SAE International

SURFACE VEHICLE RECOMMENDED PRACTICE

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Superseding J845 NOV2007

(R) Optical Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles

RATIONALE

The definition of LIGHT SOURCE was renamed to EWD LAMP ASSEMBLY.

Test voltages were added to accommodate the electrical system voltages of industrial vehicles.

The flash rate limits were revised from “at least 1 Hz and not more than 4 Hz” to “at least 1.0 Hz and not more than 4.0 Hz” to eliminate rounding errors.

References to SAE J2139 were added as an alternative to SAE J575 to accommodate devices intended for vehicles wider than 2032mm.

A provision was added to allow the use of the wideband random vibration test defined in SAE J575 in place of the vibration test procedure specified in SAE J2139 for large devices, such as light bars, since these devices are too large to be accommodated on the vibration machine specified in SAE J2139.

A requirement was added that test samples which exhibit a partial outage of non-filament EWD lamp assemblies must still comply with the photometric requirements upon the completion of any of the required tests.

The photometric test procedure was revised to ensure that sources whose output increases prior to stabilizing will still comply with the photometric requirements at their lowest output levels.

The photometric test procedure was revised to clarify how optical warning devices containing multiple EWD lamp assemblies should be evaluated.

The optical warning device class definitions were revised to differentiate between omnidirectional and selective coverage devices.

The definition of pseudo-random flash pattern was added.

Requirements for pseudo-random flash patterns were added to section “FLASH RATE AND FLASH PATTERNS”.

Sections 5.7 and 6.7 were renamed “FLASH RATE AND FLASH PATTERNS”.

The “Optical Warning Devices Containing Multiple Light Sources” and “Flash Pattern Compliance” guidelines were moved from the Installation Guidelines section to the appropriate locations in Section 5, “Tests”.

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1. SCOPE

This document provides design guidelines, test procedure references, and performance requirements for omnidirectional and selective coverage optical warning devices used on authorized emergency, maintenance and service vehicles. It is intended to apply to, but is not limited to, surface land vehicles.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J575 Test Methods and Equipment for Lighting Devices for Use on Vehicles Less than 2032 mm in Overall Width

SAE J576 Plastic Material or Materials for Use in Optical Parts Such as Lenses and Reflex Reflectors of Motor Vehicle Lighting Devices

SAE J578 Color Specification

SAE J759 Lighting Identification Code

SAE J1330 Photometry Laboratory Accuracy Guidelines

SAE J1889 L.E.D. Signal and Marking Lighting Devices

SAE J2139 Tests for Signal and Marking Devices Used on Vehicles 2032 mm or more in Overall Width

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J387 Terminology - Motor Vehicle Lighting

SAE J595 Directional Flashing Optical Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles

SAE J2498 Minimum Performance of the Warning Light System Used on Emergency Vehicles

3. DEFINITIONS

3.1 OMNIDIRECTIONAL OPTICAL WARNING DEVICE

An optical warning device that projects light in a horizontal 360 degree arc and vertically from 5 degrees up to 5 degrees down. It will project flashes of light to an observer positioned at a fixed location within the arc of coverage. This would include all 360 degree beacons.

3.2 SELECTIVE COVERAGE OPTICAL WARNING DEVICE

An optical warning device that projects light in a defined horizontal arc of more than 40 degrees, but less than 360 degrees and vertically from 5 degrees up to 5 degrees down. It will project flashes of light to an observer positioned at a fixed location within the arc of coverage. This would include all directional warning devices and omnidirectional devices within a lightbar that have a portion of their light beam blocked by internal components.

3.3 EWD LAMP ASSEMBLY

Any single, independently mounted, light-emitting component in the lighting system. An Emergency Warning Device (EWD) lamp assembly may consist of a single optical element or a fixed array of any number of optical elements whose geometric positioning relative to each other is fixed by the manufacturer of the device and not intended to be modified. To be considered a single source, the optical elements must be adjacent and operate simultaneously in all modes if the mode of the device is vehicle operator adjustable.

