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INTERNATIONAL
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SURFACE VEHICLE RECOMMENDED PRACTICE

Submitted for recognition as an American National Standard

SAE J2009

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DISCHARGE FORWARD LIGHTING SYSTEM

1. *Scope*—This SAE Recommended Practice applies to motor vehicle Forward Illumination Systems which use light generated by discharge sources. It provides test methods, requirements, and guidelines applicable to the special characteristics of gaseous discharge lighting devices which supplement those required for forward illumination systems using incandescent light sources. This document is intended to be a guide to standard practice and is subject to change to reflect additional experience and technical advances.

2. *References*

2.1 **Applicable Documents**—The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J575—Tests for Motor Vehicle Lighting Devices and Components
SAE J578—Color Specification
SAE J759—Lighting Identification Code
SAE J1113—Electromagnetic Susceptibility Measurement Procedures for Vehicle Components
SAE J1211—Recommended Environmental Practices for Electronic Equipment Design
SAE J1383—Performance Requirements for Vehicle Headlamps
SAE J1816—Performance Levels and Methods of Measurement of Electromagnetic Radiation From Vehicles and Devices (Narrow Band), 10 kHz - 1000 MHz

2.1.2 ANSI PUBLICATIONS—Available from American National Standards Institute, Inc., 11 West 42nd Street, New York, NY 10036.

ANSI Z311.1—Photobiological Safety for Lamps and Lighting Systems
ANSI C78.376—Spectroradiometrically Determined Assignments

2.1.3 FMVSS PUBLICATIONS—Available from the National Highway Traffic Safety Administration, 400 Seventh Street SW, Washington, DC 20024-0002.

FMVSS 108—Lamps, Reflective Devices, and Associated Equipment (Available as 49 CFR 571.108)
FMVSS 112—Headlamp Concealment Devices (Available as 49 CFR 571.112)

Printed in U.S.A.
90-1202B EG

2.1.4 CIE PUBLICATION—Available from Commission Internationale de L'eclairage, 52 Bd Malesherbes, F-75008 Paris, France.

CIE Pub. 13.2—Method of Measuring and Specifying Color Rendering Properties of Light Sources (TC3.2) 1974

2.1.5 ACGIH PUBLICATIONS—Available from American Council of Governmental Industrial Hygienists, 6500 Glenway Avenue, Building D-7, Cincinnati, OH 45211.

Threshold Limit Values and Biological Exposure Indices for 1989-1990, American Conference of Governmental Industrial Hygienists

2.2 Definitions

2.2.1 DISCHARGE FORWARD LIGHTING (DFL) SYSTEM—An automotive lighting system, providing forward illumination, comprised of the headlamps, discharge source, ballast/starting system, and interconnecting wiring.

2.2.2 DISCHARGE SOURCE—An electric light source in which light is produced by a stabilized arc.

2.2.3 START-UP TIME—The period of time between the instant when the user operates a switch to power a lamp ON and the instant when the DFL system reaches a level within X% of "steady-state" output level.

2.2.4 RESTART—The ability of the "hot" DFL system to relight before its temperature has returned to initial ambient.

2.2.5 PHOTOMETRIC MAINTENANCE—Change in beam intensity of the test points of the beam pattern light output over time (life).

2.2.6 LIFE—Time in hours and starting cycles of a DFL system during which it meets specified operational characteristics under specified test conditions.

2.2.7 RATED LAB LIFE—Life specified by the manufacturer as the period during which the DFL system meets the performance specifications. (Rated lab life equals design life.)

2.2.8 COLOR RENDERING INDEX (LIGHT SOURCE—CRI)—Measure of the degree of color shift objects undergo when illuminated by the light source as compared with the color of those same objects when illuminated by a reference source of comparable color temperature.

2.2.9 ULTRAVIOLET RADIATION—Radiation in the spectral region between 200 and 400 nm. Definitions and terminology are adopted in accordance with proposed ANSI specification standard Z311.

a. UVA flux—Radiant energy flux between 320 and 400 nm
b. UVB flux—Radiant energy flux between 260 and 320 nm
c. UVC flux—Radiant energy flux between 200 and 260 nm

2.2.10 STEADY-STATE—A condition under which the light output of the device is considered to be stable or changing at such a slow rate as to be insignificant. A "Steady-state" condition would be generally measured in terms of a "maximum percent change per time period."

