SURFACE VEHICLE STANDARD

J2121™ JUL2023

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Superseding J2121 JUL2009

(R) Requirements for Composite Lighting Assemblies Used on Construction and Industrial Machinery

RATIONALE

This document has been revised to include provisions for replacing incandescent light sources with LED sources. In addition, specific vibration test criteria have been added.

1. SCOPE

This SAE Standard provides general design performance requirements and related test procedures for composite lighting unit assemblies, other than signaling and marking devices, used on earthmoving and road building and maintenance off-road work machines as defined in SAE J1116.

1.1 Purpose

To provide general guidelines and design parameters for lighting assemblies used on construction and industrial machinery.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise specified, 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 +1 724-776-4970 (outside USA), www.sae.org.

SAE J180 Electrical Charging Systems for Off-Road Work Machines

SAE J994 Alarm - Backup - Electric Laboratory Performance Testing

SAE J1029 Lighting and Marking of Construction, Earthmoving Machinery

SAE J1116 Categories of Off-Road Self-Propelled Work Machines

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
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For more information on this standard, visit
https://www.sae.org/standards/content/J2121_202307

SAE J1330 Photometry Laboratory Accuracy Guidelines

SAE J2357 Application Guidelines for Electronically Driven and/or Controlled Exterior Automotive Lighting Equipment

SAE J2895 LED Work Lighting Devices

2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM B117-90 Standard Test Method of Salt Spray (Fog) Testing

3. DEFINITIONS

3.1 COMPOSITE LIGHTING ASSEMBLY

A lighting device fitted with a replaceable light source and typically comprised of lens, reflector and holding mechanism, and housing.

3.2 DESIGN BEAM PATTERN

The beam distribution which establishes 90% of the light output. It is defined typically by angular degrees horizontal by angular degrees vertical.

3.3 DESIGN VOLTAGE OR TEST VOLTAGE

That voltage assigned by the burner manufacturer to establish the specifications for current and light output.

3.4 TEST FIXTURE

A fixture which simulates the mounting interface of the lighting unit to a machine. It may be used for the icing and pressure water test.

3.5 DESIGN LIFE

The rated quiescent average life of a burner or light source in hours, at rated voltage on a test stand (the B50 stand life).

3.6 APPLICATION VOLTAGE

The voltage, generated and distributed by the machine electrical system, that is applied to the lamp terminals.

3.7 LED

An indivisible discrete light source unit containing a semiconductor in which visible light is non thermally produced when a forward current flows as a result of applied voltage.

4. LIGHT SOURCE REQUIREMENTS

4.1 Interchangeability

The light source shall be replaceable with an equivalent light source and acceptable lamp assembly performance be maintained.

4.1.1 LED Replacement of Incandescent Light Source

If an incandescent light source is replaced by an LED equivalent, additional testing is required, as defined in Section 5 of SAE J2895.

4.2 Life

Acceptable life is often determined by the application requirements. These are primarily shock, vibration, voltage transients, and steady-state voltage. The average bench life of the light source shall be mutually agreed upon between lamp manufacturer and machine manufacture

4.3 Steady-State Voltage

The control of steady-state voltage can be very important in the application of a light assembly (especially tungsten lamps).

For tungsten lamps, the re-rating rules are:

a. Rerated light power = $(V/V_D)^{3.5}$ x light power at V_D

b. Rerated life = $(V_D/V)^{12}$ x life at V_D

c. Rerated current = $(V/V_D)^{0.55}$ x current at V_D

where:

V = application voltage

V_D = design voltage

In order to maximize the life and effectiveness of a lamp, the application voltage should be identical to the design voltage. The application voltage is the result of the following:

a. Alternator output voltage which is dictated by the requirements to re-charge the battery.

b. Voltage drops resulting from the various control devices such as switches, circuit breakers, etc., in the lamp circuit.

c. Voltage drop in the electrical cables and ground return of the lamp circuit.

The application voltage is typically adjusted by selecting the lamp circuit cable to provide the appropriate resistance and voltage drop.

Quiescent life tests shall be performed at the nominal design voltage level within 0.1 V. The voltage shall be measured at the light assembly electrical interface.

