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SAE J1889 JUN88

L.E.D. Lighting Devices

SAE Recommended Practice
Issued June 1988

Submitted for Recognition as an American National Standard

The Engineering Society For Advancing Mobility Land Sea Air and Space ®

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HIGHWAY VEHICLE PRACTICE

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L.E.D. LIGHTING DEVICES

1. SCOPE:

This technical report applies to motor vehicle signalling and marking lighting devices which use light emitting diodes (L.E.D.) as light sources. This report provides test methods, requirements, and guidelines applicable to the special characteristics of L.E.D. lighting devices. These are in addition to those required for devices designed with incandescent light sources. This report is intended as a guide to standard practice and is subject to change to reflect additional experience and technical advances.

2. DEFINITIONS:

2.1 Semiconductor: A material whose resistivity lies in the broad range between conductors and insulators.

2.2 L.E.D.: An indivisible, discrete light source unit containing a semiconductor junction in which visible light is non-thermally produced when a forward current flows as a result of applied voltage.

2.3 L.E.D. Lighting Device: A lighting device in which light is produced by an array of L.E.D. light sources.

2.4 Incandescence: The generation of light caused by heating a body to a high temperature. Generally this heating is obtained by passing an electric current through a wire filament. The resistance of the filament to the current causes the filament to heat up and emit radiant energy, some of which is in the visible range. Ordinary automotive bulbs have incandescent light sources.

2.5 L.E.D. Light Source Center: For a single L.E.D., the point that is, located at the geometric center of the junction where the luminescence takes place.

2.6 Lighting Device Light Center: The geometric center of all the single L.E.D. light source centers within the L.E.D. array(s) used to illuminate the device function, or the geometric center of the illuminated area if the light output is produced indirectly.

3. TESTS:

The following section describes individual tests which need not be performed in any particular sequence. Testing may be expedited by performing two or more tests simultaneously on separate samples.

3.1 SAE J575 is a part of this report. Unless otherwise specified, the following tests are applicable with modifications as indicated.

3.1.1 Vibration Test: The evaluation of the sample at the completion of the test shall also include a functional lighting check. If a partial outage is observed, a photometry test (3.1.5) shall be performed and the results recorded.

3.1.2 Moisture Test

3.1.3 Dust Test: If dust is found, the change in the maximum photometric luminous intensity of the sample shall be determined by using the photometric measurement procedures in 3.1.5.

3.1.4 Corrosion Test

3.1.5 Photometry Test: The photometric output (luminous intensity) of a L.E.D. lighting device typically decreases as the temperature of the L.E.D. light sources increases. In addition to the test procedures in SAE J575 the following shall apply:

3.1.5.1 Design Voltage: The device shall be operated at its design voltage during all photometric tests.

3.1.5.2 Photometric Maximums: For measurements to photometric maximum requirements, first allow the test device to stabilize at laboratory ambient temperature (23 ± 5°C) unenergized. After all the device components are at laboratory ambient temperature, energize the test device and record the maximum photometric value(s) within 60 s of the initial on-time.

3.1.5.3 Photometric Minimums: For measurements to photometric minimum requirements, the test device light output shall first be stabilized by energizing the device at laboratory ambient temperature (23 ± 5°C) until either internal heat buildup saturation has occurred or 30 min has elapsed, whichever occurs first.

3.1.6 Warpage Test on Devices With Plastic Components: Not required.

3.2 Color Test: SAE J578 is a part of this report.

3.3 Thermal Cycle Test:

3.3.1 Scope: This test evaluates the ability of the sample device to resist optical, electrical, or physical malfunctions due to exposures to repeated changes from hot to cold temperature extremes. Devices installed in vehicle locations that could produce temperatures outside the test range specified may necessitate special test requirements.

3.3.2 Test Equipment: A thermal cycle chamber capable of providing the temperature extremes and rates of change of temperature in the temperature - time profile specified in Fig. 1.