Steady-state light level (100%) is established by allowing the lamp to operate for 120 s after being switched "on." The average light level within the period from 120 to 140 s will be defined as the 100% level.

If the light output is not stable to within ± 10% during the 120 to 140 s time interval, the test should be repeated on the system. If a system fails to stabilize after three attempts, a new system should be selected for a test sample.

2.2.11 AUTOMOTIVE BALLAST—A device for stabilizing the operating characteristics of a discharge lamp. The ballast contains all the necessary circuitry to ignite a lamp and cause it to operate within a specified power profile range. It controls the required light output characteristics of the automotive discharge lighting system. The ballast may consist of one or more separate components.

2.2.12 INTEGRAL BEAM—An "Integral Headlamp" produces a light pattern when normal vehicle voltage is applied. It cannot be disassembled by the user for the purpose of replacing any failed subassemblies within the lamp or housing package.

Discharge headlamps in which the ballast subunit is remote from the starter/lamp subunit, may be considered integral if the user cannot disconnect the two subunits. Such a lamp may be disassembled and serviced by the manufacturer for the purpose of recycling the assembly by replacing nonfunctioning parts. It may also be disassembled and serviced by a service factory or dealer service facility. In any case, there is the assumption that the servicing facility will certify that the performance of the serviced device will meet all standards applicable to the original equipment.

3. Lighting Identification Codes, Markings, and Notices

3.1 Headlamps shall be marked in accordance with SAE J759.

3.2 The DFL system shall contain a label indicating the presence of high voltage, e.g., the International electric shock hazard symbol ("lightning bolt").

4. Tests—All sample DFL systems shall be seasoned for 20 h prior to being subjected to the tests that follow and a new DFL system may be used for each test.

NOTE—The power supply used for all testing should have its output isolated from the input to prevent any potential danger to laboratory personnel when running test as required.

4.1 Lamp/System Starting Procedures—The headlamp shall be held in its normal operating position and mechanically aimed with a photocell or cells at the test points shown in Table 1. Tests shall be conducted at room temperature (23 °C ± 3 °C), at 12.8 VDC ± 0.1 VDC, and for a duration required to obtain a reading. The response time of the measurement instrument should be less than 100 ms.

TABLE 1—TEST POINTS FOR DFL HEADLAMP STARTING TESTS

Lower Beam Lamp	Upper Beam Lamp
1.5 D - 2 R	H - V

4.1.1 INITIAL START-UP—The DFL system (ballast/starter) shall be activated and the luminous intensity at the photometric test points of Table 1 sampled and recorded for each headlamp from initial actuation through the intervals specified in Figure 1 or Figure 2. The test lamp(s) is then turned off.

4.1.2 SWITCHING (COLD LAMPS)—The DFL system (ballast/starter) shall be activated and the luminous intensity at the photometric test points of Table 1 sampled and recorded for each headlamp from initial activation through the intervals specified in Figure 1 or Figure 2.

Time(sec)	Low or High Beam Non-Continuous Low Min (%)	Max (%)
0.25	20	300
0.50	30	300
0.75	50	300
1.00	60	200
2.00	70	200
3.00	70	150
5.00	70	130
60.00	70	130

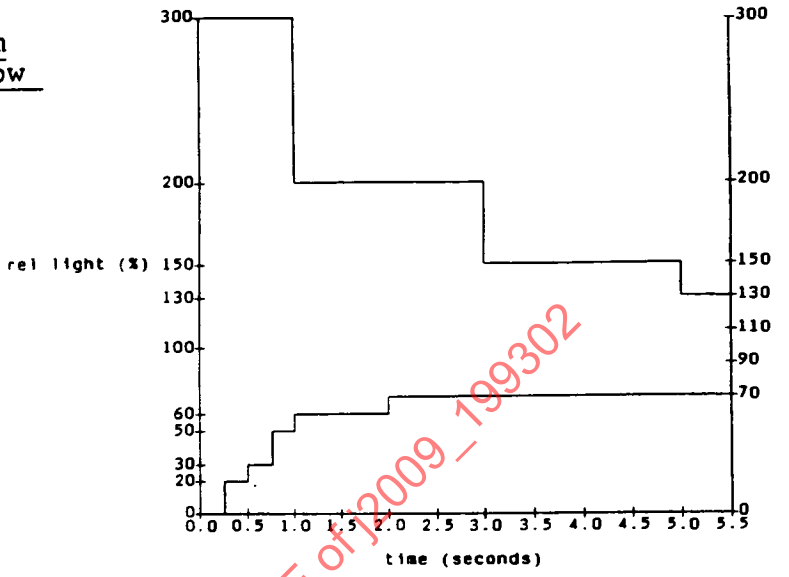

FIGURE 1—LAMP OUTPUT VS START-UP TIME
LOW OR HIGH BEAM NONCONTINUOUS LOW

Time(sec)	Low or High Beam Continuous Low Min (%)	Max (%)
0.25	10	300
1.00	25	200
2.00	50	200
3.00	70	150
5.00	70	130
60.00	70	130

