



AEROSPACE RECOMMENDED PRACTICE

ARP5029™**REV. B**

Issued 1998-12
Reaffirmed 2007-07
Revised 2019-07

Superseding ARP5029A

Measurement Procedures for Short Pulse Width Strobe Anticollision Lights

RATIONALE

Revised to clarify the technology covered by this ARP, namely short pulse width anticollision lights such as xenon strobe lights and the special considerations required for measurement of this technology; e.g., lens color shift, recommended measurement distance, and detector type. References to documents relating to other technologies, such as LED anticollision lights, are provided.

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1. SCOPE

This SAE Aerospace Recommended Practice (ARP) provides the user with standardized guidelines for the measurement of effective intensity of short pulse width strobe anticollision lights for aircraft in the laboratory, in maintenance facilities, and in the field. A common source of traceability for calibration of the measurement systems, compensation for known causes of variation in light output such as the use of colored lenses, and recommendations which minimize sources of errors and uncertainties are included in this document. Estimates of uncertainty and error sources for each class of measurement are discussed.

1.1 Purpose

This document recommends the test methods and equipment necessary to perform photometric measurements used to determine the effective intensity of red and white short pulse width strobe type anticollision lights for aircraft.

1.2 Limitations

This document does not include the measurements of long duration flashes, such as those achieved with rotating beacons, flashed incandescent lamps or LED lighting. This procedure only applies to short pulse width strobe technology, which is defined as the condition where the pulse width is insignificant compared to the Blondel-Rey factor of 0.2 second as described in 2.2.4 of this document. The measurement of long duration flashes and the iterative calculation process required to determine the effective intensity from the intensity-time curve is discussed in FAA Advisory Circular 20-74. An example of a method and suitable equipment for measuring long pulse width strobes is detailed in 4.3.1.3 of ARP5825. Measurement of the effective intensity of bursts of flashes or multiple closely spaced flashes is not included in this document. Guidelines for calculating the effective intensity of multiple flashes are provided in AS8017.

1.3 Categories of Test

The measurements are divided into three categories. The categories in descending order of accuracy and detail are:

- a. Laboratory measurements.
- b. Maintenance facility measurements.
- c. Field measurements.

1.4 Test Considerations

Photometric calibration traceability for each type of measurement is recommended. The uncertainties of the measurement system, causes for variations in intensity of the lights, and sources of error for each type of measurement are reviewed in Appendix H. Particular attention is given to the effect of temperature on the transmittance of red glass. In the laboratory test section, a procedure is outlined for compensating for this temperature dependent effect when making intensity measurements.

1.5 Safety

Observe the following safety recommendations when working with strobe based anticollision light systems. Particular attention should be paid to the appropriate requirements of the photobiological standards and guidelines listed in Section 2:

CAUTION: EXPLOSION HAZARD! Do not operate the strobe light without the fitted lens securely in place. Always wear eye protection when testing strobe lights. The flash tube is under pressure, and possible injury can occur if flash tube explodes.

CAUTION: HIGH VOLTAGE! Use care when handling cables, power supply and strobe lights during test, as high voltage is present. Allow adequate time for voltage to bleed off or manually discharge the system.

CAUTION: HOT SURFACES! Do not touch the strobe light during or immediately after operation, as surface temperatures near the lamp may be hot enough to cause injury.

CAUTION: INTENSE LIGHT! Do not look directly at strobe light during operation as eye injury could result. Use protective eyewear, or assure that the light is properly enclosed within the test compartment.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

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 Aerospace Technical Report Style Manual Dated Jan., 1996

AS8017	Minimum Performance Standard for Anticollision Light Systems
ARP5825	Design Requirements and Test Procedures for Dual Mode Exterior Lights
SAE J575	Test Methods and Equipment for Lighting Devices for Use on Vehicles Less than 2032 mm in Overall Width
SAE J1330	Photometry Laboratory Accuracy Guidelines

2.1.2 U.S. Government Publications

Copies of these documents are available online at <https://quicksearch.dla.mil/>.