3.4 OPTICAL ELEMENT

Any discrete light emitter such as, but not limited to, an incandescent filament, HID or individual light emitting diode.

3.5 PRIMARY OPTICAL WARNING DEVICE

A device or group of devices that is intended to provide the primary visual optical warning signal as called out in each service class. Unless prohibited by law or regulation, a Class 1 device may be used in place of a Class 2 device and a Class 1 or 2 device may be used in place of a Class 3 device.

3.6 SECONDARY OPTICAL WARNING DEVICE

A device or group of devices of lower performance that can be used to provide supplemental optical warning to that provided by the primary optical warning device or devices.

3.7 CLASS 1A OMNIDIRECTIONAL OPTICAL WARNING DEVICE

A device utilized on authorized vehicles to capture the attention of motorists and pedestrians and warn of a potentially hazardous activity or emergency situation. It provides 360 degrees of visual warning coverage. The device can also consist of an array of individual selective coverage EWD lamp assemblies within a common housing whose coverage angles overlap or adjoin such that 360 degrees of warning coverage results.

3.8 CLASS 1S SELECTIVE COVERAGE OPTICAL WARNING DEVICE

A device utilized on authorized vehicles to capture the attention of motorists and pedestrians and warn of a potentially hazardous activity or emergency situation. A single device of this Class will not provide 360° of warning coverage.

3.9 CLASS 2A OMNIDIRECTIONAL OPTICAL WARNING DEVICE

A device utilized on authorized vehicles to capture the attention of motorists and pedestrians and warn of traffic hazards such as a lane blockage or a slow moving vehicle. It provides 360 degrees of visual warning coverage. The device can also consist of an array of individual selective coverage EWD lamp assemblies within a common housing whose coverage angles overlap or adjoin such that 360 degrees of warning coverage results.

3.10 CLASS 2S SELECTIVE COVERAGE OPTICAL WARNING DEVICE

A device utilized on authorized maintenance or service vehicles to capture the attention of motorists and pedestrians and warn of traffic hazards such as a lane blockage or a slow moving vehicle. A single device of this Class will not provide 360° of warning coverage.

3.11 CLASS 3A OMNIDIRECTIONAL OPTICAL WARNING DEVICE

A device utilized on authorized vehicles to identify them to pedestrians and motorists. It provides 360 degrees of visual identification coverage. The device can also consist of an array of individual selective coverage EWD lamp assemblies within a common housing whose coverage angles overlap or adjoin such that 360 degrees of warning coverage results.

3.12 CLASS 3S SELECTIVE COVERAGE OPTICAL WARNING DEVICE

A device utilized on authorized vehicles to identify them to pedestrians and motorists. A single device of this Class will not provide 360° of warning coverage.

3.13 LIGHT PULSE

A single, visually continuous emission of optical energy. High frequency modulation is permitted.

3.14 FLASH

A light pulse or a train of light pulses, where a dark interval of at least 160 ms separates the light pulse or the last pulse of the train of light pulses from the next pulse or the first pulse of the next train of light pulses. To be considered a train of light pulses, each pulse in the train must begin within 100 ms after the end of the preceding light pulse. Dark interval luminous intensity shall not exceed 2% of the maximum luminous intensity of a flash.

3.15 OPTICAL POWER

The integration of the luminous intensity of the flashing EWD lamp assembly for a time of 60 s ($\int$Idt). Units are Candela·s/min.

3.16 PSEUDO-RANDOM FLASH PATTERN

A flash pattern that varies over time and is composed of blocks of compliant flashes presented in a sequential or random order.

4. LIGHTING IDENTIFICATION CODE, MARKINGS, AND NOTICES

In accordance with SAE J759, the optical warning device may be identified by the codes:

"W3-1", for Class 1A omnidirectional devices
"W3-2", for Class 2A omnidirectional devices
"W3-3", for Class 3A omnidirectional devices
"WS3-1", for Class 1S selective coverage devices
"WS3-2", for Class 2S selective coverage devices
"WS3-3", for Class 3S selective coverage devices

If the optical warning device is a selective coverage device the angle of coverage may also be indicated in parentheses. For example, a Class 1 device providing 120 degrees of signal may be marked WS3-1 (120).