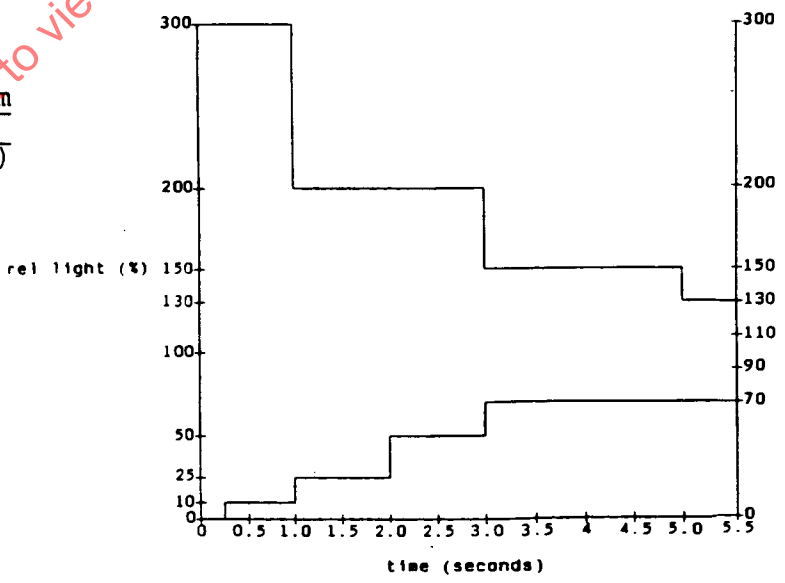

FIGURE 2—LAMP OUTPUT VS START-UP TIME
LOW OR HIGH BEAM CONTINUOUS LOW

NOTE—(%) = Percent of steady-state light intensity. Each beam should be measured at the point prescribed in Table 1, with the other beam blocked or not operating.

4.1.3 SWITCHING (HOT RESTART)—The lamp shall be energized for 5 min minimum. After this time period, a restart test shall be conducted once for every time interval as follows:

a. Cool down times for DFL hot restart test—1 s, 4 s, 10 s, 20 s, 30 s, 1 min

The system shall be switched off for the period of time shown as previously stated in order to simulate momentary switching to the alternate beam. The test lamp shall be energized and the luminous intensity at the applicable photometric test point shown in Table 1 sampled.

4.1.4 SWITCHING (CONTINUOUS LOW BEAM MODE)—For DFL systems designed to have the lower beam on continuously, the lower beam lamp shall be operated during the test. However, only the photometric characteristics of the upper beam switching shall be measured. The tests for "continuous low beam mode" are identical to those described in 4.1.3 except that only the upper beam lamp is tested.

4.2 Electrical Characteristics

4.2.1 SYSTEM OPERATING WATTAGE RANGE—DFL system wattage shall be measured at 12.8 VDC ± 0.1 VDC with all components in normal operating orientation using the equipment described in 4.2.3.

4.2.2 SYSTEM OPERATING VOLTAGE RANGE—The DFL system shall operate in the regulated mode from 9.0 to 18.0 VDC with all components in normal operating orientation using the equipment described in 4.2.3. Additional considerations for voltages between 9.0 and 4.5 V are presented in 6.10.

4.2.3 EQUIPMENT REQUIREMENTS—The input terminals of the DFL system shall be connected to a laboratory power supply which shall have a range of voltages from at least 4.0 to 18.5 VDC and which shall be capable of controlling voltage to ± 0.1 VDC input voltage. In addition, the power supply shall be capable of satisfying the DFL system's current drain in all operational modes.

4.3 Photometric Maintenance—The DFL system shall be operated under nominal laboratory operating test conditions (23 °C ± 3 °C) at 12.8 VDC ± 0.1 VDC input voltage. The test cycle shall be the same as for the life test (6.2). The photometric maintenance test shall be performed after 70% of rated life of operation (e.g., 1400 h for a 2000 h design value of rated life).