4.4 Voltage Transients

As shown in Table 1, voltage transients take on many forms depending on their source. Transients can cause immediate failure or significantly shorten the life of the lamp. The system design shall take into account these transients to eliminate or reduce their effect on the life of the light assemblies.

Table 1 - Transient voltages

Cause	Effect
Voltage Regulator Failure	50% over voltage
Jump Starts	100% over voltage
Alternator Load Dump (Disconnect Battery)	12 V system: $(14+100\ e^{-t/.2})$ V 24 V system: $(28+200\ e^{-t/.2})$ V (t = time in seconds)
Inductive Load Transients	$\pm 200\ e^{-t/.2}$ V (t = time in seconds)
Mutual Coupling in Harness	$\pm 200\ e^{-t/.001}$ V (t = time in seconds)
Accessory Noise	1.5 vpk (50 Hz to 10 kHz)
Radio Frequency Interference	RF energy
Machine Welding	100% over voltage

5. OPERATING AMBIENT TEMPERATURE

The light assembly shall operate throughout the temperature range of -40 to 85 °C. No permanent deformation or cracking is acceptable throughout this range over the design life of the assembly.

6. MAXIMUM OPERATING TEMPERATURE

If contact with the lens or housing is likely due to the lamp mounting location, consideration shall be given to the surface temperatures and the protection that may be required.

7. THERMAL ENDURANCE

Expose the assembly to the specified maximum ambient temperature (85 °C) for the time required to reach thermal stability, then turn on the supply voltage and operate the light for 100 hours. The light assembly shall remain functional throughout the test. At the end of 100 hours, turn off the supply voltage, the light shall be cooled to ambient tempereature and tested for light output and integrity. The light output after the test shall be at least 80% of the initial H-V light output.

8. SHOCK AND VIBRATION

Shock and vibration are common in off-road equipment and the following situations are typical: operating over rough terrain, running into immovable objects, and using the mounted tools as hammers. The shock levels induced, and the resulting structural vibrations have a negative effect upon light filament life. Light mounting methods and locations should be selected to reduce shock and vibration effects. Both level and frequency are important to the overall life of the light. Lower voltage filaments are more rugged and are better able to withstand shock and vibration.

The light output after the test shall be at least 80% of the initial H-V light output prior to vibration test. Incandescent light source may be replaced after the test, but the initial LED light source shall remain.

8.1 Vibration Test

The light assembly shall be fastened to the table of the vibration test machine, mounted on its standard supplied support, and the test shall be conducted as follows.

8.1.1 Resonance Search

Determine and record the resonant frequencies of the test item for each position (x-y-z axis) by slowly varying the frequency of applied vibration through 10 to 500 Hz with sufficient amplitude to excite the item. Resonance of components is determined by visual observation, strain-gaging of components, observing signal interruptions of the electronic circuit, or a combination of these. See Figure 1.

8.1.2 Resonance Dwell

Vibrate the test item at a 5 g (peak to peak) level at the most severe resonant frequency and at no more than three other significant resonant frequencies (if they were found) along each axis as determined in 8.1.1. For resonant frequencies below 19 Hz, vibrate at a costant amplitude of of 6.75 mm as shown in Figure 1. If the resonant frequency changes during this test, immediately record its time of occurrence and adjust the frequency to maintain peak resonance. Record final resonant frequency.

8.1.3 Vibration Cycling

Use a cycle time of 15 minutes to ascend to 500 Hz and descend to 10 Hz (see Figure 1). Vibration cycling will be along each axis (x-y-z) at 5 g (peak) for the frequencies between 19 Hz and 500 Hz, while at constant double amplitude (displacement) of 6.75 mm for the frequencies below 19 Hz. The total time for each axis is 3 hours. During the final 15 minutes cycle (on the axis checked last), connect the power to the light to check that it functions continuously throughout the cycle. At the end of vibration cycle repeat the light output tests (Section 13).