14 CFR Part 23	Airworthiness Standards: Normal, Utility, and Acrobatic Category Airplanes
14 CFR Part 25	Airworthiness Standards: Transport Category Airplanes
14 CFR Part 27	Normal Category Rotorcraft
14 CFR Part 29	Transport Category Rotorcraft

2.1.3 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

FAA Advisory Circular 20-74	Aircraft Position and Anticollision Light Measurements
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2.1.4 IEC Publications

Available from IEC Central Office, 3, rue de Varembe, P.O. Box 131, CH-1211 Geneva 20, Switzerland, Tel: +41 22 919 02 11, www.iec.ch.

IEC62471:2006	Photobiological Safety of Lamps and Lamp Systems
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2.1.5 CIE Publications

Available from CIE Central Bureau, Babenbergerstrasse 9/9A, 1010 Vienna, Austria, Tel: +43 1 714 31 87, www.cie.co.at.

CIE Publication 69 Methods of Characterizing Illuminance Meters and Luminance Meters

CIE S 009/E:2002 Photobiological Safety of Lamps and Lamps Systems

2.1.6 NIST Publications

Available from NIST, 100 Bureau Drive, Stop 1070, Gaithersburg, MD 20899-1070, Tel: 301-975-6478, www.nist.gov.

NIST Special Publication 250-37 Photometric Calibrations

2.1.7 Other Publications

Spectroradiometry, Kostkowski, ISBN 0-9657713-O-X, Reliable.

Handbook of Applied Photometry, ed. Casimer DeCusatis, ISBN 1-56396-416-3.

Lighting Handbook. Eighth Edition, ed. Mark S. Rhea (Illuminating Engineering Society of North America, New York, 1993).

Y. Ohno and Y. Zong, Establishment of the NIST Flashing-Light Photometric Unit, Proceedings of SPIE, Vol. 3140, Photometric Engineering of Sources and Systems, 2-11 (1997).

2.2 Definitions

2.2.1 LABORATORY STANDARD PHOTOMETER

A photometer which maintains the primary standard of flashing light measurements for the laboratory and provides traceability to the NIST standard.

2.2.2 INTEGRATED ILLUMINANCE

Integrated illuminance, E_v , [lux-second (lx·s), footcandle-second (fc·s)], is the integral of the instantaneous illuminance, $E(t)$, [lx, fc], of a flashing light source over the entire flash duration, $(t_2 - t_1)$, as given by:

$$E_v = \int_{t_1}^{t_2} E(t) dt \quad (\text{Eq. 1})$$

2.2.3 INTEGRATED LUMINOUS INTENSITY

Integrated luminous intensity, I_v , [candela-second, (cd·s)] is the integral of instantaneous luminous intensity $I(t)$, [cd] of a flashing light source over the entire flash duration, $(t_2 - t_1)$, as given by:

$$I_v = \int_{t_1}^{t_2} I(t) dt \quad (\text{Eq. 2})$$

To obtain I_v from E_v :

$$I_v = E_v \cdot D^2 \quad (\text{Eq. 3})$$

where:

D = distance from the source to the photometer

D is expressed in [meters] when the integrated illuminance, E_v , is in [lx·s], and [feet] when E_v is in [fc·s]. Equation 3 is valid only when D is large enough to enable the source to behave as a point source, where illuminance is inversely proportional to distance squared. For strobe measurements, D must never be less than 2.4 m. A minimum of 9 m is recommended for laboratory tests.

2.2.4 EFFECTIVE INTENSITY

The concept of effective intensity [cd] of a flashing signal is intended to represent the luminous intensity [cd] of a steady light source with equivalent visual conspicuity. The Blondel-Rey equation defines effective intensity as:

$$I_c = \frac{\int_{t_1}^{t_2} I(t) dt}{0.2 + (t_2 - t_1)} \quad (\text{Eq. 4})$$

where:

$(t_2 - t_1)$ = flash duration [seconds]

The [0.2] in the denominator was derived experimentally under certain experimental conditions. In this document, the equation for effective intensity is based on a simplified Blondel-Rey Equation. Since the pulse duration $(t_2 - t_1)$ for a xenon flash is very small compared with 0.2 second, it may be omitted from the denominator of the effective intensity equation. This will insure more uniform results by removing the uncertainty introduced by variation in determining the pulse width. For xenon strobe measurements, the effective intensity is, therefore, expressed as:

$$I_e = \frac{I_v}{0.2} = 5 \cdot \int_{t_1}^{t_2} I(t) dt \quad (\text{Eq. 5})$$

For the purposes of determining the performance of the anticollision light, I_e is expressed in candelas (also referred to as effective candelas in other documents, or ecp in 14 Code of Federal Regulations). The photometer should be capable of measuring a single flash or averaging multiple flashes. Usually, the integral of several flashes is measured and the average result calculated. Refer to AS8017. This procedure recommends that the measurements be based on the average of a minimum of eight flashes.