4.4 Color and CRI

4.4.1 COLOR—The color coordinates shall be tested and fall within the chromaticity limits in SAE J578 for "White" light.

4.4.2 COLOR RENDERING—The color rendering properties of a DFL system shall be determined using the procedure outlined in CIE Publication Number 13.2 (TC 3.2) 1974, "Method of measuring and specifying color rendering properties of light sources." See 6.8 for performance criteria.

4.5 Environmental Tests—Testing shall be accomplished on a complete DFL system, i.e., ballast, interconnections, and headlamp unless otherwise specified in the specific test.

4.5.1 LEAKAGE CURRENT/BREAKDOWN TEST—The test shall be made on a system positioned in its design orientation by completely covering the exterior of the DFL system to be tested with aluminum foil. The foil is to be connected to a current-sensing device which terminates at the power source common (chassis ground). The sensing device shall be a noninductive resistor of 1000 Ω. The leakage current occurring during starting and operating (transient and steady-state) shall be measured using an oscilloscope with a bandwidth capability five times the bandwidth being measured for the observed frequencies and rise times. Current readings shall be recorded during the first 10 s of the initial start. The unit shall then continue to operate for 30 min, be turned off, and immediately restarted. The current readings shall again be recorded during the first 10 s after restart. After completion of this procedure, and without submitting the unit to any other tests, the environmental test shall be carried out on the unit. Within 30 min of the completion of the environmental test, the breakdown test shall be repeated. The final readings are then compared with the respective (initial and 30 min) readings made before the environmental test.

4.5.2 THERMAL CYCLE—A DFL system shall be mounted on a test fixture in its design orientation and shall be exposed to the test described in J1383 "Thermal Cycle Test." In addition, electronic components shall be subjected to the test in SAE J1211, Section 4.1 using conditions that are appropriate for the location of the DFL system components in the vehicle.

4.5.3 HUMIDITY—The DFL system shall be mounted on a test fixture in its design orientation and shall be subjected to the test described in SAE J1383 "Humidity Test." The DFL system shall be tested before and after the humidity test in accordance with the Breakdown Test in 4.5.1. Photometric testing shall begin at 10 min ± 1 min following completion of the humidity test. In addition, electronic components shall be subjected to the test in SAE J1211 Section 4.2 using conditions that are appropriate for the location of the DFL system components in the vehicle.

4.5.4 INTERNAL HEAT TEST—The DFL system shall be subjected to the conditions specified in SAE J1383 "Internal Heat Test." The DFL system shall be tested before and after the internal heat test in accordance with the Breakdown Test in 4.5.1.

4.5.5 DUST TEST—Conducted per SAE J575 Section 4.3. "DFL System" replaces "Headlamp" in the specifications. The DFL system shall be tested before and after the dust test in accordance with the Breakdown Test in 4.5.1.

4.5.6 CORROSION TEST—Test the DFL system per J575 Section 4.4. "DFL System" replaces "Headlamp" in the test. The DFL system shall be tested before and after the corrosion test in accordance with the Breakdown Test in 4.5.1.

4.5.7 CHEMICAL RESISTANCE TEST—The DFL system shall be tested per SAE J1383 "Chemical Resistance Test," except "DFL System" replaces "Headlamp" in the test. In addition, electronic components shall be subjected to the test specified in SAE J1211 Section 4.4 using conditions that are appropriate for the location of the DFL system components in the vehicle. The DFL system shall be tested before and after the chemical test in accordance with the Breakdown Test in 4.5.1.

4.5.8 VIBRATION TEST—The DFL system shall be tested as specified in SAE J575 Section 4.1 except "DFL System" replaces "Headlamp" in the test. In addition, electronic components shall be subjected to SAE J1211 Section 4.7 and 4.8 using conditions that are appropriate for the location of the DFL system components in the vehicle. The DFL system shall be tested before and after the vibration test in accordance with the Breakdown Test in 4.5.1.

4.5.9 ALTITUDE TEST—Electronic components shall be subjected to the requirements of Section 4.6 of SAE J1211 using conditions that are appropriate for the location of the DFL system components in the vehicle. The DFL system shall also be tested before and after the altitude test in accordance with the Breakdown Test in 4.5.1.