A device may only have one class rating if its mode of operation is vehicle operator adjustable. The rating shall be based on the mode with the lowest performance level.

5. TESTS

All tests are to be performed using the test voltages indicated in Table 1 below:

TABLE 1 - TEST VOLTAGES

System Voltage	Test Voltage	Test Voltage Tolerance
12	12.8	± 0.1
24	25.6	± 0.2
36	38.4	± 0.3
42	44.8	± 0.35
48	51.2	± 0.4
72	76.8	± 0.6
80	85.3	± 0.66

CAUTION: Adequate care must be exercised in order to maintain a safe test environment when handling voltages higher than 36 V.

Tests are to be made using the wiring supplied by the device manufacturer or wire of the minimum size recommended by the device manufacturer. For devices intended to be hard wired into the vehicle electrical system, the voltage shall be measured at 300 mm from the point at which the wiring exits the device. For portable devices equipped with an electrical connector, the voltage shall be measured at the supply side of the connector.

Either SAE J2139 or SAE J575 is a part of this document. The choice of which Recommended Practice is used depends on the width of the vehicle the warning light is intended to be used on. The following tests are applicable with the modifications as indicated.

5.1 Vibration Test

The wideband random vibration test defined in SAE J575 may be used for large devices, such as light bars, in place of the vibration test procedure specified in SAE J2139.

5.2 Moisture Test

5.3 Dust Test

The change in intensity may be measured at the HV location.

5.4 Corrosion Test

5.5 Warpage Test for Plastic Components

The device shall be operated in the mode with the highest optical power.

5.6 Photometry

In addition to the test procedures in SAE J2139 or SAE J575, the photometric performance shall be determined by measuring the optical power and the peak intensity of each flash. Photometry shall be performed with the EWD lamp assembly flashing.

An integrating photometer shall be used to determine the optical power projected over 60 s. Any measurement period not less than 20 s may be used. These measurements shall then be corrected to obtain the optical power in units of cd·s/min. If the flasher or power supply/flasher has more than one flash pattern, the optical power shall be measured and recorded for each pattern.

5.6.1 Photometric Stability

All photometry tests shall be performed in accordance with SAE J1330 and all EWD lamp assemblies shall operate until the photometric output is stable as defined in SAE J1889 prior to testing. Because the photometric output of a LED lighting device may either increase or decrease as the temperature of the LED EWD lamp assembly increases, the following stabilization and measurement method is required:

Energize the test device and record the H-V photometric value after 1 minute. Continue to energize the test device until photometric stability occurs. Record the photometric values at all the required test points. Calculate the ratio between the 1 minute H-V reading and the photometric stability H-V reading and apply the ratio to all of the required test points to determine the 1 minute photometric performance.

5.6.2 Device Mounting and Orientation

Photometric measurements shall be made with the device mounted in its normal operating position and all measurements shall be made with the geometric center of the EWD lamp assembly of the device at least 18 m from the photometer sensor.

The device shall be mounted so that the horizontal plane through the photometer sensor axis passes through the center of the EWD lamp assembly. The vertical axis through the center of the EWD lamp assembly shall be perpendicular to this horizontal plane. If the EWD lamp assembly is composed of an array of optical elements, the geometric center of the array shall be used.

The H-V reference point for omnidirectional devices shall be determined by turning the device about its vertical axis until the photometer indicates the minimum optical power reading.

The H-V reference point for selective coverage devices shall be either (1) the midpoint of its coverage angle or (2) as indicated on the device, if it is so marked. The coverage angle of Selective Coverage devices shall be included in the test report.