2.2.5 FIELD OF COVERAGE

An aircraft's anticollision light system consists of one or more lights which produce an intensity pattern covering 360 degrees horizontally around the aircraft and vertically over a specified range. The field of coverage of a strobe light refers to that portion of the entire anticollision light pattern which must be produced by that light. See Figure 1 for a pictorial representation of field of coverage.

2.3 Conversion Factors

1 candela (cd) = 1 lm/steradian

1 footcandle = 10.76 lux

1 footcandle = 1 lm/ft²

1 lux = 1 lm/m²

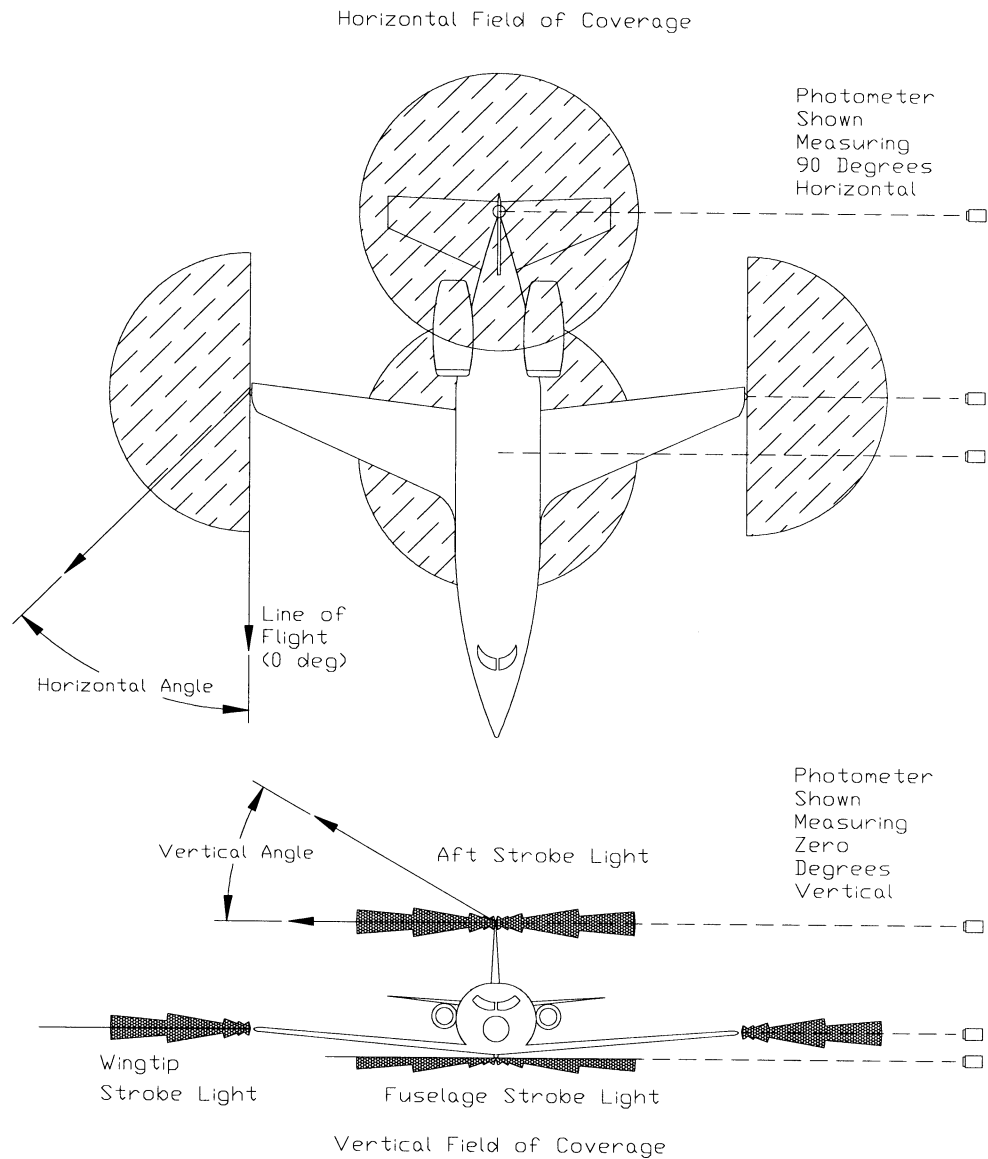


**Figure 1 - Illustration of the field of coverage of various strobe lights
0 degree vertical, 90 degrees horizontal photometer location shown**