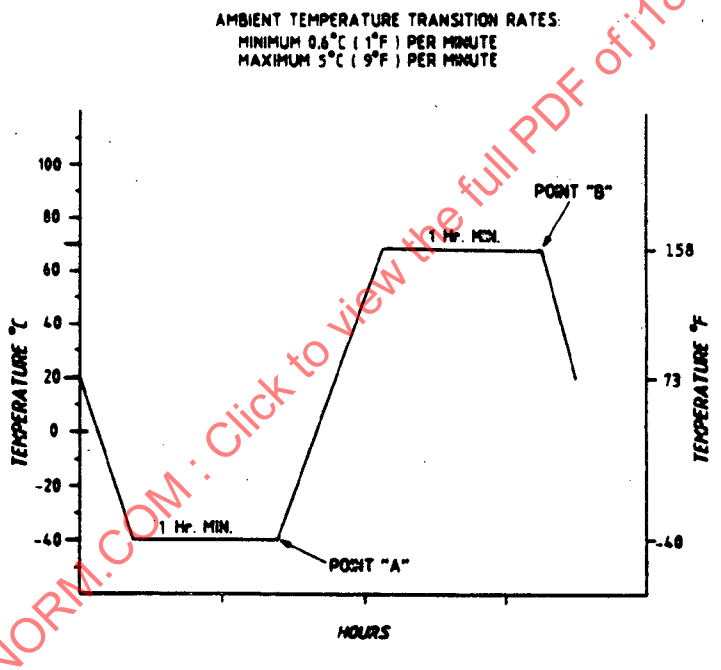

FIGURE 1 - Thermal Cycle Profile

3.3.3 Test Procedure: The sample device, mounted on a test fixture shall be subjected to thermal cycles as follows.

3.3.3.1 Thermal Cycle: The device shall be exposed to the thermal cycle profile shown in Fig. 1.

3.3.3.2 Device Operation: The device shall be energized at design voltage commencing at point "A" of Fig. 1 and de-energized at point "B" of each cycle. When energized, the lighting function(s) shall be cycled as specified in SAE J575, Table 1.

3.3.3.3 Test Duration: The test shall consist of 25 complete cycles of the thermal cycle profile shown in Fig. 1.

3.3.3.4 Sample Evaluation: During the final thermal cycle, the sample lighting function(s) shall be continuously checked for permanent or intermittent outages while energized from Point "A" (cold temperature) to Point "B" (hot temperature) on Fig. 1 and the results recorded. If partial outage is observed, a photometry test (3.1.5) with the remaining functional L.E.D. segments lighted shall be performed and the results recorded. Upon completion of the thermal cycle exposure the sample device shall be visually examined for any cracking, rupture or warpage of parts and the results recorded. If any of the above changes are observed that could result in failure of the other tests contained in Section 3, these test(s) shall be performed on the same sample used for the thermal cycle test and the results recorded.

4. REQUIREMENTS:

4.1 Performance Requirements: A L.E.D. lighting device when tested in accordance with the test procedures specified in Section 3 shall meet the following requirements.

4.1.1 Vibration: SAE J575. The following requirements also apply.

4.1.1.1 After completion of test procedure 3.1.1, all L.E.D. light sources contained within the device shall function or the device shall comply with the photometric requirements in 4.1.5 of this report.

4.1.2 Moisture: SAE J575

4.1.3 Dust: SAE J575

4.1.4 Corrosion: SAE J575

4.1.5 Photometry: SAE J575. The photometric performance requirements in the applicable SAE technical report for the lighting function being tested shall also apply. Specified photometric maximum and minimum test points shall be determined as specified in 3.1.5.2 and 3.1.5.3 of this report. The following requirements shall also apply.