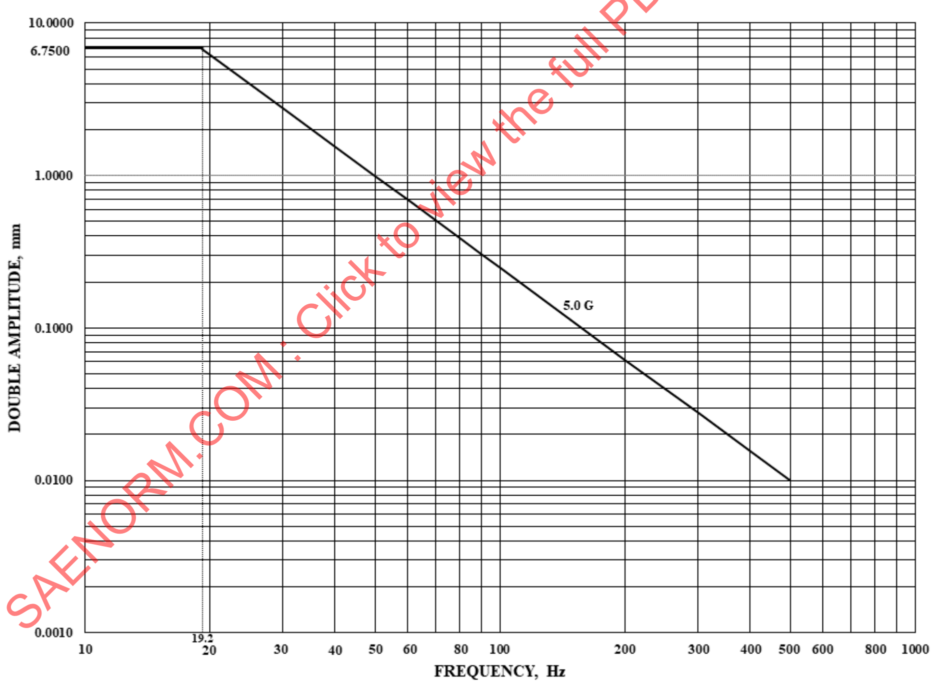


Figure 1 - Vibration test

Upon completion of the vibration test procedure, there shall be no observed rotation, displacement, cracking, or rupture of parts of the device (except bulb filaments or headlamp light source filaments) which would result in failure of any other tests contained in this document. Looseness of parts as evidenced by rattling heard when the part assembly is shaken shall also constitute a failure. Cracking or rupture of parts of the device affecting its mounting shall also constitute a failure.

9. DUST

The light assembly shall be sealed to dust and the following dust test shall be used. An initial light power test to measure peak candlepower shall be performed. An enclosure, with a minimal inside dimension of 1 m, shall contain 15 kg of AC fine dust (as referenced in SAE J180). The light assemblies shall be mounted not closer than 150 mm from any wall in the normal operating orientation toward the bottom of the enclosure. Every 15 minutes the dust shall be agitated by a fan blower for enough time to completely and uniformly diffuse the dust throughout the enclosure. The dust is then allowed to settle.

This test is to continue for 500 hours. After the dust test, each assembly exterior is to be cleaned and the peak candlepower determined. The light assembly shall be operable within 90% of its initial value to pass this test.

10. MOISTURE SEALING

At the end of each test, the light assembly shall produce at least 90% of its pre-test light output.

10.1 Pressure Washer

The light assembly, as installed, shall not accept water internally from a high-pressure washer when operated at 140 bar with a solid cone angle and orifice of 2 mm. The nozzle shall pass not closer than 300 mm from the front surface of the light during washing while the light is mounted into its test fixture in its proper orientation.

10.2 Rain and Shine

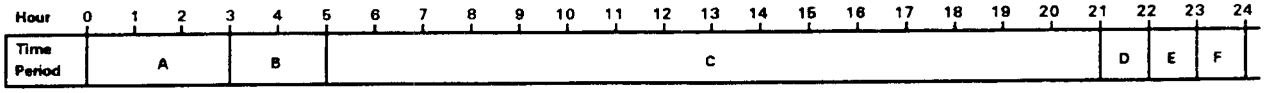
The light assembly, as installed, shall be subjected to 100 cycles of rain and shine operation. Each cycle shall consist of 1 hour of simulated precipitation of 5.0 mm/h of water from one or more solid cone nozzles followed by 1 hour where the test sample lamp is energized at rated voltage. After the 100-cycle test, the samples shall be examined. Moisture ingression or corrosion that results in degradation in performance shall constitute a failure.