5.6.3 Photometric Considerations for Devices Containing Multiple EWD Lamp Assemblies

The photometric performance and arc of coverage of light bars and other types of optical warning devices containing multiple EWD lamp assemblies can be determined directly by testing the entire device or a representative portion of the device, e.g. one half of a full size light bar. Alternatively, photometric testing of each individual EWD lamp assembly, or type of EWD lamp assembly and combining the results both geometrically and mathematically may be done. To combine the results from individual EWD lamp assemblies, the test results from each individual EWD lamp assembly must be adjusted geometrically for its direction when mounted in the light bar. The effect of transparent and opaque structures within the light bar on the photometric performance of the individual EWD lamp assemblies must be considered and be accounted for when combining results. In addition, each individual EWD lamp assembly used to determine the total photometric performance, arc of coverage, and Class of performance of a light bar in a given mode must comply with the flash characteristics defined in this document and be of the same or better Class of performance. Once these requirements have been met the total photometric performance of the light bar, its arc of coverage, and its Class of performance may then be determined.

When determining the photometric performance of devices containing multiple EWD lamp assemblies' the following characteristics must be considered and satisfied:

5.6.3.1 The geometric positioning of the individual EWD lamp assemblies relative to each other is fixed by the manufacturer of the device and not intended to be modified.

5.6.3.2 The optical power of individual EWD lamp assemblies may be summed in areas where the beam pattern of two or more individual EWD lamp assemblies overlap provided the individual EWD lamp assemblies are of the same color. An example of this is shown in Figure 1.

5.6.3.3 The peak intensity of individual EWD lamp assemblies may be summed in areas where the beam pattern of two or more individual EWD lamp assemblies overlap provided the flash characteristics are simultaneous, synchronous, and the individual EWD lamp assemblies are of the same color. An example of this is shown in Figure 1.

	V	10° R	20° R	30° R
5° U	2101	1579	1357	960
2.5° U	4313	3878	3299	2545
H	5077	4233	3732	2887
2.5° D	3413	2768	2420	1847
5° D	1426	1066	915	780
Zone Total	16330	13524	11723	9019

Light Source 1
Not Compliant to Class 1A or 1S

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	V	10° R	20° R	30° R
5° U	989	1633	2069	2590
2.5° U	2618	4051	5000	5889
H	3085	4076	5248	6650
2.5° D	1254	1910	2696	3828
5° D	451	600	779	1055
Zone Total	8397	12270	15792	20012

Light Source 2
Compliant to Class 1A or 1S at 30°R Only

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	V	10° R	20° R	30° R
5° U	3090	3212	3426	3550
2.5° U	6931	7929	8299	8434
H	8162	8309	8980	9537
2.5° D	4667	4678	5116	5675
5° D	1877	1666	1694	1835
Zone Total	24727	25794	27515	29031

Device
Compliant to Class 1A or 1S

FIGURE 1 - EXAMPLE OF SUMMING OPTICAL POWER OR PEAK INTENSITY VALUES OF OVERLAPPING, INDIVIDUAL EWD LAMP ASSEMBLIES

5.6.3.4 Individual EWD lamp assemblies of the same Class of performance, and of the same or different colors may have their arcs of coverage summed to determine the arc of coverage of the total device. An example of this is shown in Figure 2.

