

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## 1. SCOPE

This specification is a general level subsystem light source specification that establishes test requirements of Light Emitting Diode (LED) components and modules for use in automotive lighting systems.

The completed test data to this test specification is intended to be provided to the OEM by the Tier I lamp set maker as part of the lamp assembly PPAP. Re-testing shall be required if any portion of the approved LED modules experiences a design, manufacturing or component change.

This document shall be applied to systems that meet the requirements for design, performance and validation established by government standards.

The LED module is defined as the LED devices and any electronics required to properly energize the LEDs using vehicle electrical power system along with any associated electrical wiring, connectors and thermal management system. Samples shall be tested as a subsystem and considered one test sample for the entire test sequence. A failure of any component in the test sample shall constitute a failure of the entire sample. *If other manufactures components are intended to be approved for use in the LED modules, then those possible combinations of components shall be considered a new LED module and shall also be tested.*

Additional testing may be required by individual OEM's to meet specific EMC, quality, reliability and durability objectives.

The following tests are to be performed under the following conditions:

- New sample
- Design or process change made to an existing module
- Completion of one calendar year as noted in the "ANNUAL TESTS" Table shown in the Appendix. *(Note: Production process control data, collected at a shorter interval per an approved control plan, may be substituted if approved by customer's responsible engineer and purchasing representative.)*



## 2. SAFETY PRECAUTIONS

Reference IEC 62471.

## 3. REFERENCE STANDARDS

In the event of a conflict between the text of this specification and the documents cited herein, the text of this specification takes precedence. Nothing in this specification, however, supersedes applicable laws and regulations unless a specific exemption has been obtained. The latest issue of reference documents shall apply.

- AEC Q101, AEC Q100, AEC Q200
- AIAG/APQP-2: Chrysler, Ford, and General Motors Advanced Product Quality Planning and Control Plan Reference Manual
- AIAG/MSA-3: Measurement Systems Analysis Reference Manual
- AIAG/FMEA-3: Potential Failure Mode and Effects Analysis Reference Manual (SAE J1739)
- AIAG/PPAP-3: Chrysler, Ford, and General Motors Production Part Approval Process Manual
- ASTM B117 (Standard Practice for Operating Salt Spray Fog Testing Apparatus)
- Chrysler, Ford, and General Motors Quality System Requirements-TS-16949 Manual
- AIAG Fundamental Statistical Process Control Reference Manual
- ASTM E595 - 07 Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment
- IEC 60068-2-1, Cold
- IEC 60068-2-2 Ba, Dry Heat
- IEC 60068-2-14 Na, Rapid Change of Temperature With Prescribed Time of Transition
- IEC 60068-2-14 Nb, Change of Temperature with Specified Rate of Change
- IEC 60068-2-27 Ea, Mechanical Shock
- IEC 60068-2-32 Ed, Free Fall
- IEC 60068-2-64, Vibration
- IPC-A-610D Acceptability of Electronic Assemblies
- ISO 16750-1 Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 1: General
- ISO 16750-2 Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 2: Electrical loads
- ISO TC 22/SC 3/WG 13 N139 Road vehicles-Environmental conditions and testing for electrical and electronic equipment – Part 1: General
- ISO TC 22/SC 3/WG 13 N140 Road vehicles-Environmental conditions and testing for electrical and electronic equipment – Part 2: Electrical loads
- ISO TC 22/SC 3/WG 13 N142 Road vehicles-Environmental conditions and testing for electrical and electronic equipment – Part 3: Mechanical loads
- ISO TC 22/SC 3/WG 13 N141 Road vehicles-Environmental conditions and testing for electrical and electronic equipment – Part 4: Climatic loads
- ISO 2575 Index M – Electrical Functions in General and Electric Road Vehicles
- SAE/USCAR – 2, Performance Standard for Automotive Electrical Connector Systems.
- SAE/USCAR – 12 Wiring Component Design Guidelines
- SAE/USCAR – 20 Field Correlated Life Test Supplement To SAE/USCAR-2
- SAE/USCAR – 21 Performance Specification for Cable-To-Terminal Electrical Crimps
- SAE/USCAR – 34 Specification for Testing Automotive Lamp Assemblies
- SAE specification for LIN control SAE J2602
- SAE J575 – Test Methods and Equipment for Lighting Devices and Components for Use on Vehicles Less Than 2032 mm in Overall Width
- SAE J578 – Color Specification
- SAE J1128 – Low Voltage Primary Cable
- SAE J1330 – Photometry Laboratory Accuracy Guidelines
- SAE J1344 – Marking of Plastic Parts
- SAE J1383 – Performance Requirements for Motor Vehicle Headlamps

- SAE J1673 – High Voltage Wiring Assembly Design
- SAE J1889 – L.E.D. Signal and Marking Lighting Devices
- SAE J2357 – Application Guidelines for Electronically Driven and/or Controlled Exterior Automotive Lighting Equipment
- SAE J2602 – LIN Network for Vehicle Applications
- SAE J2650 – Performance Requirements for Light Emitting Diode (LED) Road Illumination Device Systems
- SAE J2938 – LED Light Source Tests and Requirements Standard
- VDA 260 Marking Standard – Federation of the Automobile Industry
- Q7-K: Chrysler, Ford Motor Company and General Motors TS-16949 Supplier Quality Requirements

**Copies of the AIAG Manuals can be obtained from AIAG (Automotive Industry Action Group) by calling (248) 358-3570 or by writing to AIAG, Dept. 77839, Post Office Box 77000, Detroit MI 48277-0839, Attn: Customer Service.



## 4. DIAGRAMS AND DEFINITIONS

### 4.1 APPENDICES

Diagrams are provided at the end of this specification to clarify the details of the test procedures. A Glossary of Terms is also included in the Appendix.

## 5. GENERAL REQUIREMENTS

### 5.1 RECORD RETENTION

Supplier must maintain a file for the storage of laboratory reports and calibration records, and establish a record retention policy concerning these records in accordance with TS-16949 and PPAP requirements. These records need not follow a standard format, but must present the required data in an orderly, professional manner. The file must be made available to any and all customer personnel upon request, including—but not limited to—representatives from the following areas: product engineering, purchasing, quality, and reliability.

#### 5.1.1 Objectives of Record Retention

Following are the main objectives for retention of test documents or records:

1. Retain records that will evidence compliance so that the supplier can appropriately respond when or if product compliance is challenged. Files must exist for the storage of all laboratory records, data, and calibration records. The files must be available at any time for audit or inspection.
2. Retain records as needed to assist in evidencing the exercise of "due care" in matters relating to product compliance, government requirements, or product liability.
3. Comply with statutory requirements for the maintenance and retention of specific records.

### 5.1.2 Retention Methods

Methods of retention may include retention of original documents, the use of film, or the use of electronic storage equipment. Records shall be stored so that they are accessible in a reasonable amount of time. Storage areas should provide adequate protection from unauthorized access, moisture, and fire.

## 5.2 SAMPLE DOCUMENTATION AND RETENTION

Engineering test samples must be identified by Industry Accepted Trade Number and manufacturer's serial number unless otherwise noted. Documentation must identify the type of test performed and describe special tests that are not a part of this specification. (Reference TS-16949 and PPAP requirements)

### 5.2.1 Required Data Package

Supplier must submit the data package for the appropriate level of submission to the customer's responsible engineer and purchasing division for approval signatures.

#### 5.2.1.1 PRODUCTION PROCESS APPROVAL

The LED Module design shall be capable of meeting the requirements of Automotive Industry Action Group (AIAG) document "Production Part Approval Process" (PPAP).

### 5.2.2 Sample Retention

Samples tested to attain part approval must be retained by the manufacturer for a period of time specified in the PPAP Manual.

## 5.3 POWER SOURCES

Supplier must use voltage regulated DC power sources for all tests to simulate an automotive battery and charging system. When Pulse Width Modulation (PWM) can be used to energize or control a function, the PWM supply shall be duplicated in each test. When vehicle electrical power system uses a Pulse Width Modulation (PWM) power supply to energize an LED module then the test must also use a PWM power supply of similar frequency and duty cycle.

### 5.3.1 Output Current

The power source must be capable of supplying a continuous output current as required by the design loads, including inrush current. Where required to simulate automotive inrush current conditions, an automotive battery or batteries with sufficient cold cranking amps may be connected in parallel with the power supply.

### 5.3.2 Output Voltage

The power source must be capable of supplying an output voltage that must not deviate more than 0.1 volt from the nominal setting over the entire load range (including surges). The power source must recover 63% of its maximum excursion within 5.0 milliseconds. Ripple voltage must not exceed 25 mV peak to peak. Power supplies used for photometric measurements must conform to SAE J1330.

## 5.4 EQUIPMENT TOLERANCES

Supplier must use test setups and equipment capable of measuring test parameters (nominal) within the limits found in Table 1.

**Table1: Equipment Tolerance**

| | |
|---|---|
| Test Chamber Temperature/Humidity | nominal ± 2 °C<br>Relative Humidity ±5% |
| Time | nominal ± 0.5% |
| Forces | nominal ± 0.1 N |
| Distances | nominal ± 0.1 mm |
| Voltages | nominal ± 0.1 V |
| MSCD | nominal ± 2.0% |

NOTE: This table is not to be used for performance dependent variable (Refer to section Measurement Accuracy).



## 5.5 MEASUREMENT ACCURACY

Meters and gauges used to assess the performance dependent variable, as defined by the basic function of the test sample, must have a smallest unit of measure one order of magnitude less than the least significant digit specified. For example, even though a 0.6 mm and 0.60 mm wire might be the same diameter, calipers capable of 0.01 mm resolution may be used to measure the first wire, but a micrometer with 0.001 mm resolution is needed for the second wire.

## 5.6 TEST REPEATABILITY AND CALIBRATION

### 5.6.1 Equipment Repeatability

All measurement equipment used for product evaluation must be repeatable to within 10% of the part tolerance according to Chrysler, Ford, and General Motors Measurement Systems Analysis Reference Manual.

### 5.6.2 Equipment Calibration

Equipment re-calibration/re-certification timing is to be calculated based on the capability of any individual instrument to retain its "Manufacture Stated Accuracy" between recall periods. However, this time shall not exceed one year.

### 5.6.3 Laboratory Masters (Photometry Only)

Lamps which are traceable to known standards are laboratory masters. Each supplier must use laboratory masters for comparison measurements, calibration of test equipment, and for evaluating long-term drift in test equipment.

## 5.7 TEST DEFAULT CONDITIONS

Tests shall be conducted under conditions and methods specified herein. When specific test conditions are not given, the following basic conditions apply.

1. Voltage input to LED module, unless otherwise specified
   - Nominal voltage Vnom shall be 13.5 Vrms
   - Low voltage Vlow shall be 9.0 Vrms
   - High voltage Vhigh shall be 16.0 Vrms
   - Any inputs which are intended to incorporate Pulse Width Modulation (PWM) shall be energized in that manner using the frequency specified by the OEM
2. Any signals utilized to control or communicate shall be included in the test setup
3. Perform tests or measurements at the following ambient temperature 23°C +/ - 2°C unless otherwise specified.

## 5.8 TEST SHARING WITHIN LIGHT SOURCE FAMILIES

The results of tests performed on one light source type may, in some cases, be used to indicate the capability of another light source type within the same family.

## 5.9 TEST FAILURE PROCEDURE

Should a test failure occur, the customer (Quality, Purchasing, and Design/Release Engineer) shall be notified immediately.

## 5.10 CONTROL PLANS

Supplier must maintain a control plan, consistent with the AIAG, for each LED component or module that contains appropriate controls to ensure that all the significant/critical characteristics covered by the tests in this document are met.