4.6 Photometry—The DFL system shall first be seasoned (per Section 4) at the nominal ballast input voltage of 12.8 V ± 0.1 V. The seasoned DFL system shall be aimed and after attaining steady-state conditions as specified in 6.5, be photometered to SAE J1383 requirements. Photometric measurements shall be made at a minimum distance of 18.3 m (60 ft) from the unit.

4.7 Electromagnetic Susceptibility (EMS)—The DFL system shall be tested to SAE J1113 (guidelines and test methods Sections 2 through 9) to evaluate compatibility with potential sources of EMI.

4.8 Electromagnetic Radiation (EMR)—DFL systems shall be tested in accordance with the guidelines of SAE J1816.

4.9 Life—DFL system(s) shall be mounted in its design orientation and operated using the following cycle to determine DFL system life. The "life test cycle" is a 1 h cycle, starting with five 10 min lighted cycles (50 min total). The operating cycle is 9 min 45 s "On" and 15 s "Off." Following the fifth operating cycle, the lamp is allowed to cool in the "Off" state for 10 min (81.25% hot time). When the DFL system "hot time" reaches 70% of rated lab life, the DFL system shall be subjected to the tests of 4.1 (starting procedures), 4.4 (color), and 4.5.1 (breakdown). Upon completion of the previous tests, the DFL system is returned to the life test cycle listed in Table 2 until it fails to restart (meet Figure 1 or Figure 2) following any off period. Test result guidelines are covered in 6.2.

TABLE 2—LIFE TEST CYCLE (FOR BOTH HIGH AND/OR LOW BEAM)

Cycle	Cycle Time (Minutes)		Total (Min)
1 - Operating Cycle	(9:45 on, 0:15 off)	=	10
1 - Operating Cycle	(9:45 on, 0:15 off)	=	10
1 - Operating Cycle	(9:45 on, 0:15 off)	=	10
1 - Operating Cycle	(9:45 on, 0:15 off)	=	10
1 - Operating Cycle	(9:45 on, 0:15 off)	=	10
1 - Off Cycle		=	10
Total Life test cycle		=	**60 min**

4.10 UV Test—UV radiation refers to the radiation in the spectral region between 200 and 400 nm.

a. UVA flux—is the energy flux between 320 and 400 nm
b. UVB flux—is the energy flux between 260 and 320 nm
c. UVC flux—is the energy flux between 200 and 260 nm

The measurement setup shall be as shown in Figure 1 of ANSI Z311 and the radiation sensor shall be located at a specified distance from the source (typically 50 cm). The source is defined as a lamp without any outermost lens(es). Energy levels shall be recorded at 10 nm intervals over the UV range.

UV weighting factors are defined in tables in ANSI Z311. (ANSI and NIOSH use the same tables, DIN values are also defined.)

5. *Performance Requirements*

5.1 Lamp/System Starting Procedures

5.1.1 INITIAL START-UP—Start-up intensities shall conform to Figure 1 or Figure 2. The test lamp photometric values shall meet the percent of the minimum values specified in J1383 for the test points in Table 1.

5.1.2 SWITCHING (COLD LAMPS)—Figure 1 or Figure 2 indicates the acceptable percent of steady-state light intensity versus time after a cold DFL lamp has been turned on, for DFL systems with noncontinuous and continuous low beam illumination, respectively. The lamp shall produce not less than the percent of the minimum light level specified in J1383 for the test points shown in Table 1. For DFL systems which are designed for "continuous" low beam operation, see 5.1.4.

5.1.3 SWITCHING (HOT RESTART)—After a thermally stabilized DFL headlamp has been allowed to cool for varying periods of time as shown in 4.1.3a, upon restart it shall produce not less than the percentage indicated in Figure 1 or Figure 2 of the luminous intensity values given in J1383 for the test points shown in Table 1. For DFL systems which are designed for "continuous" low beam operation, see 5.1.4.

5.1.4 For DFL systems which are designed for "continuous" low beam operation, the luminous intensity of the low beam at the upper beam test point is combined with that of the upper beam to determine conformance to this specification.

5.2 Electrical Characteristics

5.2.1 SYSTEM OPERATING WATTAGE RANGE—At an input voltage of 12.8 V, the power consumption of the DFL system shall stabilize at its rated value with a maximum deviation of ± 7.0%.

5.2.2 SYSTEM OPERATING VOLTAGE RANGE—Ignition and hot reignition of the lamp shall occur for all voltage settings between 9.0 and 18.0 VDC, and the arc shall be maintained to a low voltage of 4.5 VDC. (Reduced lumen output is acceptable for the 4.5 to 8.9 VDC range.)