3. LABORATORY TESTS

3.1 Scope

This section describes the required equipment, test procedure, safety precautions, and other information necessary to perform white or red short pulse width strobe anticollision light measurements in a photometric laboratory.

3.2 Minimum Required Equipment

- a. Calibrated photometer for measuring strobe light as described in Appendix A.
- b. Goniometer for positioning strobe light as described in Appendix B.
- c. Photometric tunnel in which light measurements are made described in Appendix C.
- d. Regulated power supply to supply electrical power to strobe light system as described in Appendix D.
- e. Temperature measurement device to read ambient temperature and temperature of strobe light lens.
- f. Hand tools, voltmeter, and any other standard laboratory equipment.

3.3 Anticollision Light Intensity and Field of Coverage Requirements

Determine the intensity and field of coverage requirements for the strobe light being tested. The field of coverage of the light must be determined relative to some reference feature of the light assembly, such as its mounting surface. Note that in some cases, the aircraft surface to which the light assembly mounts changes angular orientation during flight. This is often the case for wingtip strobes where the wing tip deflects upward during flight. It may be necessary to consider this mounting surface deflection when defining the field of coverage relative to the mounting surface of the light.

3.4 Safety Considerations

Verify that all safety considerations have been met, as discussed in 1.5. The potential hazards of the strobe light system include high temperatures, high voltage, pressurized components, and intense light.

3.5 Test Preparation

- 3.5.1 Apply power to the photometer system and allow it to stabilize for at least 30 minutes. Confirm that all lenses, filters, and optical elements are clean and free from fingerprints as this can adversely affect the measurements.
- 3.5.2 Install the unit-under-test (UUT) onto the goniometer. Position and align the UUT onto the goniometer such that its total field of coverage can be measured.
- 3.5.3 Record the laboratory temperature and humidity.
- 3.5.4 Record the distance from the reference surface of the photometer to the center of the light source of the UUT. The distance should be as long as possible so that the light source will behave as a point source (i.e., the illuminance is inversely proportional to distance squared). For this procedure, a minimum of 9 m is recommended for laboratory tests. Additionally, the peak instantaneous illuminance must lie well within the linear response range of the photometer.
- 3.5.5 Red Lens Temperature Dependence Correction

Red glass lenses darken significantly (i.e., transmits less of the xenon spectrum) with increased temperature. See Appendix E. This section of the procedure will allow the intensity data taken under a laboratory condition (hot stabilized lens) to be corrected to be more representative of the conditions encountered in flight (ambient temperature lens). A clear glass lens may be installed in place of a red glass lens prior to making the measurements and a correction factor applied to the data. When testing a UUT with a red glass lens, follow the procedure below; otherwise, proceed directly to 3.6.

- 3.5.6 Install a temperature sensor on the glass lens (i.e., cover glass, red filter) and record its temperature. This location shall remain fixed for all lens temperature measurements called out in this procedure.
- 3.5.7 Apply power to the UUT and record the input voltage and current. The applied power must be in accordance with Appendix D.
- 3.5.8 Record the average integrated illuminance (lens - room temperature) of eight or more flashes over the horizontal field of coverage in 20 degrees (or smaller) increments, with a vertical angle of 0 degree. The lens must be at room temperature ($25\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$) during these measurements. Cooling air is permissible during this test. It may be necessary to power off the unit between orientations to allow the lens to cool down. This is the measurement of illuminance at room temperature.
- 3.5.9 Once again apply power to the UUT and record the input voltage and current. Allow UUT to stabilize for at least 60 minutes. No cooling air is permissible during this portion of the test.
- 3.5.10 Record the lens temperature, using the temperature sensor location of 3.5.6.
- 3.5.11 Record the average integrated illuminance (lens - hot steady state) of eight or more flashes in the same orientations as in 3.5.8 with the lens temperature stabilized hot. The lens temperature must be within $\pm 3\text{ }^{\circ}\text{C}$ of the temperature recorded in 3.5.10.
- 3.5.12 Compute the correction factor for each horizontal orientation (vertical angle is zero):

$$\text{temperature correction} = \frac{\text{Illuminance (lens - room temperature)}}{\text{Illuminance (lens - hot steady-state temperature)}} \quad (\text{Eq. 6})$$