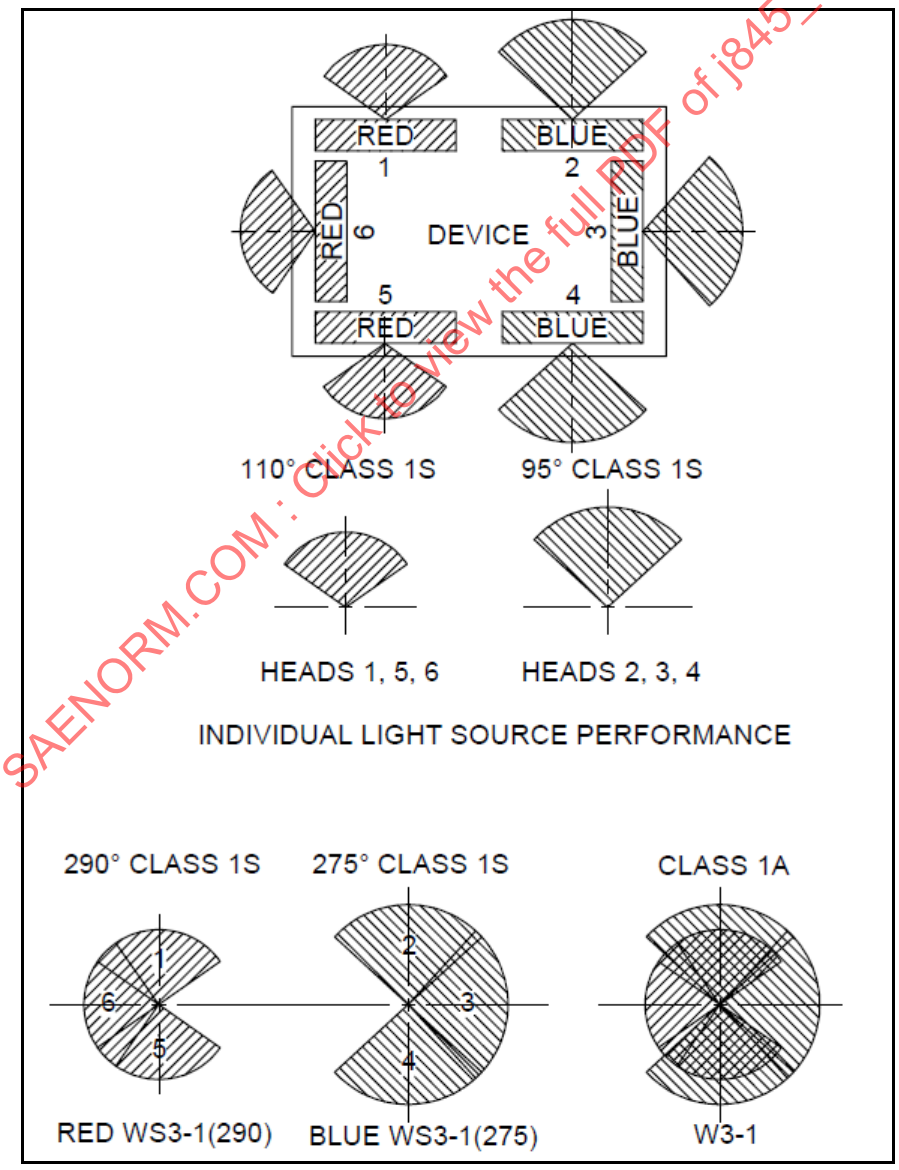


FIGURE 2– RESULT OF COMBINING INDIVIDUAL EWD LAMP ASSEMBLIES AFTER ADJUSTING THEM GEOMETRICALLY FOR THEIR DIRECTION WITHIN THE DEVICE

5.6.3.5 The flash pattern of all the individual EWD lamp assemblies within the device in a given mode must meet the flash characteristics defined in this document. In addition, the combined flash pattern of two or more adjacent individual EWD lamp assemblies of the same color and in the same mode shall meet the flash characteristics defined in this document.

5.7 Flash Rate and Flash Patterns

Any device incorporating an integral flasher, an external flasher, or a combined power supply and flasher supplied by the manufacturer of the device, shall be tested with this flasher.

If a flasher is required and no flasher is supplied by the manufacturer of the device, the device shall be tested using a flasher having a flash rate of 1.20 Hz ± 0.14 Hz with a 50% ± 2% current on time.

5.8 Color Test

SAE J578 is a part of this document.

Incandescent devices may be measured while in a steady state mode at design voltage.

5.9 High Temperature Flash Rate Test

The device shall be subjected to an ambient temperature of 50 °C ± 3 °C for a period of 6 h. The device shall be off (not operating) during the first hour and shall operate continuously for the next 5 h of the test. The flash rate shall be measured starting 1 min after the device is activated and at the conclusion of the test. If the device has multiple flash patterns then the pattern with the highest optical power shall be used. The start time shall be measured at time of activation.

5.10 Low Temperature Flash Rate Test

The device shall be subjected to an ambient temperature of -30 °C ± 3 °C for a period of 6 h. The device shall be off (not operating) during the first 5 h and shall operate continuously for the last hour of the test. The flash rate shall be measured starting 1 min after the device is activated and at the conclusion of the test. If the device has multiple flash patterns then the pattern with the lowest optical power shall be used. The start time shall be measured at time of activation.