## 5.11 RELIABILITY PROGRAMS AND METHODS

### 5.11.1 Reliability Growth and Ongoing Quality Improvements

Suppliers must establish and implement a plan to improve demonstrated product quality and reliability. They must establish procedures for analyzing and correcting end-of-line defects and predominant failure modes identified by the field return program. True reliability growth occurs when design changes to the design or manufacturing process are made to eliminate the failure modes.

### 5.11.2 Notification of Process Changes

PPAP resubmission and approval is required unless all customers agree that PPAP resubmission is not required.

### 5.11.3 Quality/Reliability Improvement Tools

Suppliers must use appropriate methods to improve the quality and reliability of their products in accordance with TS-16949. Examples of such methods are Field Return Programs, Design Failure Mode Effects Analysis (DFMEA), Process Failure Mode Effects Analysis (PFMEA), and Fault Tree Analysis (FTA) or Fishbone Diagrams. Further information on these methods is available from the Automotive Industry Action Group (AIAG).

## 5.12 HAZARDOUS MATERIAL RESTRICTION

Any regulated substance that is identified by any federal, state, provincial, or local government unit or automotive manufacturer, shall not be used in the manufacturing process of any LED module components. Any LED module components manufacturer that is currently supplying hazardous material in a component will submit a timeline to General Motors, Ford, and Chrysler for the removal of said product.

Materials selected for use in the LED modules shall not produce corrosive or deleterious fumes under manufacturing, assembly, operating or test conditions stated herein. Materials used within the .

### 5.12.1 RECYCLABILITY

The LED module is considered a recyclable item and the design shall utilize recyclable materials where practical.

#### 5.12.1.1 RECYCLING INFORMATION

The LED modules shall be marked with recycling information with either specific instructions or molded marking in accordance with SAE J1344, VDA 260, or equivalent document as appropriate.

### 5.12.2 ITEM DIAGRAM

A block diagram for the LED modules and interfacing elements is required. Internal partitioning, content, design and construction details to meet requirements of this specification are at the discretion of subsystem supplier except as otherwise specified herein.

## 5.13 DOCUMENTATION

### 5.13.1 Component

The LED components used in a LED Module shall be documented and provided in the PPAP. The documentation shall identify the LED supplier, LED supplier part number, LED package type, LED encapsulation method, output viewing angle, the color BINs used, forward voltage, and flux or brightness, any voltage and color matching requirements for the module, along with the required current draw for each flux or brightness BIN.

### 5.13.2 Module

The PPAP shall document the module input operating voltage, current, functional behavior, and power dissipation across the operation temperature and I/O voltage range which produce the required functions at a level required by the OEM.

Any fault detection functionality, including outage detection used to comply with regulatory requirements, shall be described in the design specification for the module. The fault detection design shall be approved by the Customer prior to module design freeze. Test requirements shall be generated to validate these functionalities and included as part of the PPAP.



## 6. ANALYSIS

The Analysis shall be used to aid in designing reliability into the component during the time when physical components are not yet available. Analysis should be the earliest activity in the A/D/V process. All Analytical activities shall be documented and provided to the Customer, including results. Analytical activities shall be completed prior to the design freeze.

### 6.1.1 Reliability

Reliability of each system including LEDs and any drive electronics shall be demonstrated based on the lifetime requirements outlined in the Luminous Intensity Maintenance section 10.1 of this document using reliability assessment MIL-HDBK-217F. Assessments shall be made for the module at its intended drive conditions and expected temperature conditions. Any component database assumptions shall be reviewed and approved by the Customer. The output should be a chart of the predicted Yearly Failure Rate in PPM or in R/1000 over operating temperature and hours of operation per year.

### 6.1.2 Nominal and Worst Case Analysis

A circuit analysis to determine voltage, current and power dissipation for each part across the operation temperature and supply and I/O voltage range shall be performed and provided. The analysis shall include a plot of current through the LEDs versus module voltage across all temperature extremes. This analysis shall verify that the design of the circuit is capable of producing the required functions under all conditions.

# 7. LED MODULE COMPONENTS

## 7.1 MODULE COMPONENTS

All electronic components contained within LED modules shall comply with all LED specifications contained in IEC 60810 and applicable AEC-Q100. In addition, all passive components shall comply with all AEC Q200 tests referenced in Tables 2 through 14 and all Integrated Circuits shall comply with all AEC - Q100 Stress Qualification for Integrated Circuits.

If any tests are considered not applicable, these exceptions shall be agreed to by the Customer. LED Module Assemblies shall adhere to the applicable requirements and recommendations contained in IPC-A-610D Acceptability of Electronic Assemblies at a Class 3 level.

Electronic modules which have a portion of the device protected in service by the lamp assembly may have that portion of the electronic module similarly shielded during the test.

All LED packages with Gold bond wires shall only use Gold Lead Frames unless the LED package has protection against corrosion (Example: Silver protected from Sulfur corrosion by epoxy encapsulation, etc).

## 7.2 LUMEN / CHROMATICITY MAINTENANCE

LED lumen maintenance testing shall be conducted according to IES LM-80-08 with the following modifications:

- Section 4.4.2 Temperature and Humidity: The third case temperature (Ts) specified in 4.4.2 shall be set at the maximum specified case temperature for the LED powered at the maximum current rating specified for the LED.

- If the maximum specified current rating and the maximum specified case temperature for the LED do not converge at a single point (Figure 1 - point a), both the maximum current rating set at the maximum case temperature for that current rating (Figure 1 - point b) and the maximum specified case temperature set at the maximum current rating for that temperature (Figure 1 - point c) shall be tested. See Figure 1.

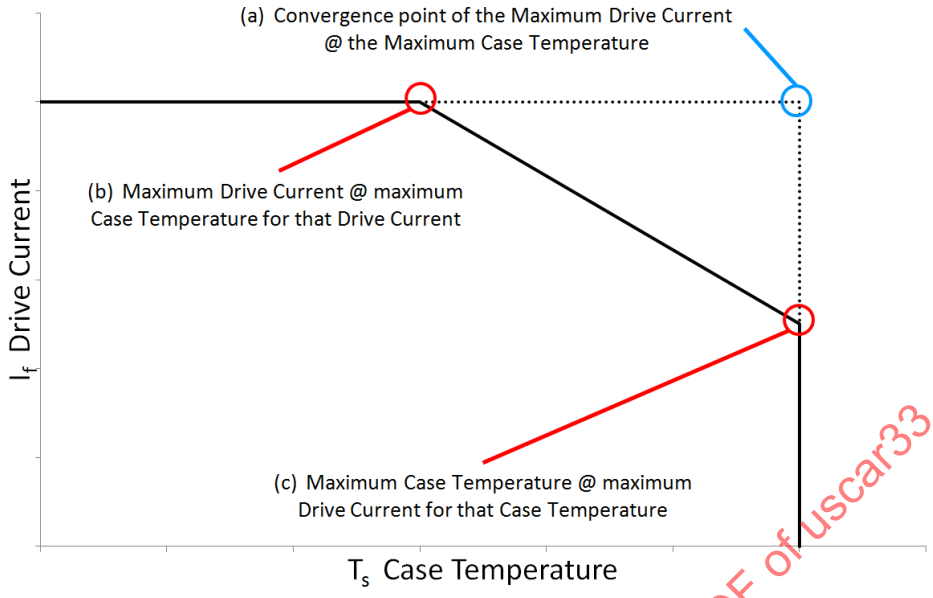



Figure 1: LED Forward Drive Current vs Case Temperature

- Section 5.3 Input Current Regulation: The current shall not be de-rated as a function of temperature when tested at the maximum case temperature specified above.
- Section 7.1 Lumen Maintenance Testing Duration and Interval: The testing interval when tested at the maximum case temperature specified above shall be no more than 500 hours. Lumen maintenance testing of the LED can be halted if the lumen maintenance drops below 50%. Catastrophic failures during testing shall be included in the lumen maintenance calculation.
- Section 7.4 Chromaticity: During the test, the color shall not shift more than 1 adjacent color Bin according to IEC 62707-1.

## 7.3 LED BINNING

White LEDs shall be Binned for color according to IEC 62707-1: LED – Binning – Part 1: General requirements and white grid and according to IEC 62707-2 & 3 for light output and forward voltage, when published.

Individual modules, regardless of LED color, shall be manufactured using a single color Bin, a single forward voltage Bin, and single intensity LED Bin (if not compensated in the module circuitry).

## 7.4 LED OVERSTRESS TESTING

### 7.4.1 Purpose

To determine the performance of an LED subjected to overstress conditions.

### 7.4.2 Test Samples

Each LED type and LED color shall be tested through each Stress Test as indicated in Table 2. A minimum of 78 LEDs are required for each stress test. LEDs shall be taken from 3 different production batches of 26 each.

### 7.4.3 Procedure

Test details are given in Table 2. Monitor LED function at regular intervals with a minimum of once a week. LEDs shall be energized such that any LED failures shall not impact the function of other LEDs.

### 7.4.4 Required Data Criteria

Data shall be provided for each Stress Test for each LED type for all samples tested. Any deviations shall be noted on the test report. Note: There are no acceptance criteria for these tests



**TABLE 2. LED OVERSTRESS TESTS**

| Stress Test | Mid Power (≤1 Watt) LED Stress Conditions | High Power (1> Watt) LED Stress Conditions | Stress Duration | Minimum Sample Size(1) | Data to Provide |
|---|---|---|---|---|---|
| High Temperature Operating Life (HTOL)(2) | $T_c$ set such that Tj = Tjmax + 30°C<br>$I_f$ = 150% $I_{f(max)}$ mA(3) | $T_c$ set such that Tj = Tjmax + 15°C<br>$I_f$ = 125% $I_{f(max)}$ mA(3) | Minimum 50% of sample size failed<br>Maximum1500 Hours | 78 | Measure and record LED parameters at beginning of test, and the surviving LEDs at the end of the test. Parameters to measure are light output, forward voltage, and color following ISO/IEC standards.<br><br>Provide parameter measurement results on all samples tested.<br><br>Use BINNING current for measurement above<br><br>Indicate any failure times |
| Low Temperature Operating Life (LTOL)(2) | $T_c$ = -40C<br>$I_f$ = 150% $I_{f(max)}$ mA(3) | $T_c$ = -40C<br>$I_f$ = 125% $I_{f(max)}$ mA(3) | Minimum 50% of sample size failed<br>Maximum1500 Hours | 78 | |
| Wet High Temperature Operating Life (WHTOL)(2) | 85°C / 85%RH Ambient<br>$I_f$ = 150% $I_{f(max)}$ mA(3) | 85°C / 85%RH Ambient<br>$I_f$ = 125% $I_{f(max)}$ mA(3) | Minimum 50% of sample size failed<br>Maximum1500 Hours | 78 | |
| Powered Temperature Cycle (PTMCL)(2) | -40°C to 25°C Ambient<br>10 minutes dwell, 20 minutes transfer (1 hour cycle), 2 minutes ON / 2 minutes OFF,<br>$I_f$ = 150% $I_{f(max)}$ mA | -40°C to 125°C Ambient<br>10 minutes dwell, 20 minutes transfer (1 hour cycle), 2 minutes ON / 2 minutes OFF,<br>$I_f$ = 130% $I_{f(max)}$ mA | Minimum 50% of sample size failed<br>Maximum1500 Cycles | 78 | |
| Thermal Shock (TMSK)(2) | -55C/150C Ambient<br>10 second transfer<br>Dwell time 15 minutes | -55C/150C Ambient<br>10 second transfer<br>Dwell time 15 minutes | Minimum 50% of sample size failed<br>Maximum 3000 Cycles | 78 | |

$T_{j,max}$ = Maximum manufacturer specified LED junction temperature (reference SAE J2938)
$T_j$ = LED junction temperature (Tjunction = Tcase + maximum power dissipation * thermal resistance)
$T_{s,max}$ / $T_{cmax}$= Maximum manufacturer specified case temperature as specified by the manufacturer of the package (reference IES LM-80-08)
$T_s$ / $T_c$ = Case temperature measured as specified by the manufacturer of the package (reference IES LM-80-08)
$I_{f(max)}$ = Maximum manufacturer specified current (mA)
$I_f$ = Specified current
Failure = open or short / no light output

Note: $T_s$ can be used instead of $T_j$ if the manufacturer specifies the LED package in this way

1. 78 LEDs taken from 3 different batches (production lot) of 26 each shall be used for each test.
2. For all surface mount solder reflowable: Preconditioning per AEC Q101 at 85°C and 85% RH for 168 hours (JEDEC LEVEL 1 MSL) followed by three Pb-Free reflow solder cycles. Reflow cycles shall be completed between 15 minutes and 4 hours after preconditioning is completed.