3.6 Intensity Measurements

- 3.6.1 Apply power to the UUT and record the input voltage and current. The voltage should be set at the nominal design voltage for the light. The applied power must be in accordance with Appendix D. Allow UUT to stabilize. No cooling air is permissible for strobe lights with red glass lenses.
- 3.6.2 Record the lens temperature. If measuring a strobe light with a red glass lens, the temperature should be within $\pm 3\text{ }^{\circ}\text{C}$ of the temperature measured in 3.5.10.
- 3.6.3 Record the average integrated illuminance of eight or more flashes over the vertical and horizontal fields of coverage. Measure in 10 degree steps over the horizontal range. Measure in 5 degree steps over vertical ranges of ± 30 degrees and every 15 degrees beyond that, if testing a light with a ± 75 degree vertical field of coverage.
- 3.6.4 As a double check of UUT stabilization, once again measure the integrated illuminance for the angular position measured at the beginning of the test. The two measurements should agree within the measurement uncertainty of the measurement equipment.
- 3.6.5 Record the lens temperature. The temperature should be within $\pm 3\text{ }^{\circ}\text{C}$ of the temperature measured in 3.5.10 if testing a strobe light with a red glass lens. The temperature is not critical for a white strobe light.
- 3.6.6 Calculate the effective intensity using the recorded distance and illuminance for all angular orientations as discussed in 2.2. The intensity data should be reported in candelas (effective intensity) in order to compare the data to 14 Code of Federal Regulations requirements.
- 3.6.7 If the strobe light was measured with a red glass lens, multiply each set of data collected at a particular horizontal angle by the temperature correction factor associated with that horizontal angle. For example, illumination values recorded at 10 degrees horizontal, -30 to 30 degrees vertical would be multiplied by the correction factor measured at 10 degrees horizontal, 0 degree vertical.

- 3.6.8 If a clear glass lens was substituted for a red glass lens prior to testing, multiply all the clear lens measurements by the transmittance of the red lens. To obtain the lens transmittance, divide the illuminance measured using a red lens by the illuminance measured using a clear lens for a particular UUT orientation. The lens temperature during the red measurement must be $25^{\circ}\text{C} \pm 3^{\circ}\text{C}$. The UUT must be in the exact orientation for both measurements, as the intensity of the source will most likely vary with orientation.

$$\text{lens transmittance} = \frac{\text{red illuminance } (25^{\circ} \pm 3^{\circ}\text{C})}{\text{white illuminance (same orientation)}} \quad (\text{Eq. 7})$$

This concludes the laboratory test procedure.

4. MAINTENANCE SHOP TESTS

4.1 Scope

This section describes the required equipment, test procedure, safety precautions, and other information necessary to perform white or red strobe anticollision light measurements in maintenance shops.

4.2 Minimum Required Equipment

- a. Calibrated photometer as described in Appendix I.
- b. Power supply as described in Appendix D.
- c. Lab meters, tape measure, hand tools.
- d. Anticollision light holding fixture.

4.3 Anticollision Light Intensity Requirements

Obtain the intensity that the strobe light is required to meet in the horizontal plane and the total horizontal angle over which the light is required to produce this intensity (the horizontal field of coverage of the light).

4.4 Safety Considerations

Strobe light testing is potentially dangerous. Ensure that all safety considerations discussed in 1.5 are met when performing the following test. The potential hazards of the strobe light system include high temperatures, high voltage, pressurized components, and intense light.

4.5 Test Preparation

- 4.5.1 Assemble and install the necessary measurement equipment and power supply as defined in 4.2.
- 4.5.2 Locate the strobe light being tested a minimum of 2.4 m away from the photometer and record the exact distance.
- 4.5.3 Make sure that the line of sight between the strobe light and detector aperture is free from obstructions.
- 4.5.4 Locate equipment and other objects in the test area to minimize the amount of reflected light reaching the photometer. Verify that if a plate is used to mount the light, that it does not reflect light in the direction of the photometer.
- 4.5.5 Clean the lens of the strobe light. Fingerprints or other contaminants on the lens can adversely affect the measurements.
- 4.5.6 Operate the photometer in accordance with manufacturer specifications. Ensure that all optical elements are clean and free from fingerprints or other contaminants as this can adversely affect the measurements.