The DFL system manufacturer shall specify the DFL minimum system voltage and current required for DFL system start-up.

5.3 Photometric Maintenance—When tested in accordance with the described test procedure, the DFL system shall meet the appropriate photometric specifications of SAE J1383, except 85% initial luminous flux value replaces 90% at 70% of life.

5.4 Color—The color of light emitted from the DFL headlamp following seasoning and attaining steady-state shall fall within the white light chromaticity boundaries as defined in SAE J578. The color of light shall be within the chromaticity limits both initially and after the photometric maintenance test of 5.3. Also see 6.1.

5.5 Environmental Requirements

5.5.1 LEAKAGE CURRENT/BREAKDOWN TEST—The acceptance criteria for this test shall be based on a comparison of the initial value of leakage current measured before the environmental test and the value measured after the test. The leakage value after the environmental test shall not exceed 200% (twice) of the initial test value.

5.5.2 THERMAL CYCLE—After the test, the DFL system shall meet SAE J1383 "Thermal Cycle Requirements" without magnification. Lens warpage shall be less than 3 mm (0.118 in) when measured normal to the lens surface at the geometric center of the lens. No breakdown shall be detected when the DFL system is tested in accordance with the Breakdown Test. In addition, electronic components shall meet the requirements of Section 5 of SAE J1211 using conditions that are appropriate for the location of the DFL system components in the vehicle.

5.5.3 HUMIDITY TEST—After the test, the DFL system shall meet SAE J1383 "Humidity Requirements" without magnification, and meet the photometric requirements of SAE J1383. There shall be no evidence of breakdown during the Breakdown Test. In addition, electronic components shall meet the requirements of Section 5 of SAE J1211 using conditions that are appropriate for the location of the DFL system components in the vehicle.

5.5.4 INTERNAL HEAT—The DFL system shall meet J1383 photometry values after the internal heat test. There shall be no evidence of breakdown during the Breakdown Test. In addition, electronic components shall meet the requirements of Section 5 of SAE J1211 using conditions that are appropriate for the location of the DFL system components in the vehicle.

5.5.5 DUST TEST—The DFL system shall meet the requirements of 4.3 of SAE J575. There shall be no evidence of breakdown during the Breakdown Test. In addition, electronic components shall meet the requirements of Section 5 of SAE J1211 using conditions that are appropriate for the location of the DFL system components in the vehicle.

5.5.6 CORROSION TEST—The DFL system shall be evaluated in accordance with 4.4 of SAE J575, except "DFL System" replaces "Headlamp" in the specifications. There shall be no evidence of breakdown during the Breakdown Test. In addition, electronic components shall meet the requirements of Section 5 of SAE J1211 using conditions that are appropriate for the location of the DFL system components in the vehicle.

5.5.7 CHEMICAL RESISTANCE TEST—The DFL system shall meet SAE J1383 "Chemical Resistance Requirement," except that "DFL System" replaces "Headlamp" in the specifications. There shall be no evidence of breakdown during the Breakdown Test. In addition, electronic components shall meet the requirements of Section 5 of SAE J1211 using conditions that are appropriate for the location of the DFL system components in the vehicle.

5.5.8 VIBRATION TEST—The DFL system shall meet the requirements specified in 4.1 of SAE J575. "DFL System" replaces "Headlamp" in the specifications. There shall be no evidence of breakdown during the Breakdown Test. In addition, electronic components shall meet the requirements of Section 5 of SAE J1211 that are appropriate for vibration tests for the location of the DFL system components in the vehicle.

5.5.9 ALTITUDE TEST—The DFL system's electronics shall comply with the applicable requirements of J1211. There shall be no evidence of breakdown during the Breakdown Test. In addition, electronic components shall meet the requirements of Section 5 of SAE J1211 using conditions that are appropriate for the location of the DFL system components in the vehicle.

5.6 Photometry—Each High and Low Beam of the DFL system shall meet the photometry specified in SAE J1383 Table 3.

5.7 Electromagnetic Susceptibility (EMS)—The DFL system shall meet the test requirements as specifically determined for the user's application and the environment. See applicable Sections 2 through 9 of SAE J1113 for guidance. After exposure to the tests in SAE J1113, the DFL system shall meet the requirements specified in 5.1.1, 5.1.2, 5.1.3, and 5.2.1.