5.11 Durability Flash Rate Test

The device shall be operated continuously for 200 h at an ambient temperature of 25 °C ± 3 °C in cycles consisting of 50 min on and 10 min off. The flash rate shall be measured starting 1 min after the device is activated and at the conclusion of the test. If the device has multiple flash patterns then the pattern with the highest optical power shall be used.

5.12 Materials Test

SAE J576 is a part of this document.

6. PERFORMANCE REQUIREMENTS

A device, when tested in accordance with the test procedures specified in Section 5, shall meet the requirements of SAE J2139 or SAE J575. For devices with non-replaceable sources, such as LEDs, 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 (see 6.2) shall be performed. The sample must still comply with the photometric requirements.

6.1 Vibration

6.2 Moisture

6.3 Dust

Upon completion of the test, the test device shall be considered to have met all the requirements of the dust test when complying with either of the following requirements:

No dust shall be found on the interior surface of the test device, or

The maximum or HV luminous intensity measured after the dust exposure test shall be at least 90% of the initial maximum or HV luminous intensity measured before the test.

6.4 Corrosion

6.5 Warpage

6.6 Photometry

To be considered compliant, a flash pattern shall meet the optical power requirements contained in Figures 3, 4, or 5 and their footnotes. The summation of the optical power measurements for the specified test points in a zone shall be at least the optical power zone value shown. Additionally, the peak luminous intensity of the pattern shall meet the photometric requirements contained in Figures 3, 4, or 5 and their footnotes. The summation of the peak luminous intensity measurements for the specified test points in a zone shall be at least the peak luminous intensity zone value shown. Compliance shall be demonstrated both at 1 minute after the device is energized and after it has reached photometric stability.

In the case of gaseous discharge devices, only compliance to the optical power requirements is required.

For a given flash pattern, compliance to the optical power requirements shall be measured in no greater than 10° increments throughout the coverage angle of the device. For the same flash pattern, compliance to the peak intensity requirements shall be measured at the point of lowest optical power in the horizontal plane within the coverage angle of the device.

6.7 Flash Rate and Flash Patterns

The flash rate for devices shall be at least 1.0 Hz and not more than 4.0 Hz at all times.

The characteristics, including peak intensity, flash rate period, number of pulses per flash, on time (electrical), off time (electrical) and pulse separation, shall be measured and recorded. If the flasher or power supply/flasher has more than one flash pattern, the characteristics shall be measured and recorded for each pattern.

The use of LEDs has made it possible to create very complex flash patterns. While the flash characteristics defined in this document attempt to accommodate these possible patterns, flash patterns that do not meet these characteristics are possible and may be desirable in special circumstances. To accommodate these complex flash patterns, the manufacturer of devices with multiple flash patterns shall indicate in the instruction manual which patterns comply with the requirements of this standard and to which class of performance, i.e., Class 1A or 1S, Class 2A or 2S, or Class 3A or 3S.

Pseudo-random flash patterns that are entirely composed of blocks of compliant flashes presented in a sequential or random order are acceptable.

6.8 Color

The color of light emitted in each mode shall be white, yellow, red, or signal blue as specified in SAE J578, except that the blue boundary for white shall be x = 0.300.

6.9 High Temperature Flash Rate Test

There shall be no evidence of operating conditions that would result in failure to comply with Section 6 of this document. Operation of the device shall begin and continue within 5 s of the beginning of each operating cycle. The measured flash rates shall not vary by more than 20% from the ambient flash rate.