11. FLUID COMPATIBILITY

The light assembly shall remain functional and shall not degrade when it comes into contact with chemicals commonly used in off-road machinery. The assembly will be brushed with engine oil, hydraulic and transmission oils, #1 diesel fuel, brake fluid, ethylene glycol, and phosphatizing agents at room temperature. The samples shall be completely brushed eight times with each fluid with a 1-hour interval between each brushing. The samples will be allowed to stand 16 hours minimum in this condition. At the completion of this period, rinse, air dry, and then test the light assemblies with criteria being 90% of its initial peak light output and no discoloration or degradation.

12. ICING

The light assembly shall show no damage when allowed to ice over. The test procedure for each 24-hour cycle is shown in Figure 2. The light assembly may be mounted into its test fixture for this test. The light assembly and test fixture shall be turned upward to aid in distributing the water over the exterior surface. The light assemblies shall be subjected to ten of these 24-hour cycles. Any assemblies found with cracks, open seams, or other damage shall be cause for failure of this test.



Time Period	Procedure
A	For 3 s every 15 min the surface of the light assembly shall be sprayed with a fine mist of water cooled to 0 to 3 °C while the light assembly is cooled from room temperature to −5 °C.
B	Spray mist shall continue with the light assembly temperature maintained at −5 °C.
C	Test fixtures shall be cooled from −5 to −40 °C over a 16 h period without any further spraying.
D	Light assembly shall be energized for 1 h and then removed from the cold chamber.
E	Light assembly shall be energized for 1 h while at room temperature.
F	Light assembly shall be rinsed, dried, and reviewed for any damage along the surfaces and seams of the light assembly.

Figure 2 - Icing test procedure

13. ILLUMINATION PERFORMANCE

The light output or performance is a function of the intended design and application. The illumination effects in any given application are very subjective and need to be quantified by measurable features. Measurable parameters of this performance are beam pattern intensities, measured in candela and displayed as photometric test point candela or as an iso-candela curve, and ground surface beam distribution illumination measured in lux and displayed in an iso-lux surface area plot.

General desirable qualities of all beam pattern distributions are smooth, even lighting gradients throughout the entire beam pattern. This will eliminate hot spots, voids, and stria which can cause false cuing or poor acuity to the operator of a machine using this light pattern.