5.8 Electromagnetic Radiation (EMR)—The DFL system shall meet the test requirements as specifically determined for the user's application and environment. See applicable sections of SAE J1816 for guidance.

6. *Guidelines*

6.1 Colorimetric Characteristics—Until an ANSI Standard[1] for colorimetric characteristics is developed for mercury, sodium, xenon, and metal halide lamps, it is required that the color of the DFL beams be perceived as essentially white light by drivers (for the accurate perception of colors in order to interpret road signs and signals). For this purpose, a color rendering index value may be established.

The "WHITE" color of a DFL headlamp device is presumed to exhibit only minor localized variations from the integrated measurement. If significant color variations exist within the projected beam, or if color changes occur during a period of time when the device is energized, the manufacturer of the device must be assured that such color will not be confused with that of an emergency warning device.

This assurance may be realized by using a panel of observers or by comparison of colorimetric measurements to standards for signal colors.

6.2 Life—Following cycle operation per 4.9 to 70% of rated life (Example—1400 h for a 2000 h design life), the DFL system shall meet the requirements of 5.1 (starting procedures), 5.4 (color), and 5.5.1 (breakdown). Upon completion of the previous maintenance checks, the DFL system shall be returned to cycle operation.

6.3 Voltage Regulation—The DFL system electrical supply shall be designed such that an inoperative or removed lamp will not affect the operation and performance of the remaining lamp(s) in the DFL system.

6.4 Light and Near-Infrared Radiation Exposure Limits—Manufacturers and users of DFL systems should ensure that the DFL system does not exceed the maximum allowable limit value for three retinal hazards as specified in 4.3 of the ANSI Standard Z311.1 (titled Photobiological Safety). Those three hazards are retinal thermal injury from short-term viewing (Z311.1 paragraph 4.3.1), retinal photochemical injury from chronic exposure (Z311.1 paragraph 4.3.2), and long-term ocular exposure to infrared radiation (Z311.1 paragraph 4.3.3). The three hazards cover wavelengths between 400 to 1400 nm. The measurement of the exposure levels is strongly dependent on the value used for the angular subtense of the light source (the parameter, alpha, in Z311.1). The handbook "Safety With Lasers and Other Optical Sources" by Sliney and Wolbarsht (1980, Plenum Press) is recommended as a reference.

6.5 Steady-State—Steady-state light level (100%) shall be established by allowing the DFL system to operate for 120 s after being switched "on." The average light level within the period from 120 to 140 s will be defined as the 100% level. If the light output is not stable to within ± 10% during the 120 to 140 s time interval, the process should be repeated. If the system selected does not stabilize within three attempts, another unit should be selected and subjected to the previous procedure. Steady-state is only used to define a system's baseline in order to evaluate test effects on the system.

6.6 High-Voltage Shock Safety—High-voltage shock from DFL systems is an important concern just as it is with other automotive components. Appropriate levels of safety must be designed in and other precautionary measures, such as use of caution labels, should be implemented to assure a sufficiently low level of risk. Since individual DFL products and vehicle applications will differ in regard to high voltage levels, power, and integrity of construction, each DFL system will require a specific evaluation with the system installed in the vehicle to assure a low problem potential. This is a vehicle design and testing issue and is beyond the scope of this document. Designs of replacement equipment will also need to be evaluated on specific vehicle models for which they are intended.

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[1] Current fluorescent lamp chromaticity standards in the United States are now based on spectroradiometrically determined assignments by the National Institute of Standards and Technology. Refer to ANSI C78.376-1969.

6.7 High-Voltage Vapor Ignition Safety—Protection from the possibility of vapor ignition from DFL high voltages is a concern. However, the concerns of vapor ignition are not too much different from those experienced from damaged high-voltage ignition systems, shorted and burning wiring, and exposed hot bulbs and filaments. Furthermore, the safety of a DFL system depends not only on its basic design, but also upon the design of the vehicle in which it is installed. Each vehicle application, therefore, needs to be individually evaluated as a complete DFL system in the vehicle to assure a low level of risk. This is a vehicle design and testing issue and is beyond the scope of this document.

6.8 CRI—The color rendering index shall meet the general criteria of Ra = 60. Each source manufacturer and user shall determine that the light produced shall readily allow the customer to distinguish between typical road sign colors.

6.9 UV Test—UV weighting factors defined in ANSI Z311 (ANSI and NIOSH use the same tables, DIN tables are also defined) shall be used to determine time for minimum effect. Measurements shall be made in accordance with 4.10. (See Table 3 for examples.)