# 8. LED MODULE ASSEMBLY TESTING

## TEST SAMPLES

All tests shall be conducted using LED modules representative of production assemblies.

LED modules shall include the vehicle power input interface, all light output devices, and any other required components for proper operation of the module in the lamp assembly including circuit boards, wiring, connectors, heat sinks, etc. Any electrical interface to the vehicle shall be represented in the module i.e. lamp connector and vehicle connector represented. Electronic modules which have a portion of the device protected in service by the lamp assembly may have that portion of the electronic module similarly shielded during the test. Conformal coating is not required, but should be considered as a means to comply with requirements in this standard.

If general approval is sought for a reuse module, the highest wattage and the lowest wattage light output devices shall be utilized during testing and all potential activation configurations shall be represented. An activation matrix (Truth Table) showing each potential combination of inputs/outputs and LED state shall be provided with the PPAP documentation.

## ENVIRONMENTAL CONDITIONS

Unless otherwise specified in any individual test, for purposes of environmental testing, nominal voltage $V_{nom}$ shall be design voltage, low voltage $V_{low}$ shall be 9.0 volts and high voltage $V_{high}$ shall be 16.0 volts. The operating voltage shall be nominal for 80%, low for 10% and high for 10% of the functional tests and/or cycles.

The LED module shall be designed to meet all performance requirements while exposed to steady state or oscillating ambient temperatures ranging from -40 °C to Tmax °C, as defined in Table 5.



## 8.1 TEMPERATURE SOAK

Temperature soak simulates the LED Modules exposed to hot and cold temperatures for prolonged periods of time during storage or use.

Reference IEC 60068-2-2, Dry Heat Test Ba ($T_{Max}$ as defined in Table 5) for a minimum duration of 96 hours and IEC 60068-2-1, Cold Test Aa ($T_{Min}$ is -40 °C) for a minimum duration of 72 hours.

### 8.1.1 Test and Measurement Apparatus

1) Environmental Chamber (circulating air type) Capable of $T_{Min}$ = -40 °C and $T_{Max}$ as defined in Table 5.
   - The environmental chambers shall be capable of maintaining the atmosphere at the appropriate temperature for the test in any region where the specimen is placed.
   - The absolute humidity in the chambers shall not exceed 20 $g/m^3$
   - The air in the chambers shall be circulated. Air velocity measured close to the test specimen shall not be greater than 2 m/s.
2) Power Source per section 5.3.

3) LED Module Mounting Fixture
   - The LED Modules shall be tested using mounting or supports with low thermal conduction, such that for practical purposes the specimen is thermally isolated. When testing several specimens simultaneously they shall be so placed that free circulation should be provided between specimens and between chamber surfaces.
   - The LED Module may be mounted in a lamp housing as designed in the lamp or otherwise protected during this testing; however, all interfaces, connectors and wiring must be exposed.

### 8.1.2 Procedure

1) Mount the LED Module on the fixture using the devices attachment points. Place the LED module(s) in the thermal chamber. No component of the LED Modules shall come into contact with the chamber surfaces.
2) Power the LED Modules to verify function.
3) Remove power from LED Modules during temperature soak.
4) Set chamber settings to $T_{Max}$ and a maximum 50% relativity humidity and allow to stabilize.
5) Soak the LED modules in the thermal chamber at $T_{Max}$ for 96 hours.
6) At the end of the 96 hour soak, power the LED Modules to verify function..
7) Remove power from LED Modules.
8) Allow to cool to room temperature. The thermal chamber door can be opened to expedite the cooling.
9) Lower the chamber temperature to $T_{Min.}$ and allow to stabilize.
10) Soak at $T_{Min}$ for 72 hours.
11) At the end of the 72 hour soak, power the LED Modules to verify function..
12) Remove power from LED Modules.
13) Allow the chamber to reach room temperature. The thermal chamber door can be opened to expedite the cooling.
14) Power the LED Modules for 1 minute at 13.5 Vdc.

### 8.1.3 Acceptance Criteria

1) The LED Module shall not show any evidence of visible fractures, warpage or deformation.
2) The light source shall illuminate continuously each time it is powered.

## 8.2 THERMAL SHOCK IN AIR (TS).

### 8.2.1 Purpose

The LED Module shall be designed to withstand thermal stresses due to power cycling and rapid changes in ambient temperature without degradation in performance.

The LED Module may be mounted in a lamp housing as designed in the lamp or otherwise protected during this testing; however, all interfaces, connectors and wiring must be exposed.

This is an accelerated test to evaluate failure mechanisms, which may be driven by mismatches in coefficients of thermal expansion.

### 8.2.2 Test and Measurement Apparatus

1. Environmental Chamber (circulating air type) #1 @ $T_{Min}$ = -40 °C
2. Environmental Chamber (circulating air type) #2 @ $T_{Max}$ as defined in Table 5.
   - The environmental chambers shall be capable of maintaining the atmosphere at the appropriate temperature for the test in any region where the specimen is placed.
   - The absolute humidity in the chambers shall not exceed 20 $g/m^3$
   - The volume of the chambers and the air velocity shall be such that after insertion of the test specimens, the temperature within the chambers shall be within the specified tolerance after a time of not more than 10% of the exposure time.
   - The air in the chambers shall be circulated. Air velocity measured close to the test specimen shall not be greater than 2 m/s.
3. Power Source per section 5.3.
4. LED Modules Mounting Fixture:
   - The LED Modules shall be tested using mounting or supports with low thermal conduction, such that for practical purposes the specimen is thermally isolated. When testing several specimens simultaneously they shall be so placed that free circulation should be provided between specimens and between chamber surfaces.
   - May be mounted in a lamp housing or otherwise protected during this testing; however, all interfaces, connectors and wiring must be exposed.

### 8.2.3 Procedure

Reference IEC 60068-2-14 Na. Upon agreement, this test can be performed during the development process without a case (or with a modified case).

1. Test Chamber #1 and #2 shall be stabilized to $T_{Min}$ and $T_{Max}$ respectively, prior to inserting test specimens.
2. The LED Modules shall soak at $T_{Min}$ for 10 minutes and then transferred to test chamber #2.
3. Transfer time between chambers shall not exceed 30 seconds.
4. The LED Modules shall soak at $T_{Max}$ for 20 minutes.
5. Repeat steps 2 through 4 for a minimum number of 1000 cycles. (refer to Table 3 Combined Thermal Shock / Power Temperature Cycling)
6. Lamp shall be energized once daily for 10 minutes at $T_{Max}$ °C and once daily at –40 °C for the last 2 minutes of the 10 minute soak.
7. Test shall be stopped if LED module fails to illuminate when energized.

### 8.2.4 Acceptance Criteria

The light source shall illuminate each time it is operated and at the completion of the test.
Solder joints shall be inspected at 250 cycles, 500 cycles, 750 cycles, and 1000 cycles. Any visual evidence of joint cracking or delaminating is considered a failure unless approved by the OEM.

## 8.3 THERMAL SHOCK WATER

### 8.3.1 Purpose

To verify the LED Modules functionality after exposure to sudden changes in temperature after a cold water splash on a hot system/component. The aim is to simulate driving through water in the wintertime.

### 8.3.2 Test and Measurement Apparatus

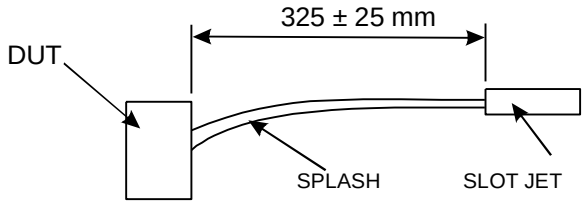
1. Spray Chamber
2. Spray Nozzle (Reference ISO WD 16750-4 N142)
    - Jet specification: Slot jet, see Figure 3.
    - Width of jet slot: 1.2 mm
    - Length of jet 220 mm
    - Water flow: (1.00 to1.33) l/s
    - Water temperature 0 to 4°C
    - If the test is conducted with several LED Modules at the same time, a jet for splashing shall be provided for each LED Module.
3. Test Fluid – de-ionized water with 3% fine Arizona dust according to ISO 12103-1; 5 % NaCI may be added.
4. LED Modules Mounting Fixture
    1. LED Module mounted as in vehicle position, accommodating any module sealed connections and mounting surfaces. (Vehicle lamp assembly may be used)
    2. Distance between the spray jet and the LED Module surfaces shall be 325mm +/- 25mm (water shall be applied over the complete width of the exposed surfaces of the LED Module components)

### 8.3.3 Procedure

1. The LED Modules is to be electrically connected as in the vehicle in the normal driving mode and continuously monitored. Any sealed connections on the module shall simulate vehicle interface. The LED Modules light source shall be inside an enclosure such as a lamp assembly to shelter the light source from water.
2. Heat the LED Module and associated components (if any) to Tmax by placing it in a thermal chamber (see Table 5) and hold this temperature for 30 min.
3. While in the thermal chamber, energize LED Module at nominal voltage during the last 15 min.
4. Quickly (within 20 s) move the LED module and associated components (if any) from the thermal chamber to the water spray chamber and splash the hot LED Modules exposed component with chilled water of 0 to 4 °C temperature for 3 s duration from one direction while being in as-installed position. If the equipment is splashed from various directions in the vehicle, then these directions shall be taken into account. Provided that this is the case, a new LED Modules may be used for each splash direction. The width of the splash directed at the LED Module shall always be greater than the width of the LED Module. If LED Module of considerable size are splashed that prove too big for one jet, several jets shall be arranged in a row to produce a line of splash impact on the LED Module.
5. Repeat steps 2 – 4 100 times.

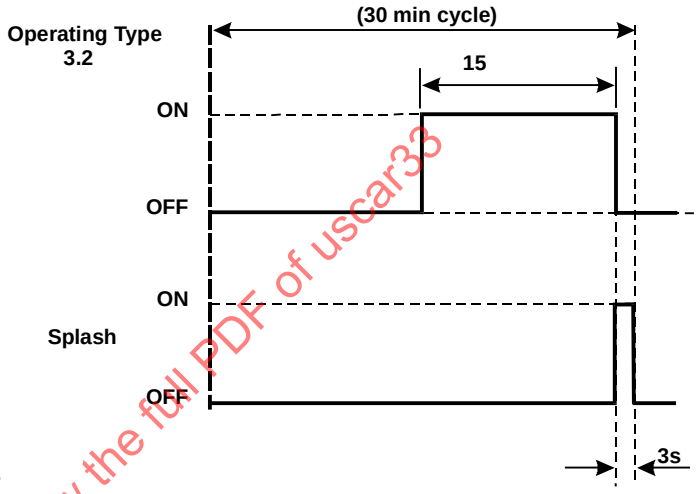
Note: It is permissible to place the water spray system within the thermal chamber; provided it meets the safety and operational limitations specified by the test equipment manufacturer and appropriate arrangement is made to drain the spray water/steam rapidly from the thermal chamber. If that option is used then it is obvious that the 20 s transport time between thermal chamber and spray chamber gets eliminated.