4.1.5.1 Lighted Sections: Applicable photometric requirements specified in other SAE technical reports which are based on the number of lighted sections shall instead be applied based on the dimensions of the L.E.D. lighting device function being tested. The maximum horizontal or vertical projected lighted linear dimension of the function shall be equivalent to the following number of lighted sections.

MAXIMUM PROJECTED LINEAR DIMENSION	EQUIVALENT NUMBER OF LIGHTED SECTIONS
150 mm or less	1
151 mm to 300 mm	2
301 mm or greater	3

4.1.6 Warpage: SAE J575. Not required.

4.1.7 Color: The color of light shall be as specified in SAE J578 and in the SAE report of the applicable device function.

4.1.8 Thermal Cycle: After completion of the thermal cycle test procedure 3.3.3, there shall be no observed cracking, rupture, displacement, or warpage of parts of the test device which would result in failure of other tests contined in paragraph 4.1 of this technical report. There shall also be no loss of function of any L.E.D. light sources while energized during the last thermal cycle which would result in failure of the photometry requirements of paragraph 4.1.5 of this technical report.

4.2 Materials Requirements: Plastic materials used in optical parts in the device, including the individual L.E.D. light source units, shall meet the requirements of SAE J576.

4.3 Design Requirements:

4.3.1 Reverse Voltage: Some L.E.D. light sources may be damaged by the application of a voltage of reverse polarity. Protection shall be provided in the device to prevent any damage when the voltage polarity to the lighting device is reversed.

5. GUIDELINES:

5.1 Photometric Design Guidelines: The photometric design guidelines in the applicable SAE technical report for the lighting function design shall be required. Specified photometric maximum and minimum values shall be measured as specified in 3.1.5.2 and 3.1.5.3 of this report. Requirements using the number of lighted sections shall apply as specified in paragraph 4.1.5.1 of this report.

5.2 Installation Guidelines: The following guidelines are provided due to the special characteristics of L.E.D. lighting devices.

5.2.1 The luminous intensity of L.E.D. lighting devices typically vary with applied voltage. The electrical system of a vehicle should, under normal operating conditions, provide design voltage to the device as closely as practicable bearing in mind the inherent variability of such systems.

5.2.2 The luminous intensity of a L.E.D. lighting device typically decreases as the temperature of the L.E.D. light sources increases. Installation of lamps on vehicles should be considered to minimize the effect of accumulating excessive temperatures in the device.

5.2.3 While L.E.D. light sources typically have a very long energized life, outage of a segment of a L.E.D. light source array may occur when one of the L.E.D. light sources within the array segment malfunctions. The user should be cautioned to replace or repair the device since the luminous intensity of the device is reduced by such an outage.

6. APPENDIX:

As a matter of additional information, attention is called to SAE J387.

RATIONALE:

This is a new technical report issued to provide tests, requirements, and guidelines for lighting devices designed with L.E.D. light sources. There are problems in trying to apply the requirements in current SAE reports to applicable lighting functions of L.E.D. sample devices. This report is intended to provide additional specifications and information which can be used in conjunction with other lighting reports on motor vehicle signalling and marking devices.

A rationale of the various sections of this report is listed by paragraph number below.

1. SCOPE - The application of the technical report is explained.

2. DEFINITIONS - The definitions of several terms used in the report are listed in this section. See also SAE J387, Terminology - Motor Vehicle Lighting, referenced in the Appendix.

3. TESTS - To expedite test timing, separate samples for tests are permitted. The necessity for some interrelated tests on one test sample is addressed in the individual test requirements.

3.1.1 VIBRATION TEST - Bulb outages are specifically excluded from SAE J575 requirements. The longer life intent of L.E.D. devices and the absence of an incandescent filament necessitate including a functional lightup check. A partial outage of the L.E.D. array will require a photometric test to determine compliance.