6.10 Low Temperature Flash Rate Test

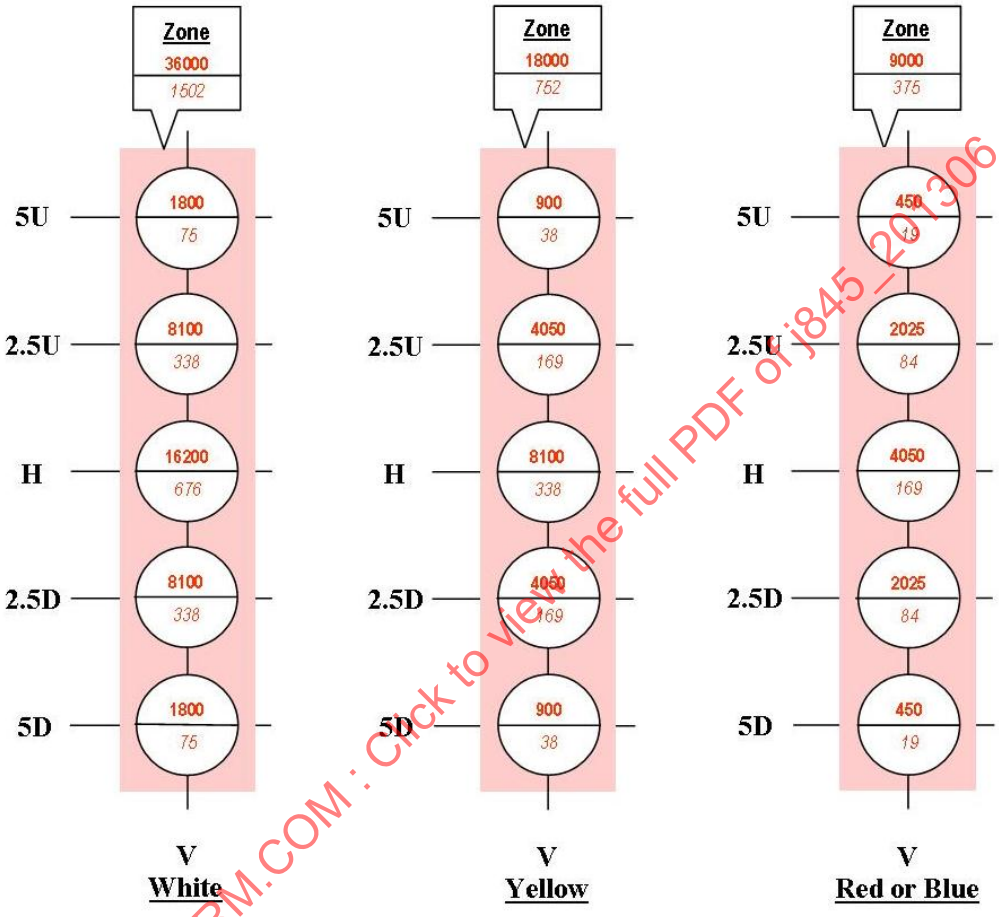
There shall be no evidence of operating conditions that would result in failure to comply with Section 6 of this document. Operation of the device shall begin and continue within 5 s of the beginning of each operating cycle. The measured flash rates shall not vary by more than 20% from the ambient flash rate.

6.11 Durability Flash Rate Test

There shall be no evidence of operating conditions that would result in failure to comply with Section 6 of this document. The final measured flash rates shall not vary by more than 20% from the initial flash rates.

6.12 Material Requirements

Plastic materials used in optical parts shall meet the requirements of SAE J576.



1. For each test point and zone total, the value shown in **bold** (top value) is the optical power requirement and the value shown in *italics* (bottom value) is the peak luminous intensity requirement.
2. The measured values at each test point shall not be less than 60% of the required minimum values shown for that individual test point location.
3. The sum of the optical power measurements and the sum of the peak luminous intensity measurements for each test point within a zone, shall not be less than the corresponding zone total requirements shown. The measurements at each discrete test point shown within the corresponding zone are the values used to calculate the specified zone total.
4. An adjustment in device orientation from the design position may be made in determining compliance to the optical power requirements, providing such adjustment does not exceed 1 degree in any direction. All zone totals must comply after reaim.

FIGURE 3 - PHOTOMETRIC REQUIREMENTS - CLASS 1A OR 1S
COLORS: WHITE, YELLOW, RED AND BLUE

Optical Power (Cd-s/min) Shown in **Bold** (top Value)
Peak Luminous Intensity (Candela) Shown in *Italics* (bottom value)