**DUT Location with Respect to Slot Jet**




DUT mounting according to as-installed condition in vehicle.

**Splash Cycle**





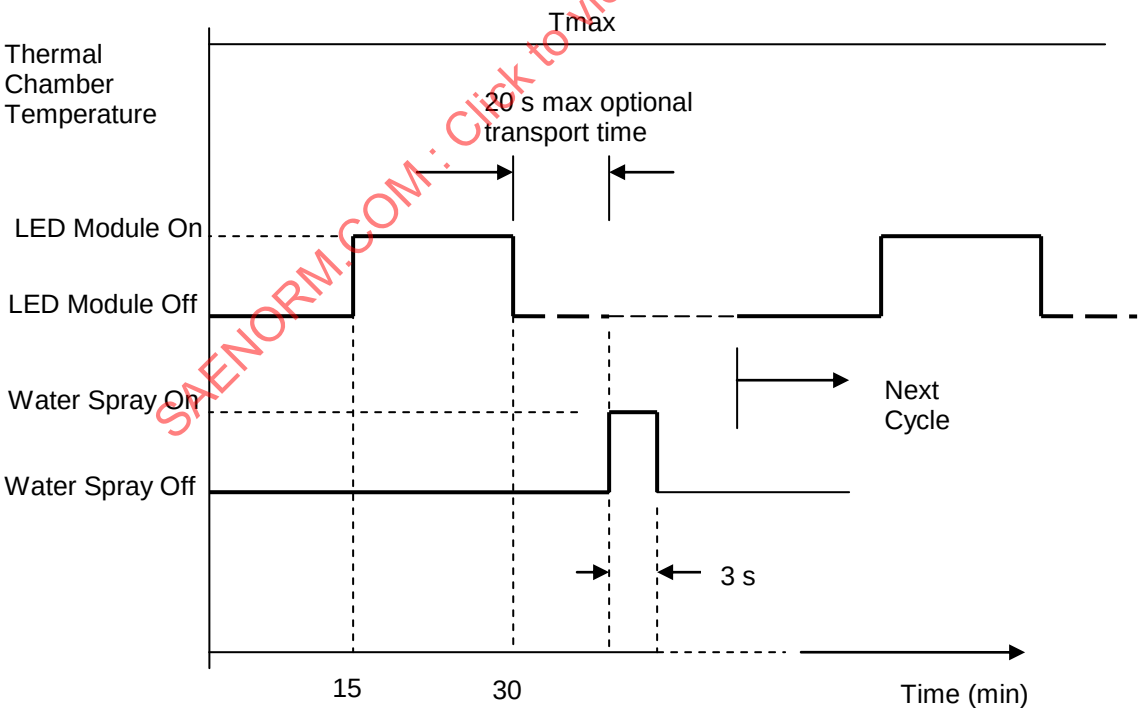




**Figure 2: Temperature Time Profile**

### 8.3.4 Acceptance Criteria

The LED Modules light source must function during 15 min lightup in each cycle of the test and meet requirements of pertinent sections for light up and luminous intensity after the test.

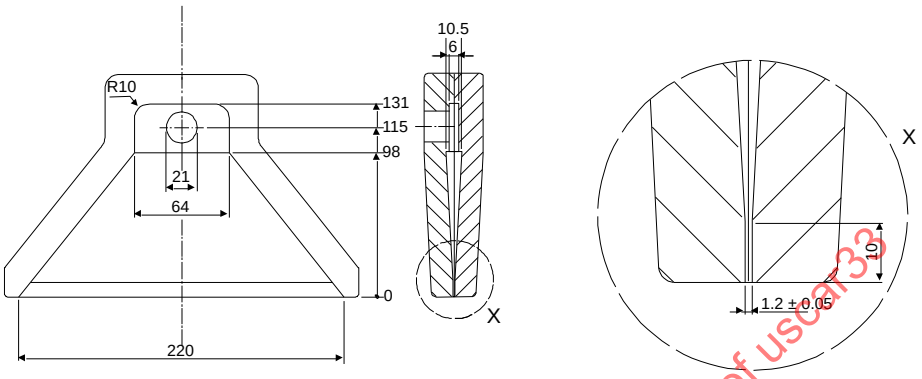



**Figure 3: Spray Nozzle**

| Temperature Range | Temperature Difference | | n-PTC-Test | Cycle Time - min | | Sam-ple Size n | N-Test | Number of Cycles | | Test Time |
|---|---|---|---|---|---|---|---|---|---|---|
| | Service | Test | | Ther-mal Shock | Power Temp | | | Ther-mal Shock | Power Temp | Days |
| (-40…+Tmax)°C | 70 | 145 | 1182 | 30 | 59 | 18 | 1329 | 300 | 729 | 36.1 |
| | 70 | 145 | 1182 | 30 | 59 | 18 | 1329 | 564 | 201 | 20 |
| | 70 | 145 | 1182 | 30 | 59 | 23 | 1176 | 300 | 576 | 29.9 |
| | 70 | 145 | 1182 | 30 | 59 | 23 | 1176 | 488 | 200 | 18.4 |

**Table 3: Combined Thermal Shock / Power Temperature Cycling**

## 8.4 POWER TEMPERATURE CYCLE (PTC) TEST.

### 8.4.1 Purpose

The purpose of this test is to determine if the LED Module is able to meet specification requirements when subjected to the power and temperature cycling stresses that cause failures related to mechanical attachments, integrated circuit dies, electro migration and solder creep.
The number of combined thermal shock and power temperature cycles shall be determined from the Table 3: Combined Thermal Shock / Power Temperature Cycling

### 8.4.2 Procedure

The PTC testing shall be performed according to IEC 60068-2-14 Nb. The input / output cycling shall be scheduled such that the required minimum number of 1 life cycle, as shown in Table 4, for each function is evenly distributed and achieved during the total PTC test. The test parts shall be powered between points “A” and “B” of the temperature-time profile shown in Figure 4. (Temperature profile of PTC test). The control instrumentation must be capable of synchronizing the LED Module on/off time with the chamber temperature transitions.

Table 4: Minimum Number of 1 Life Cycles

| | |
|---|---|
| (To be filled out by Customer Engineering and approved by OEM Engineering) | |
| Function | Number of Cycles |
| On / Off | 300 minimum |
| | |
| | |

Table 5: Power Temperature Cycle Parameters

| | |
|---|---|
| Temperature Range | -40 °C to Tmax<br>Tmax is equal to:<br>125°C when located under hood behind engine radiator<br>105°C when located under hood in front of engine radiator (typical headlamp)<br>105 °C when located in the interior above the belt line<br>85°C for all other locations unless otherwise specified by the customer |
| Operating Type | Normal operating mode with continuous monitoring. |
| Temperature Transition Rate | (3 ± 2) °C/min or modified with the approval of Engineering |
| Dwell time after temperature stability in the chamber has been reached | The time at -40 °C should be 10 minutes minimum. The time at Tmax °C should be 20 min minimum. |
| Minimum number of thermal cycles | 300 cycles (see Table 4). |
| Power on | At the end of the cold soak – Point “A” |
| Power off | At the end of the hot soak – Point “B” |
| Supply Voltage | % of Operational Cycles<br>$V_{low}$ 10<br>$V_{nom}$ 80<br>$V_{high}$ 10 |



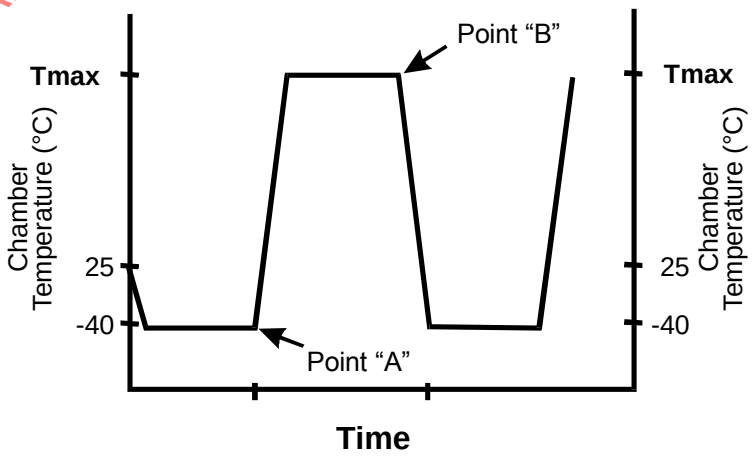



Figure 4: Temperature profile of PTC test

Apply power to all functions at end of cold soak, turn off at end of hot soak. Power shall be applied to all functions simultaneously regardless of if they can be powered simultaneously in the vehicle (ie DRL and Low Beam shall be powered simultaneously). Functions which are designed to flash shall flash during the test. Transition rate to be 3 +/- 2 deg C/min. Change Device Internal Temp to Chamber Temperature.

Any inputs/outputs in an incorrect state or any incorrect on vehicle messages shall be considered a nonconformance to specification requirements.

### 8.4.3 Acceptance Criteria

Samples shall operate normally during and at the conclusion of the test.

The lumen maintenance shall not change by more than 10 percent from the initial measurements when measured according to IES LM-80-08 or another repeatable method to measure lumen maintenance.

## 8.5 SALT FOG/SPRAY

### 8.5.1 Purpose

This test is designed to show the LED Module's ability to withstand exposure to salt spray and fog as experienced in coastal regions and road salt environments. This applies to externally mounted LED Module devices (e.g. module mounted external to the lamp assembly) Any sealed connections or areas on the module which are designed to be sealed in the final assembly shall be simulated.