3.1.2 MOISTURE TEST - No change from SAE J575

3.1.3 DUST TEST - The additional procedure for measuring the photometric maximum is referenced here.

3.1.4 CORROSION TEST - No change from SAE J575

3.1.5 PHOTOMETRY - No change in the photometric luminous intensity values specified in the applicable SAE report is required. The perceived values of L.E.D. and incandescent light sources were shown to be comparable in a SAE lighting demonstration in September 1986 and in SAE report No. 870065. A significant change in photometric luminous output with the actual temperature of a L.E.D. light source has been observed. This requires additional temperature controls during photometry as listed below.

3.1.5.1 DESIGN VOLTAGE - The application of a rated current used with incandescent bulbs is not applicable with L.E.D. devices since they contain multiple L.E.D. in arrays. Therefore, L.E.D. devices must be operated at design voltage.

RATIONALE (Continued):

3.1.5.2 PHOTOMETRIC MAXIMUMS - An immediate reading of all photometric maximum values while each L.E.D. is at room laboratory temperature is required. This prevents obtaining variable and lower value measurements due to internal heat up of the L.E.D. array. Still higher photometric readings could theoretically be obtained by measurements at colder than room temperature ambients. This possibility would only affect maximum requirements and was not considered to be a sufficient reason to impose routine laboratory photometric measurement requirements at a temperature other than laboratory room ambient. (Typical data shows the L.E.D. luminous output can almost double when the L.E.D. temperature is lowered from room temperature ambient down to -40°C. In the L.E.D. lighting demonstration in September 1986 it was noted that at double intensity comparisons less than 25% of the observers rated the doubled output as significantly more attention getting than the base output.)

3.1.5.3 PHOTOMETRIC MINIMUMS - An opposite consideration from 3.1.5.2 is necessary when measuring photometric minimum requirements. The stabilized, lower photometric measurements are required after internal heat saturation. This condition also tends to duplicate the lower photometric values obtained immediately after energizing a L.E.D. device in an elevated ambient temperature environment. (The maximum sun heat soak temperature of a lighting device mounted in an exterior body panel on a black car in Arizona has been found to be approximately 70°C. This is about the same temperature that has been measured for a typical L.E.D. device after internal heat saturation at room temperature ambient. Higher heat soak temperatures have been measured on devices mounted inside the passenger compartment, but these devices are subject to a rapid cool-down during actual vehicle operation.) It also was not considered to be practical to impose routine laboratory photometric measurement requirements at temperatures other than normal laboratory ambient conditions.

3.1.6 WARPAGE TEST ON DEVICES WITH PLASTIC COMPONENTS - Since this is a SAE J575 test which is normally specified in other SAE device reports, it is included here as "not required" for clarity. The operational and test temperatures specified in the thermal cycle test (3.3) are equal to, or more severe than those specified in SAE J575 Warpage Test. Special warpage tests, not duplicating SAE J575, would be specified in the individual function technical report and would also apply to L.E.D. devices.

3.2 COLOR TEST - The color test and requirements are identical to those specified in the applicable device report.

3.3 and 3.3.1 THERMAL CYCLE TEST - Testing data has indicated that the function of L.E.D. devices can be affected by repeated cycles of high and low temperature extremes. This additional test is required to evaluate some of the unique construction techniques used in L.E.D. lighting devices.

3.3.2 TEST EQUIPMENT - A commonly available thermal cycle chamber was specified to allow additional laboratory usage for other testing needs.

3.3.3 TEST PROCEDURE - The overall thermal cycle test procedure is comparable to the cycle specified in SAE J1383, Performance Requirements for Motor Vehicle Headlamps. The modifications are listed below.

RATIONALE (Continued):

3.3.3.1 and Fig. 1 THERMAL CYCLE - The high temperature was reduced from 80°C to 70°C to better reflect commonly encountered high temperatures in the areas where signal and marking lamps are commonly used on motor vehicles. Vehicle installation locations which could produce higher temperature exposures should be addressed by special thermal cycle or plastic warpage test requirements.