TABLE 3—EXAMPLE: 175 W MULTIVAPOR LAMP MEASURED AT 50 cm

Standard	Type	Time for Min. Effect
NIOSH (200-320)	ERYTH	124.4 h
DIN (240-325)	ERYTH	677.6
DIN (300-440)	PIGMT	26.0
DIN (220-305)	CONJT	29435.

The ANSI Z311 Standard shall be used (voluntary draft at present). Energy level to be determined by application.

It is recognized that ultraviolet radiation (UV) normally emitted by arc discharge sources may pose health hazards at certain levels and durations of exposure. The magnitudes of acceptable levels of exposure are outlined in documents such as those published by NIOSH or ACGIH (American Conference of Governmental Industrial Hygienists). These tables may be used as references when determining the exposure potential of DFL headlamps.

The concern with UV light may be addressed by the device manufacturer by using shields, coatings, and/or absorbing materials. It is anticipated that most lens materials will normally provide safe UV levels by absorption/reflection. However, where the possibility exists that lens protection may be lost while the arc source remains functional (stone damage or low-energy impact), it is the device manufacturer's responsibility to assure that protection from UV is provided to all who may be exposed to the light.

6.10 System Operating Voltage Range—Vehicles are designed to continue operating at voltage levels below 9.0 V. The vehicle manufacturers must define acceptable reductions in light output for voltages below 9.0 V and determine system dropout voltage.

PREPARED BY THE SAE ROAD ILLUMINATION DEVICES STANDARDS COMMITTEE

Rationale

1. ***Scope***—Light for the DFL system is generated by a gaseous electrical discharge source. The light source is composed of a confining vessel, referred to as an envelope or tube, and contains a variety of elements typically including mercury, metal halide salts, and a rare gas. The discharge is maintained between electrodes composed of tungsten or related material. The discharge and surrounding envelope taken as a unit is called a discharge source.

   The discharge source must be operated with an auxiliary power regulator called a ballast. The ballast performs the functions of initiating the discharge and regulating the electrical properties of the source.

   The discharge source and ballast, when combined with a suitable reflector/lens assembly, forms the DISCHARGE FORWARD LIGHTING (DFL) system.

1.1 **Replacement Compatibility**—This document has been formulated so as to avoid requirements or guidelines which could restrict technical progress. Changes are expected in distribution voltage, different arc-tube technologies for performance gains, lower starting voltages, faster warm-up, shorter arc gaps, improved color, etc. This recommended practice is directed toward functional requirements associated with discharge sources. Much of the rationale is based on the assumption that the DFL system will have a significantly longer life than current headlamp systems.

2.13 **Steady-State**—DFL systems typically have a continuous low level of variation/oscillation in light output. Steady-state light level (100%) must be defined in order to establish a baseline for photometric testing. The definition was established to allow the selection of a system as a test sample. If a system fails to stabilize to within ± 10% during the 120 to 140 s time interval within three attempts, a different system should be selected for testing.

4. ***Seasoning***—DFL system operating characteristics differ from filament lamps. Unlike filament lamps where lumen drop off occurs at a relatively steady rate over life, DFL system lumens drop rapidly during the initial burning hours and then tend toward a more level rate of drop around 100 h. Depending on the DFL system design, this initial lumen drop could be 5 to 10%. With the long lives anticipated for DFL systems (2000 or more hours), test procedures need to address performance over the longer time interval. DFL systems will, therefore, require longer seasoning times to stabilize photometry. However, seasoning for 100 h is not practical. 20 h seasoning was agreed upon as a reasonable compromise.

   If a higher degree of maintenance accuracy is required, an alternate seasoning method could be used to monitor the light intensity at one test point. Start the photometric test after the rate of change has stabilized at (X), where X is defined as:

$$X = 100\ (I_{t-1} - I_t)/I_{t-1} \qquad \text{(Eq.1)}$$

   where:

   I = light intensity
   t = now
   t-1 = 1 h ago

   "Stability" would be considered as three consecutive hours (or some other agreed period) at or below X. Assuming 90% initial intensity at 100 h and 80% at a projected life of 2100 h gives a value for:

$$X = 100\ (90 - 80)/(2100 - 100) = 100\ (0.005)\ \%/h$$

   So X should be ≤0.005 (suggested value) for three consecutive hours before starting the photometric test.