### 8.5.2 Test and Measurement Apparatus

Salt Spray Chamber per ASTM B117

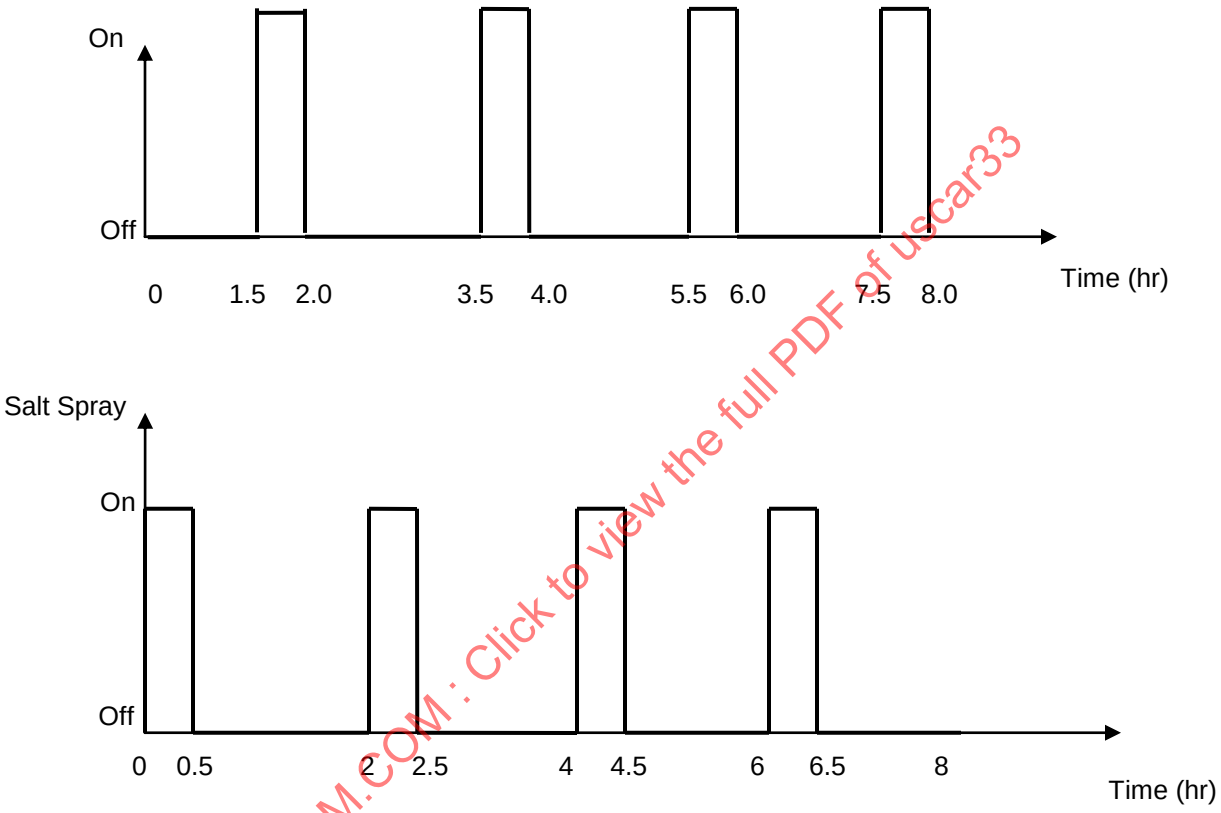
### 8.5.3 Procedure

1. The LED Module shall be set up in the "On Vehicle Position" such that it will not be exposed to dripping moisture. The vehicle interface connector and associated harness shall be connected to the LED module input at all times during this test with the opposite end of the harness kept outside the chamber or sealed off at the end. Similarly the output of the LED module must be connected to the LEDs using appropriate connector and wiring harness.
2. Measure initial contact resistance of the electrical connectors per ASTM B539 - 02(2008) Standard Test Methods for Measuring Resistance of Electrical Connections (Static Contacts)
3. This test requires LED Modules be subject to four 30 minute salt-water applications during each of the three environmental conditions defined below. Each salt spray application should be spaced (1.5 ± 0.01) hour apart. Each step shall be run done successively without interruption. (see Fig. yy below)
   a) Ambient Environment Soak – 8 hour at ambient room temperature with a relative humidity of (30 … 50) %.
   b) Humid Environment Soak – 8 hour at a temperature of +49 °C and a relative humidity of (95…100) %.
   c) Dry Environment Soak – 8 hour at a temperature of +60 °C and a relative humidity ≤30%.

      Note: One test cycle totals 24 hours

4. During 7th hour of 2(c) Dry Environment soak apply power to the LED Module for 15 minutes.
5. Repeat steps 2 and 3 for a total of 10 test cycles.
6. After the final cycle, verify function of the LED Module within 1 hour of test completion. The LED Module shall also be inspected for signs of corrosion. An external and connector cavity inspection is required at this time; an internal inspection is optional. The LED Module shall not be cleaned prior to proceeding onto other tests in the test sequence.

T






Salt spray timing is shown here. To complete one cycle of test this spray pattern has to be repeated three times; once under each of 2(a), (b) and (c) described above. In all ten test cycles are required.

### 8.5.4 Acceptance Criteria

The acceptance criteria for corrosion is not limited to conditions as observed at the end of the Salt-Spray Test. Since corrosion could start and continue at different parts of the test sequence, the corrosion acceptance criteria may apply to the entire sequence.

a) The LEDs connected to the LDM module must illuminate within specified limits.
b) No significant corrosion at the input /output terminals of the LED module as evidenced by change of contact resistance that is no less than 80% of the initial value.

c) Structural corrosion damage that reduces any structural physical properties of a material at the corrosion site is not acceptable. Structural corrosion damage is defined as corrosion related to material loss or degradation that weakens the physical properties related to the structural integrity and strength of the device/assembly/packaging. These properties include, but are not limited to, yield strength, hardness, pierce strength, mass buckling or flex resistance, etc.
d) Some external (cosmetic) corrosion, that does not affect performance characteristics of the system, may be allowed on surfaces, with agreement of customer.

## 8.6 HUMIDITY

Reference IEC 60068-2-38-Z/AD Cyclic Temperature/Humidity Test.

### 8.6.1 Purpose

The purpose of this test is to determine in an accelerated manner the resistance of specimens to the deteriorative effects of high temperature/humidity and cold conditions.

This cyclic temperature/humidity test is designed to reveal defects in test specimens caused by breathing as distinct from the absorption of moisture.

The test employs temperature cycling at high-relative humidity and will produce a “breathing” action. The accelerated breathing and the effect of the freezing of trapped water in cracks and fissures are the essential features of this composite test.



### 8.6.2 Test and Measurement Apparatus

1. One chamber capable of the following two parameters or two separate chambers.
    a. Temperature and humidity of 25 °C ± 2 °C to 65 °C ± 2 °C and 93% ± 3% relative humidity (rh) during constant and rising temperatures and 80% rh and 96% rh during falling temperature periods.
    b. The second low temperature must be maintained at -10 °C ± 2 °C.
2. Test Fixture(s) with LED Modules light source center axis mounted horizontal to the ground and module(s) mounted in any intended design position(s).
3. The LED Module connector that interfaces to the vehicle shall have a representative mating connector with sealed pigtail wires or plugged to avoid wicking of water through the wires.
4. The LED Module shall not be powered during exposure to the humidity cycles.

### 8.6.3 Procedure

1. Verify LED Module meets the requirements of the Photometrics Section prior to running this test.
2. Mount the LED Module to the test fixture(s) and place in the test chamber.
3. Expose the LED Module to the following humidity cycle(s).
4. **Temperature humidity sub-cycle** - Applicable to all cycles, see Figures 5-A and 5-B. At “zero time” of every 24 h cycle, the chamber condition shall be controlled to a temperature of 25±2°C and relative humidity of 93±3%.

a) The temperature of the chamber shall be continuously raised to 65±2°C in a period of between 1.5 and 2.5h. During this period, the relative humidity shall remain within the limits 80% and 96%.

b) The temperature and relative humidity in the chamber shall be maintained at 65±°C and 93±3% respectively until 5.5 h after the start of the cycle.

c) The temperature shall then be allowed to fall to 25±2°C in a period of between 1.5h and 2.5h. During this period, the relative humidity shall remain within the limits 80% and 96%.

d) Beginning 8h after the start of the cycle, the temperature shall again be continuously raised to 65±2°C in a period of between 1.5 and 2.5h. During this period, the relative humidity shall be 93±3%.

e) Beginning 13.5h after the start of the cycle, the temperature shall then be allowed to fall to 25±2°C in a period of between 1.5 and 2.5h. During this period, the relative humidity in the chamber shall remain within the limits 80% to 96%.

f) The chamber shall then continue to run at a stabilized temperature of 25±2°C and relative humidity of 93±3% until the start of the cold sub-cycle or until the end of the 24h cycle, as appropriate.

5. **Cold Sub-Cycle** - Applicable to any five of the first nine cycles (see Figure 5-A).
   a) Following the completion of the temperature humidity sub-cycle (a-f in Figure 5-A), the chamber is maintained at a temperature of 25±2°C and relative humidity of 93±3% for a period of at least one but not more than 2h.

   b) The specimen shall then be exposed to cold by lowering the temperature of the chamber or transferring to a second chamber. If the specimen is transferred from one chamber to another, the transfer should be completed within a period of 5 min. Beginning 17.5h after the start of the cycle, the ambient temperature of the chamber shall be reduced to -10±2°C. The temperature shall be reached 18h after the start of the cycle.

c) Beginning 18h after the start of the cycle, the temperature shall be maintained at -10±2°C. This temperature shall be reached 18h after the start of the cycle. No requirement for humidity is prescribed during the entire cold sub-cycle.

d) Beginning 21h after the start of the cycle, the temperature shall be raised to 25±2°C. This temperature shall be reached 22.5h after the start of the cycle (see Figure 5-A). If the specimen is transferred from one chamber to another, the transfer shall be completed within a period of 10min to 15min.

e) The temperature of the chamber shall be maintained at 25±2°C until the 24h cycle is completed. During this period, the relative humidity shall be 93±3%.

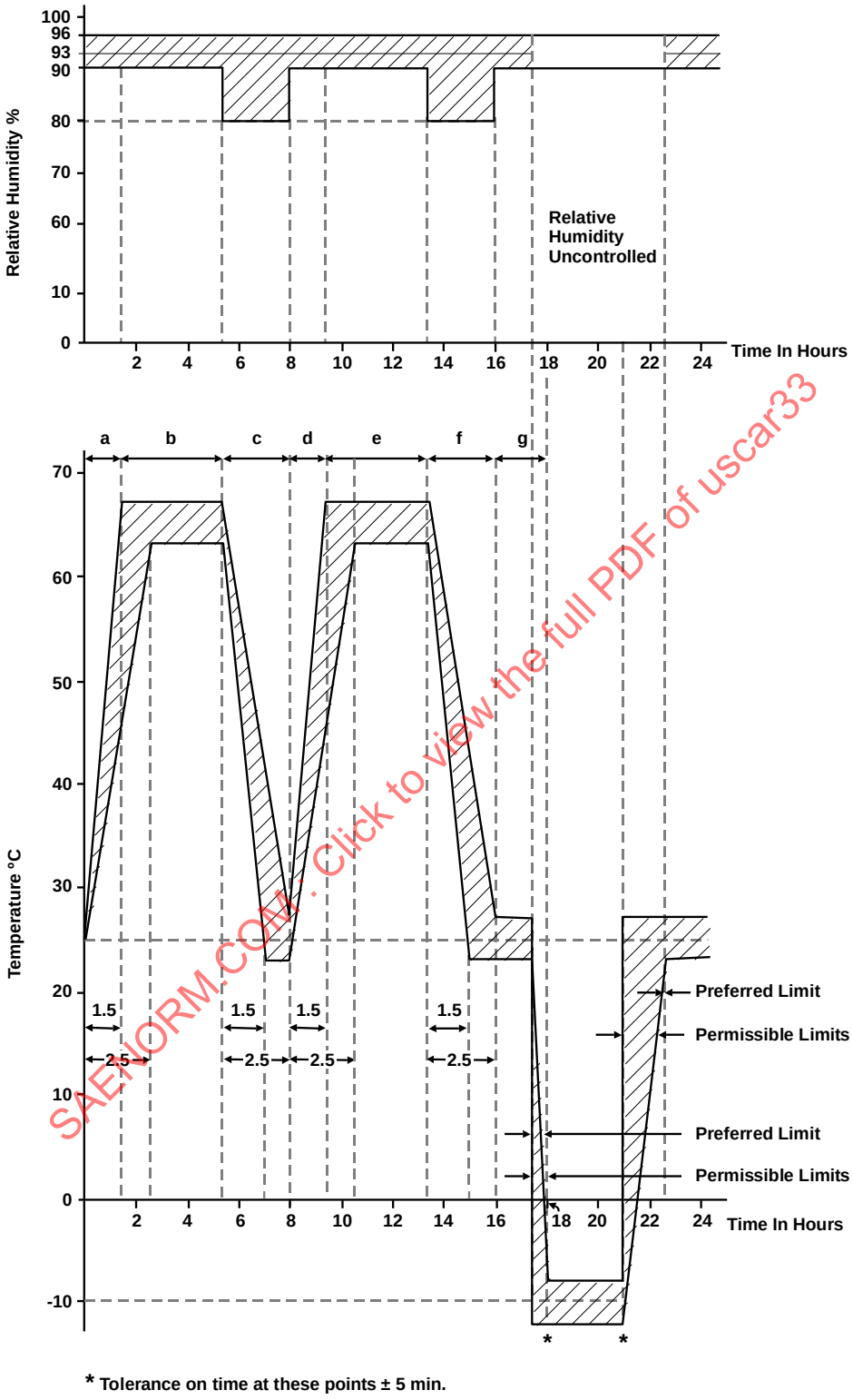
6. **24 Hour Cycles with No Exposure to Cold** - This is applicable to the remaining four of the first nine cycles (Figure 5-B). Cycles which do not include a cold sub-cycle following the humidity temperature sub-cycle are the same as described in Humidity Procedure a-g, except that in paragraph g the chamber shall be maintained at a temperature of 25±2°C and relative humidity of 93±3% until the 24h cycle is completed.