3.3.3.2 DEVICE OPERATION - The device is energized during a portion of the cycle which includes the entire temperature range to accelerate actual commonly expected field temperature and operation combinations. The energizing mode of each function was made identical to SAE J575 Plastic Warpage Test so that the warpage test requirement could be deleted (See 3.1.6).

3.3.3.3 TEST DURATION - 25 thermal cycles were selected since test data on typical devices indicated that most failures due to the thermal cycle test occurred before 25 cycles. This produces a reasonable test time duration of approximately 3 days.

3.3.3.4 SAMPLE EVALUATION - Requirements similar to the SAE J575 Plastic Warpage Test are included. A partial outage of the L.E.D. array will require a photometric test with the outage duplicated to determine final compliance.

4.1 PERFORMANCE REQUIREMENTS - All requirements listed in 4.1 are referenced to the test procedures in Section 3.

4.1.1 VIBRATION - See 3.1.1. If all of the L.E.D. light sources in the array function after the vibration test and the other requirements specified in SAE J575 are met, an additional photometric test is not required.

4.1.2 MOISTURE - See 3.1.2

4.1.3 DUST - See 3.1.3

4.1.4 CORROSION - See 3.1.4

4.1.5 PHOTOMETRY - See 3.1.5, 3.1.5.1, 3.1.5.2 and 3.1.5.3

4.1.5.1 Some SAE reports include requirements based on the number of lighted sections in the test device. L.E.D. arrays typically cannot be defined in terms of lighted sections like those in incandescent lighting devices with multiple bulb compartments. Therefore, a L.E.D. device is divided into equivalent lighted sections in terms of its maximum projected linear dimension. 150 mm per lighted section represents a typical large lighted section in present incandescent lighting device designs.

4.1.6 WARPAGE - See 3.1.6

4.1.7 COLOR - See 3.2

4.1.8 THERMAL CYCLE - See 3.3

RATIONALE (Continued):

4.2 MATERIALS REQUIREMENTS - Additional exposure requirements on the plastic materials in the individual L.E.D. light source components are added to insure proper weathering resistance on exposed or covered L.E.D. plastic components. Correlated sampling and accelerated test methods are permitted.

4.3.1 REVERSE VOLTAGE - A design requirement to provide reverse voltage protection of the device is added due to the special nature of L.E.D. light sources. Reverse voltage exposure is normally not a concern with incandescent light sources.

5.1 PHOTOMETRIC DESIGN GUIDELINES - This section references any photometric design guidelines specified in the applicable device SAE report. It also references the special photometric test procedures to measure maximum and minimum requirements specified in 4.1.5, and defines the number of lighted sections specified in 4.1.5.1.

5.2 INSTALLATION GUIDELINES - Various installation guidelines applicable to L.E.D. devices are listed below.

5.2.1 The intention to apply design voltage to the device in its vehicle installation is specified.

5.2.2 The need to be aware of the characteristic light output change with ambient temperature of L.E.D. devices (See 3.1.5) and to minimize that effect in the vehicle installation is specified.

5.2.3 The possibility of array segment outages of L.E.D. devices due to the failure of one L.E.D. in a typical electrical series wiring arrangement is listed. The obvious effect of such an outage on the photometric luminous output is also pointed out. Specific repair or replacement information is not included because there is, at present, no standard design L.E.D. or segment in use. Most L.E.D. device designs are capsules which do not permit replacement or repair of individual device components.

RELATIONSHIP OF SAE STANDARD TO ISO STANDARD:

Not applicable.

REFERENCE SECTION:

SAE J387 JUL83, Terminology - Motor Vehicle Lighting

SAE J575 JUL83, Tests for Motor Vehicle Lighting Devices and Components

SAE J576 SEP86, Plastic Materials for Use in Optical Parts Such as Lenses and Reflectors of Motor Vehicle Lighting Devices

SAE J578d, Color Specification for Electric Signal Lighting Devices