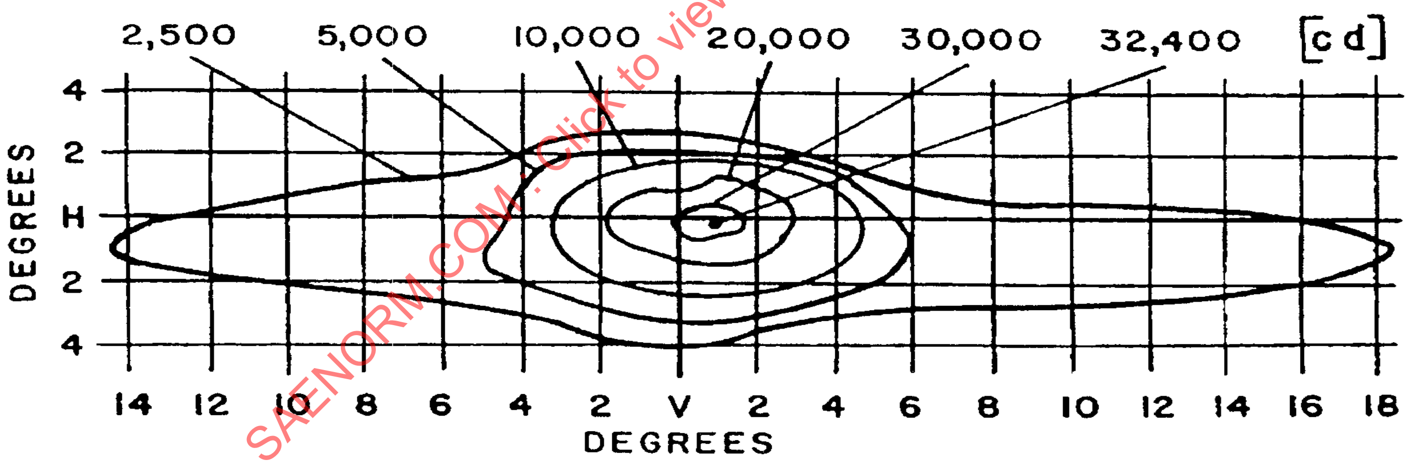


Figure 3 - ISO-candela curve

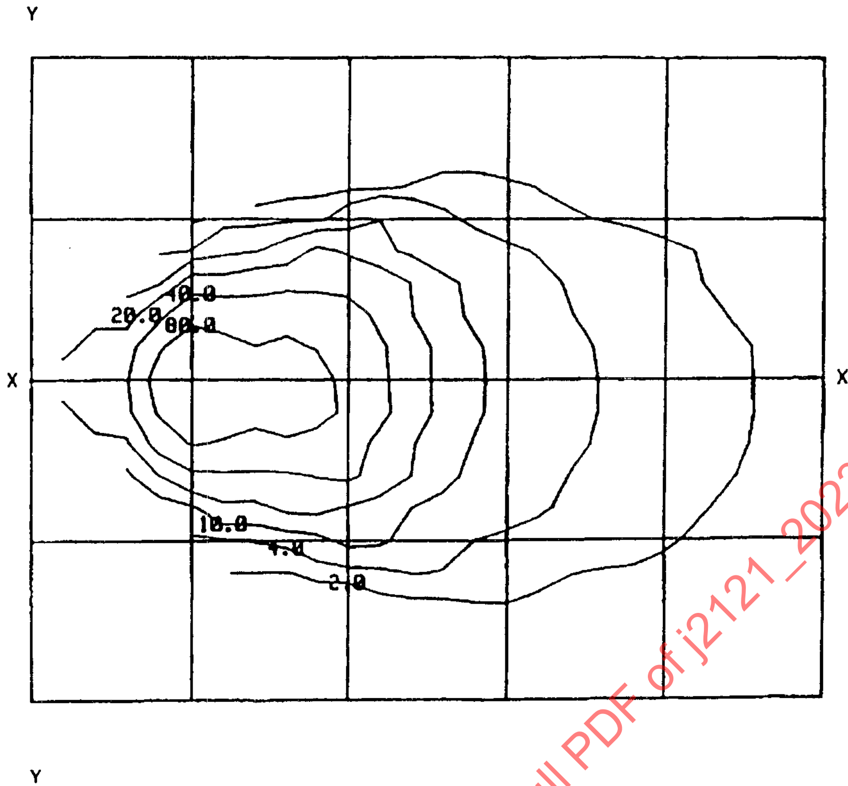


Figure 4 - ISO-lux curve

NOTE: The isometric lux plot is dependent on the angle and distance between the light source and the illuminated plane. For this reason, the candela plot is preferred.

14. PHOTOMETRY TEST

All photometry tests should be performed in accordance with SAE J1330.

The lamp shall be mounted on a test fixture simulating the vehicle mounting system and any optically significant surrounding area that would either enhance or block the beam. The device shall be operated at room temperature with the design voltage applied. The beam pattern listed in Table 1 will detail the photometric performance for the trapezoid beam. The beam pattern listed in Table 2 will detail the photometric performance for the flood beam.

14.1 Photometric Stability and Beam Pattern for LED Light Sources

Photometric output (luminous intensity) of a LED lighting device typically changes as the temperature of the LED light source increases; therefore, the following stabilization and measurement methods are required.

Energize the light and record the H-V photometric value after 1 minutes (the initial H-V value). Keep the light energized until the photometry value is stable to within ±3% within any 15-minute period.

Record the photometric values at all the required test points and repeat the H-V value as the final value. Calculate the ratio between the 1-minute initial and final H-V readings and apply it to all the required test points to determine the 1-minute photometric performance. Compliance shall be demonstrated both at 1 minute after the device is energized and after it has reached photometric stability.