7. **Final Cycle** - In the final ($10^{th}$) cycle, following the completion of the temperature and humidity sub-cycle, the chamber is maintained at a temperature of 25±2°C and relative humidity of 93±3% for a period of 3.5h.

8. Remove parts from chamber.

### 8.6.4 Acceptance Criteria

The LED Module shall meet the requirements of the Photometrics Section within one hour and after 24 hours after removal from the test chamber.






* Tolerance on time at these points ± 5 min.

**Figure 5-A: Humidity Cyclic Test**

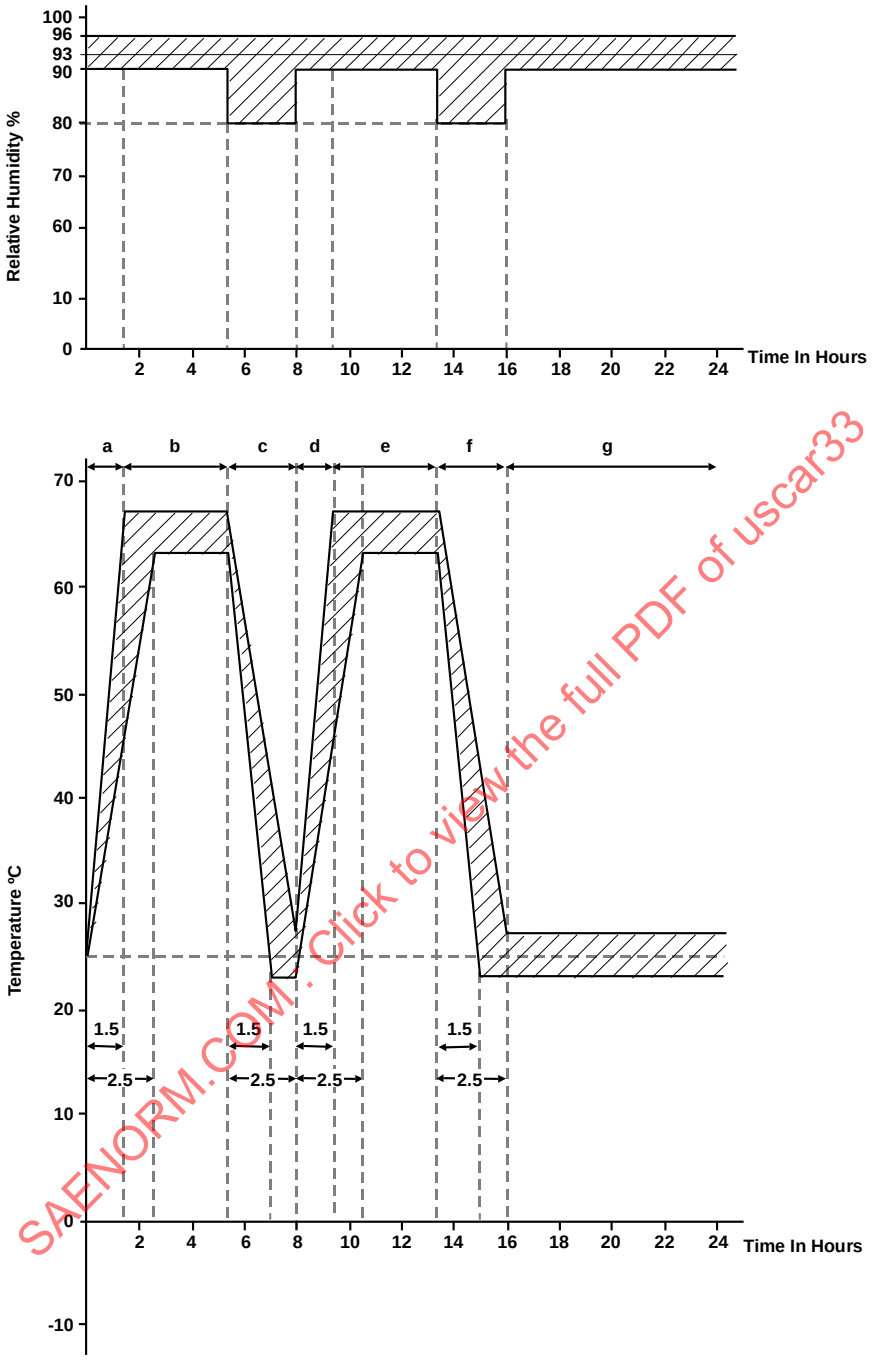





**Figure 5-B: Humidity Cyclic Test without Exposure to Cold**

## 8.7 ALTITUDE

Reference IEC 60068-2-13. Low Air Pressure

### 8.7.1 Purpose

The test simulates pressure conditions due to operating at 4,850 m and being shipped in an unpressurized aircraft at 10,400 m. Any sealed connections or areas on the module which are designed to be sealed in the final assembly shall be simulated.

### 8.7.2 Test and Measurement Apparatus

Test Chamber capable of maintaining pressure at 25kPa and 55kPa ± 0.1kPa.

### 8.7.3 Procedure

1. Place the test specimens in the chamber.
2. Connect the LED module to the vehicle interface connector and associated harness.
3. Apply specified voltage LED module.
4. After 5 minutes turn off power.
5. Verify that each sample lighted up and stayed lit while the voltage was applied.
6. Lower atmosphere in the chamber to 55kPa at a rate not to exceed 10kPa per minute and maintain for 16 hours.
7. Every 15 minutes, during the 16 hour soak, repeat steps 3 & 4.
8. Every 4th hour, 32 cycles, verify the sample is lit during the power on cycle.
9. At the end of the 16 hour test, change chamber to 25kPa at a rate not to exceed 10kPa per minute and allow the test chamber to reach steady state.
10. Soak the samples for an additional 16 hours without applying power.
11. After the 16 hour soak, allow the chamber to return to normal atmosphere conditions at a rate not to exceed 10kPa per minute.
12. Repeat steps 3 thru 5 after pressure is normalized.

### 8.7.4 Acceptance Criteria

Samples must meet the light-up sampling criteria as described above in 8.6.3.

## 8.8 DUST

The LED Module shall be designed to withstand exposure to environmental sand and dust concentrations of fine and coarse particulates during in-service use without degradation in electrical performance.

### 8.8.1 Test and Measurement Apparatus

- Dust test set up (Reference SAE J 575) (see Figure 6)
- Fine powered cement in accordance with ASTM C 150-84 – 3kg to 5 kg dust suspension in a maximum 2 $m^3$ test chamber volume.
- Mating connectors
- Fixture with surface and sealed compartment to mount any connections intended to be sealed to the interior of a lamp assembly (see Figure 6)

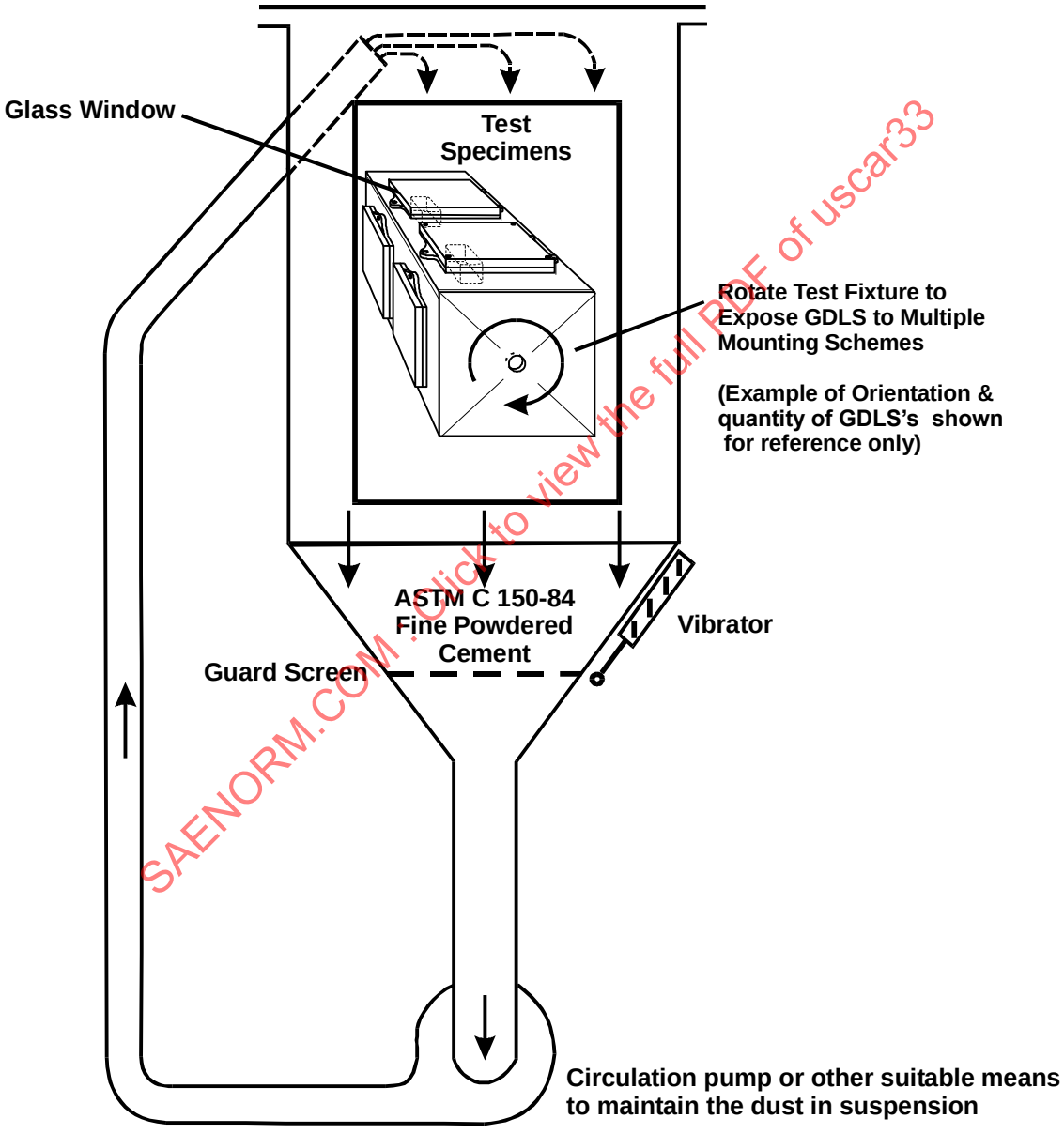





Figure 6: Dust Test Set Up

### 8.8.2 Procedure

1. Mount the LED Module to the test fixture inside the dust chamber with mating connectors installed and any other intended sealing simulated. (see Figure 6)
2. Rotate test fixture at one revolution per minute to expose multiple sides of the LED Module to the circulating dust
3. Agitate the dust every 15 minutes for 6 seconds during a total test period of 8 hours.

### 8.8.3 Acceptance Criteria

The protection is satisfactory if, on inspection, dust has not accumulated in a quantity or location such that, as with any other kind of dust, it could interfere with the correct operation of the equipment or impair safety. No dust shall deposit where it could lead to unintended electrical conductive paths or interference with intended electrical conductivity. No dust shall be removed from the DUT if the test is conducted in a sequence.

The protection is satisfactory if no deposit of dust is observable inside the enclosure at the end of the test.

## 8.9 WATER SPRAY

This test subjects the LED Module to wet conditions such as road splash, extreme condensation, rain or deliberate washing. The LED Module is presumed to be mounted outside a lamp assembly.

Suppliers are cautioned that electronic components mounted internally or externally to the lamp housing will undergo further moisture testing as part of lamp validation.