4.5.7 Mount the strobe light onto its holding fixture. The holding fixture should be able to hold the UUT in a known angular orientation relative to the photometer such that the intensity in a particular direction from the light can be measured. Orient the UUT to the desired horizontal and vertical angle. It is recommended that a vertical angle of zero be used for maintenance shop measurements.

4.5.8 Apply power to the UUT and record the input voltage and current. The voltage should be set at the nominal design voltage for the light.

4.6 Intensity Measurements

4.6.1 Darken the room and confirm that any remaining ambient light will not interfere with the photometric measurements.

NOTE: It is not necessary to darken the room if it can be verified that the ambient light does not influence the measurement.

4.6.2 Record the average integrated illuminance of eight flashes or more. If the strobe light lens is made of red glass, make the measurements with the lens close to room temperature. A lens temperature of $25\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ is recommended.

4.6.3 Calculate the effective intensity based on illuminance and distance as discussed in 2.2 and record the results. The data should be reported in candelas (effective intensity) in order to compare it to 14 Code of Federal Regulations requirements.

This concludes the shop test procedure.

5. FIELD TESTS

5.1 Scope

This section describes the recommended practices for making white and red short pulse width strobe anticollision light measurements on the aircraft. It is recommended that each light which comprises the aircraft's strobe anticollision light system should be tested using this procedure.

5.2 Minimum Required Equipment

- a. Calibrated portable photometer as described in Appendix I.
- b. Tape measure (if distance measurement is not part of portable photometer).
- c. Aircraft power source.

5.3 Anticollision Light Intensity Requirements

Obtain the intensity that the strobe light is required to meet in the horizontal plane and the total horizontal angle over which the light is required to produce this intensity (the horizontal field of coverage of the light).

5.4 Safety Considerations

Ensure that all safety considerations have been met, as discussed in 1.5. The potential hazards of the strobe light system include high temperatures, high voltage, pressurized components, and intense light. Follow all warnings and cautions contained in the applicable aircraft maintenance manuals, component maintenance manuals, and test equipment manufacturer manuals.

5.5 Test Preparation

5.5.1 Inspect the area around the light to be tested to make sure that ambient light and reflections off nearby surfaces will not adversely affect the measurement. Follow recommendations by the test equipment manufacturer regarding environmental considerations.

- 5.5.2 Confirm that the line of sight between the strobe light to be tested and the photometer is free from obstructions.
- 5.5.3 Inspect the general conditions of each strobe light to be tested. The exterior of the lens should be clean. Fingerprints or other contamination on the lens can adversely affect the measurement.
- 5.5.4 Inspect the photometer for proper operation. Verify that all the optical elements of the photometer are clean and free from fingerprints. Fingerprints and other contamination can adversely affect the measurement.
- 5.5.5 Verify that the calibration of the photometer is current.
- 5.6 Intensity Measurement Procedure
 - 5.6.1 Locate the portable photometer at the same elevation as the strobe light, within the horizontal field of coverage of the strobe light, at the distance recommended by the photometer manufacturer. A minimum distance of 2.4 m is recommended. A discussion of measurement distance is given in 2.2.3.
 - 5.6.2 Apply power to the strobe light.
 - 5.6.3 Individual flashes from strobe lights can vary in intensity. Measure the effective intensity for a sample of flashes in a fixed orientation until a representative measurement is made. It is recommended that the average of eight or more flashes be made. The intensity data should be reported in candelas (effective intensity) in order to compare it to 14 Code of Federal Regulations requirements (see 2.2.4).
 - 5.6.4 If the strobe light has a red glass lens, avoid allowing the lens to get hot during the measurement, as this will adversely affect the data. It is recommended that the intensity be measured with the lens as close to ambient temperature as possible. A lens temperature of $25\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ is recommended.

This concludes the field measurement procedure.

6. NOTES

6.1 Revision Indicator

A change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY SAE COMMITTEE A-20, AIRCRAFT LIGHTING