### 8.9.1 Test and Measurement Apparatus

- Spray Chamber and table per DIN 40050 Part 9 Degree of Protection Code 4k or JIS D 0203 Test S2.

### 8.9.2 Procedure

1. The LED module is to be mounted with all sealed interfaces connected as in vehicle.
2. Perform Water Spray per DIN 40050 Part 9 Degree of Protection Code 4k or JIS D 0203 Test S2.
3. Test duration shall be for one hour.
4. Remove samples from chamber and within 5 minutes apply power for 10 minutes.
5. Remove power and allow drying at room temperature for twenty-four hours and re-applying power for 10 minutes.

### 8.9.3 Acceptance Criteria

The LED Module shall illuminate the light source and maintain illumination as long as power is applied.

## 8.10 FLUID RESISTANCE

### 8.10.1 Purpose

This test evaluates the material compatibility when exposed to various fluids commonly found in and around road vehicles. This applies to externally mounted LED Module devices (e.g. LED module mounted external to the lamp assembly). Any sealed connections or areas on the module which are designed to be sealed in the final assembly as in the vehicle.

### 8.10.2 Test and Measurement Apparatus

- Laboratory Fume Hood
- Stainless steel tanks or Pyrex beakers
- Explosion-proof Heat Chamber

### 8.10.3 Procedure

1. A minimum of 1 LED Module assembly per test fluid is required. Assembly must include all applicable components, seals, etc.
2. Completely coat at least 1 test sample with each fluid listed in Table 6. Fluids are to be stabilized at specified temperatures. Each sample is to be coated in one fluid only, unless otherwise requested.

CAUTION: Follow all Federal, state, and local safety regulations, standards, and procedures when performing this test.

3. Do NOT shake off any excess fluid. Leave the samples "wet" and store them in a suitable area at room temperature for one week. Do not allow samples coated in different fluids to touch each other and do not allow any dissimilar fluid drippings to intermingle.
4. At the conclusion of the storage period, samples may be dried sufficiently to allow inspection and to avoid contamination of test apparatus.

**Table 6: TEST FLUIDS**

| FLUID TYPE | FLUID DESCRIPTION* | STABLIZATION TEMPERATURE °C |
|---|---|---|
| Brake Fluid | SAE RM66-XX** | 50 ± 5 |
| Oil | ISO 1817, Oil No. 2 | 50 ± 5 |
| Gasoline | ISO 1817, liquid C | 25 ± 5 |
| Engine Coolant | 50% ethylene glycol + 50% distilled water | 50 ± 3 |
| Automatic Transmission Fluid | Dexron III | 50 ± 5 |
| Windshield Washer Solvent | 50% Isopropyl Alcohol + 50% Water | 25 ± 5 |
| Power Steering Fluid | ISO 1817, Oil No. 3 | 50 ± 5 |
| Diesel Fuel | 90% ISO 1817, Oil No. 3+ 10% P-Xylene | 25 ± 5 |
| E85 Ethanol Fuel | 85% Ethanol + 15% ISO 1817 liquid C | 25 ± 5 |
| Tar Remover | 45% Xylene + 55% Petroleum base mineral spirits | 25 ± 5 |

*Solutions are determined as percent by volume
**Use latest available SAE reference fluid
*See appendix B for suggested fluid source list*



### 8.10.4 Acceptance Criteria

The LED Module shall operate after exposure to the fluids. The fluid shall not melt, crack, craze, or crystallize the surface of the part. Graphics and labeling appliqués shall not chip, crack, dissolve, or be removed upon application of the fluid.

## 8.11 OUTGASSING

### 8.11.1 Purpose

The Outgassing Test is intended to ensure that the LED module assembly will not distort or out-gas to cause a fog precipitate to form on reflectors or lenses of a lamp assembly in which they may be used.

### 8.11.2 Test and Measurement Apparatus

Per ASTM E595.

### 8.11.3 Procedure

Per ASTM E595.

### 8.11.4 Acceptance Criteria

All materials used in the LED module shall conform to ASTM E595 Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment.

## 9. MECHANICAL

The LED Module shall be designed to meet performance criteria when exposed to mechanical stresses that may be encountered during vehicle assembly and operation. Conformance to this requirement shall be demonstrated as follows:

### 9.1 STEADY STATE LOADS (CRUSH)

#### 9.1.1 Purpose

This test simulates an external load placed on the LED Module exposed surface(s).

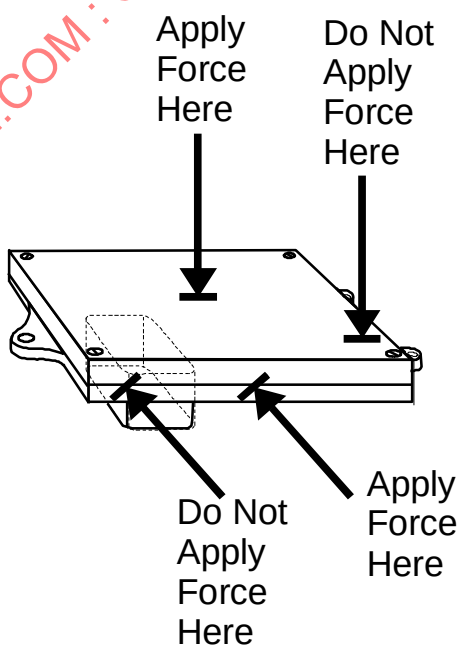
#### 9.1.2 Test and Measurement Apparatus

1) 13mm diameter probe
2) Force gauge

#### 9.1.3 Procedure

1) Mount the device under test in a fixture that simulates vehicle mounting of the LED module. The fixture must have provisions to apply loads described below on surfaces that are not obstructed by sheet metal or other parts in the vehicle.
2) Subject the LED Modules to an evenly distributed 110 N force normal to any 13.0 mm diameter area for 1.0 s. For force applications choose surfaces that are not protected by sheet metal or other vehicle features. See diagram for load Placement. Do not conduct this test on the input / output electrical power socket of the LED module.





### 9.1.4 Acceptance Criteria

The LED Modules shall be capable of meeting the continued testing as shown in Appendix C “Test Sequence”

## 9.2 VIBRATION

Reference IEC 60068-2-64, random vibration & IEC 60068-2-14 Nb Change of Temperature

### 9.2.1 Purpose

The vibration test profiles check the LED Modules for strength and durability when subjected to simulated vehicle vibration levels while exposed to a change of temperature.

### 9.2.2 Test and Measurement Apparatus

- Vibration table mounted inside a hot/cold temperature chamber capable of -40 °C to 125 °C.
- Power supply
- Monitoring Device

### 9.2.3 Procedure

1. Subject LED Modules to vibration load testing and to temperature change simultaneously during the vibration test cycle.
2. The LED Modules shall be electrically operated and continuously monitored while on test.
3. Simultaneously subject lamp assembly to the vibration profile from ISO Standard 16750-3 (sprung mass), temperature profile and voltage cycling with the max acceleration of 1.81Grms (fore, aft and lateral) and 2.84Grms (vertical)
4. Run vibration & temperature profile for 8 h for each X, Y, Z co-ordinate axis of the lamp assembly. (Option: If the vibration equipment is capable, all 3 axis may be run simultaneously.)
5. The test cycle is defined in Chart 1 below.
6. Verify that the LED Modules illuminates the light source during the “on time”.

**Note**Reference IEC 60068-2-64, random vibration & IEC 60068-2-14 Nb Change of Temperature.

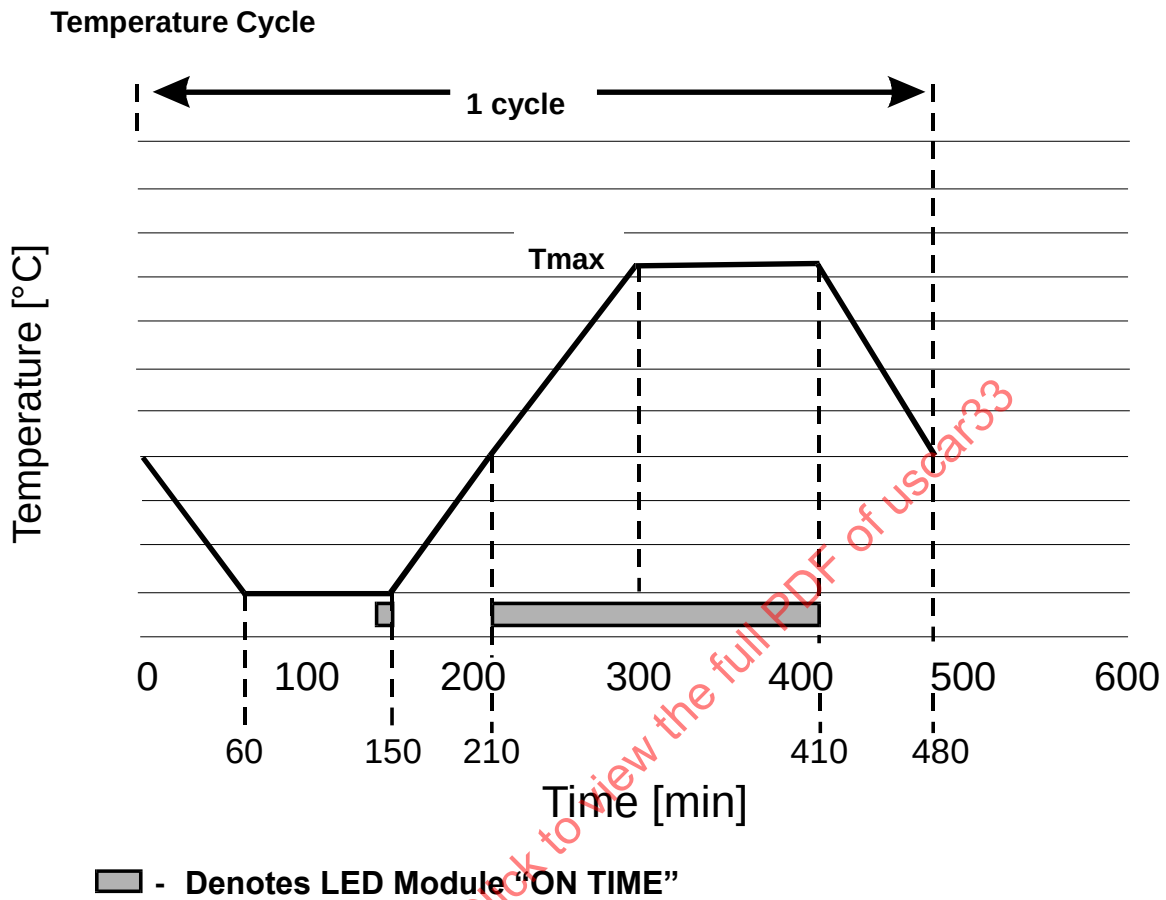



Chart 1: Temperature cycle



#### 9.2.4 Acceptance Criteria

1. Any inputs/outputs in an incorrect state shall be considered a nonconformance to specification requirements.
2. The LED Module shall be able to withstand the above vibration levels without damage resulting in degradation of performance, objectionable squeak, rattle, or non-functional operation.
3. The LED Module must illuminate the light source during the entire duration of "on times".

### 9.3 MECHANICAL SHOCK

Reference IEC 60068-2-27 Ea.

#### 9.3.1 Purpose

The purpose of this test is to determine if the LED Module is able to meet specification requirements when subjected to the mechanical stresses resulting from driving conditions such as potholes and minor collisions.

### 9.3.2 Test and Measurement Apparatus

- Power Supply
- Shock Tester
- Test Fixture that rigidly holds the Module and burner.

### 9.3.3 Procedure

1) Mount the LED Module to the shock test fixture. (Accelerometer measurement must be taken at the module). Wire harness between the module and the burner shall not be secured to the test fixture.
2) Connect the LED Module to the vehicle interface connector and associated harness.
3) The shock test must be performed independent of the vehicle installation position.
4) The LED Module Shall be connected and powered during the test.
5) The Test pulse shall be 100g half sine wave for a period of 11 ms.
6) The LED Module shall be subjected to 3 shocks in both directions for each of the three axes. 3 x 6 = 18 total.

### 9.3.4 Acceptance Criteria

The LED Module samples shall light up during testing and remain lit for 5 minutes after the last test pulse.

## 9.4 FREE FALL (DROP)

Reference IEC 60068-2-32, Ed

### 9.4.1 Purpose

To determine if the LED Module is able to meet specification requirements or to show significant damage so as to not be used in assembly when subjected to the mechanical stresses encountered by being dropped from a one-meter height.

### 9.4.2 Test and Measurement Apparatus

- Test Surface shall be a smooth, hard, rigid surface made up of concrete or steel.
- 1 meter measuring device.

### 9.4.3 Procedure

1) Select three LED Module samples with light source removed.
2) LED Module is not connected.
3) Drop the LED Module from a height of 1 m
4) Repeat step 3 for each of the remaining two axes.
5) Repeat steps 3 and 4 for the other two samples.

#### 9.4.4 Acceptance Criteria

- If there is no visible external damage to the LED Module, then the LED Module shall have no internal damage and the LED Module samples shall light up and remain lit for 5 minutes after the test.

- If there is visible external damage to the LED Module and the damage is judged by Engineering to be insignificant, then the LED Module shall have no internal damage and the LED Module samples shall light up and remain lit for 5 minutes after the test.

- If there is visible external damage to the LED Module and the damage is judged by Engineering to be significant, then the LED Module does not have to light up.

## 10. ELECTRICAL

### 10.1 JUMP START (OVER-VOLTAGE) AND REVERSE POLARITY

#### 10.1.1 Purpose

The LED Module shall be immune from damage due to positive over-voltage and reverse polarity voltage applied to the input connections.

#### 10.1.2 Test and Measurement Apparatus

Power supply capable of 30 Vdc and 8 amps steady state/30 amps inrush

#### 10.1.3 Procedure for Jump Start (Over-Voltage)

1. Turn on the power supply and set the power supply voltage to 26V±0.1
2. Turn off the power supply
3. Connect LEDs to the output terminals of the LED module and power supply to the input power terminals of the LED Module
4. Turn on the power supply for 1 minute.
5. Turn off power supply and disconnect from the LED Module
6. Turn on power supply and adjust voltage to 13.5V±0.1
7. Turn off power supply and connect LED Module
8. Turn on power supply and verify that LED Module illuminates, if applicable

#### 10.1.4 Procedure for Reverse Polarity

1. Turn on the power supply and set the power supply voltage to -13.5V±0.1
2. Turn off the power supply
3. Connect the power supply to the battery input of the LED Module
4. Turn on the power supply for 2 minutes.
5. Turn off power supply and disconnect from the LED Module
6. Turn on power supply and adjust voltage to 13.5V±0.1
7. Turn off power supply and connect LED Module
8. Turn on power supply and verify that LED Module illuminates

### 10.1.5 Overvoltage

1. Turn on the power supply and set the power supply voltage to 18V±0.1. Electronic modules which contain over voltage protection circuits that switch off power consumption shall instead have the power supply set to continuously cycle between +16 V and +18 V at 1 V/minute . Electronic modules with over voltage protection shall be declared to the OEM.
2. Turn off the power supply
3. Connect the power supply to the battery input of the LED Module
4. Turn on the power supply for 60 minutes providing voltage level specified in 1.
5. Turn off power supply and disconnect from the LED Module
6. Turn on power supply and adjust voltage to 13.5V±0.1
7. Turn off power supply and connect LED Module
8. Turn on power supply and verify that LED Module illuminates

### 10.1.6 Acceptance Criteria

LED Module must illuminate normally in step 8 of each test.

## 10.2 BATTERY VOLTAGE DROPOUT

### 10.2.1 Purpose

The LED Module shall be immune from damage due to decreases in battery voltage due to engine cranking or battery rundown.

### 10.2.2 Procedure

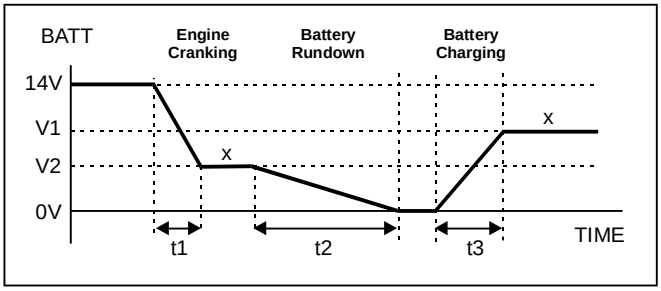
1. Soak the LED Module un-powered until its temperature has stabilized to -40 °C
2. Set up the battery voltage dropout waveform shown in Battery Rundown Test Cycle Graph.
3. Power up the LED Module and apply the battery voltage dropout test waveform per test cycle #1 as shown in Table 7.
4. Verify LED Module illuminates at some level at (X) point, between the $t_1$ and $t_2$ time intervals shown in Battery Rundown Test Cycle Graph.
5. Verify LED Module illuminates normally at (X) point after the $t_3$ time interval at $V_1$ voltage`.
6. Repeat steps (1) through (5) for test cycles 2 through 4.
7. Repeat steps (2) through (6) at Tmax °C.



Table 7: Battery Rundown Test Cycle

| Test Cycle | Voltage (V) | | Time (s) | | |
|---|---|---|---|---|---|
| | $V_1$ | $V_2$ | $t_1$ | $t_2$ | $t_3$ |
| 1 | 10.0 | 6.0 | 0.01 | 10 | 1 |
| 2 | 10.0 | 6.0 | 0.1 | 600 | 10 |
| 3 | 10.0 | 6.0 | 0.5 | 3600 | 120 |
| 4 | 10.0 | 6.0 | 1 | 28800 | 7200 |

Battery Rundown Test Cycle Graph




### 10.2.3 Acceptance Criteria

The LED Module shall illuminate at point (X) after $t_1$ and shall function normally at point (X) after $t_3$.

## 10.3 SUPERIMPOSED ALTERNATING VOLTAGE

### 10.3.1 Purpose

The LED Module shall be immune from damage when the supply voltage is super-imposed with a sinusoidal alternating voltage.

### 10.3.2 Test and Measurement Apparatus

- Power Supply
- Waveform Generator
- Environmental Chamber capable of -40 °C to 105 °C

### 10.3.3 Procedure

1. Mount the sample inside the temperature chamber.
2. Connect Power Supply to the sample.
3. Lower and stabilize temperature at -40 °C.
4. Setup the Superimposed Alternating Voltage Test according to Ripple Sweep Test Figure 7.
5. A sweep time of 1 minute to 5 minute is to be used.
6. Power the LED Module and inject the specified wave form for 2 hours.
7. Raise and stabilize temperature at Tmax °C (Section 8.4.2).
8. Repeat steps 4 through 6.

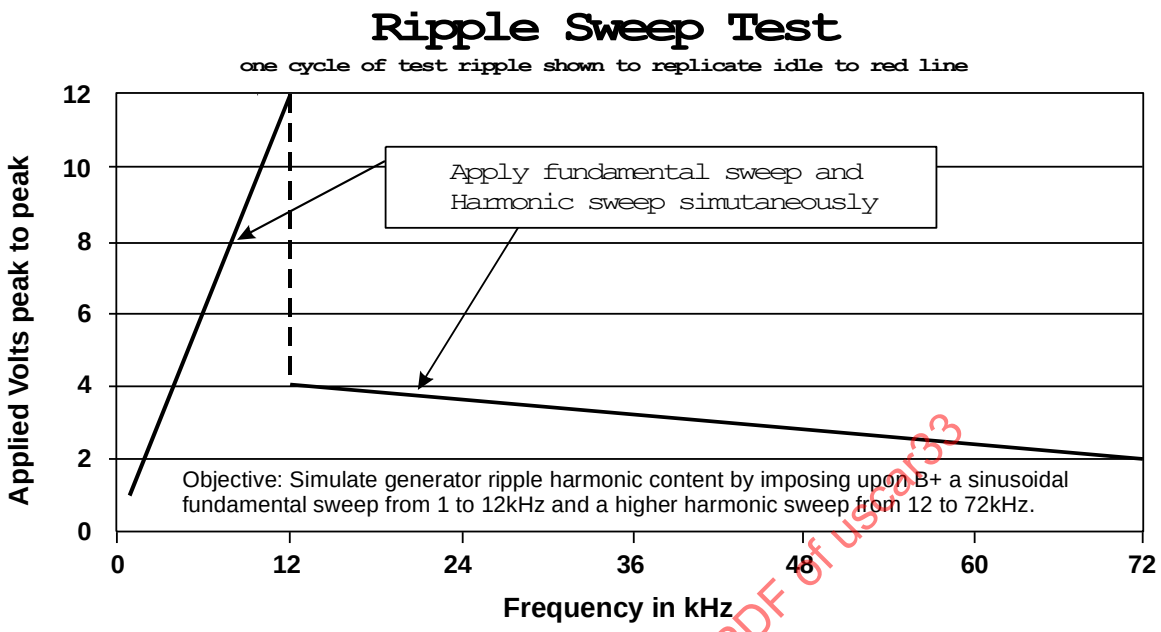



Figure 7: Ripple Sweep Test



### 10.3.4 Acceptance Criteria

Verify samples light up and remain lit for the entire duration of the test.

## 10.4 SHORT CIRCUIT

### 10.4.1 Purpose

The LED Module shall be immune from damage due to intermittent and continuous short circuit conditions.

### 10.4.2 Test and Measurement Apparatus

- Temperature Chamber
- Power Supply
- Programmable Controller Device

### 10.4.3 Procedure

1. Mount sample inside the thermal chamber.
2. Disconnect light source from the system and create a switch able short circuit at all connectors.
3. Raise and stabilize the chamber temperature to Tmax °C.
4. At time t=0 seconds apply 16.0 ±0.1V to module.
5. At time t=15 seconds apply short circuit condition for 330 seconds.
6. At t=360 seconds remove the power.
7. At t=480 seconds repeat steps 4 through 7 until 85 cycles are complete.

8. After completing 85 cycles connect a light source and verify the correct operation of the LED Module.
9. Remove the light source again and repeat steps 4 through 8 except with 9.0 ± 0.1V applied to module.
10. Lower and stabilize the chamber temperature to -40 °C and repeat steps 4 through 8 with 9.0 ± 0.1V applied to the module.
11. Adjust power supply voltage to 16 ± 0.1V and repeat steps 4 through 8.

### 10.4.4 Acceptance Criteria

The LED Module shall illuminate and stay lit when the light source is attached and the system powered. The LED Module shall not generate any feedback through the power connection as defined in each OEMs EMC specification.

## 10.5 OPEN CIRCUIT

### 10.5.1 Purpose

The LED Module shall be designed so that an open circuit fault between output of LED module and the LEDs shall not prevent any other interface from meeting its requirements. Additionally, the LED Module shall return to normal operation after the open circuit condition is removed.

### 10.5.2 Test and Measurement Apparatus

- Power Supply
- High Voltage Switch
- Oscilloscope

### 10.5.3 Procedure

1. Set up test with High Voltage Switch between module and light source on ground wire.
2. Apply power to LED Module.
3. Open switch for 2 minutes.
4. Close switch.

### 10.5.4 Acceptance Criteria

The LED Module shall illuminate when switch is closed. The LED Module shall not generate any feedback through the power connection as defined by each OEMs EMC specification.

## 10.6 ISOLATION

### 10.6.1 Purpose

This test is to verify that the LED Module meets the requirements for electrically isolated adjacent terminals and metal housings.