SAE Aerospace
An SAE International Group

AEROSPACE RECOMMENDED PRACTICE

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Superseding ARP4087B

(R) Wing Inspection Lights – Design Criteria

RATIONALE

This document complements current FAA regulations on wing icing detection lights by specifying the light levels and the wing area that is required to be illuminated. Information contained herein has been expanded from ARP4087B in the areas of measurement conditions, lumen maintenance, and the inclusion of specific information relative to the use of Light Emitting Diode source technology. It provides minimum requirements for night operation. However, the Wing Inspection Lights shall be capable of daytime operation as well.

1. SCOPE

This SAE Aerospace Recommend Practice (ARP) is intended to cover the external lights on fixed wing aircraft for illuminating the wing leading edge and engine nacelles and the upper surfaces of the wing. The addition of an ice detection system should be implemented when the areas to inspect are not visible from the aircraft cockpit. It is not intended that this Recommended Practice require the use of any particular light source such as Halogen, LED or other specific design of lamp.

1.1 Purpose

The purpose of this document is to set forth basic considerations and criteria which should be observed when designing wing inspection lights for all aircraft.

2. 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 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.

J1330 Photometry Laboratory Accuracy Guidelines.

ARP5414 Aircraft Lightning Zoning

ARP6253 LEDs and Aircraft Applications

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

2.2 Code of Federal Regulations (CFR)

Available from the United States Government Printing Office, 732 North Capitol Street, NW, Washington, DC 20401, Tel: 202-512-0000, www.gpoaccess.gov.

Code of Federal Regulations Title 14, Part 25 and 121

Some applicable sections may include, but are not limited to the following:

14 CFR PART 121.341 Equipment for operations in icing conditions

14 CFR PART 121.629 Operation in Icing Conditions

14 CFR PART 25.1403 Wing Icing Detection Lights

14 CFR PART 25.1397 Color Specifications

2.3 RTCA Publications

Available from Radio Technical Commission for Aeronautics Inc., 1828 L Street, NW, Suite 805, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

DO-160 Radio Technical Commission for Aeronautics (RTCA), Environmental Conditions and Test Procedures for Airborne Equipment (latest applicable revision).

2.4 U.S. Government Publications

Available from the Document Automation and Production Service (DAPS), Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-9495, https://assist.daps.dla.mil/quicksearch/.

MIL-DTL-7989 Covers, Light-Transmitting, for Aeronautical Lights, General Specification for

3. GENERAL PROVISIONS

3.1 As described in Part 25.1403 and Part 121.341, unless operations at night are known or forecast icing conditions are prohibited by an operating limitation, a means must be provided for illuminating or otherwise determining the formation of ice on the parts of the wings that are critical from the standpoint of ice accumulation. Any illumination that is used must be a type that will not cause glare or reflection that would handicap crewmembers in the performance of their duties.

Wing inspection lights are used to illuminate the wing leading edges, engine nacelles, upper and/or lower wing surfaces, and any other external surfaces so that they may be visually inspected by the flight crew and/or ground personnel for ice accumulation or any other critical conditions at night or daytime (such as during low light ambient conditions). Inspection may be performed when the aircraft is on the ground, or in-flight, with and without fuel. Therefore, the wing deflection range during flight under all various conditions (i.e., as affected by air loads) needs to be considered for the lamp design.

NOTE: it may also be appropriate to use existing airport lighting for the inspection of snow/ice accumulation.

3.2 When aircraft geometry permits, over wing inspection lights are recommended to illuminate the upper wing surfaces so that they may be visually inspected for snow/ice accumulation primarily during ground inspection.

3.3 On military aircraft the wing inspection lights may be used to provide visual reference to the boom operator in aerial refueling. In this case, it may be desirable to increase the illuminated areas on the inboard upper and/or lower surfaces of the wings.

3.4 The lights shall be designed to provide proper illumination for the crew members, but care shall be taken in the design and installation location so that they will not cause objectionable glare or halation that might handicap crew members in the performance of their duties as required in Part 121.629 i.e., for the pilot or the dispatcher can determine that the wings, control surfaces and other critical surfaces as defined in the certificate holder's program are free of frost, ice or snow.

3.5 Aircraft geometry shall dictate the size, number, and location of lights required to perform the intended function(s).

4. SPECIFIC DESIGN REQUIREMENTS

4.1 Lighting Coverage

4.1.1 The aircraft surfaces that require illumination vary among aircraft designs. The parameters are dictated by aircraft geometry, aircraft mission (commercial or military), and crew member visual accessibility.

4.1.1.1 Aircraft Geometry

For different aircraft configurations, the wing area coverage will vary. Consideration should be given to aircraft with supplementary wings, for example, canards, and the necessity for providing illumination on them.

4.1.1.2 Aircraft Mission

For aerial refueling, the wing inspection lights may provide significant additional reference information for the boom operator. In order to maximize this, additional factors shall be considered:

a. Shield light sources from the direct vision of the boom operator.

b. Provide continuous or stepped intensity control.

4.2 Illuminance

4.2.1 The recommended minimum illuminance for wing leading edge is 21.5 lux (2.0 ft-c) measured normal to the incident light. See Figure 1 and Figure 2. The aircraft's surface finish and reflectance properties should be considered when validating photometric performance. Also, the lights should be evaluated to insure that minimum intensities are achieved at the maximum viewing distances with respect to the flightcrew.

4.2.2 The recommended minimum illuminance for wing leading edge applies to all possible wing positions (in-flight or on the ground, loaded with fuel).

4.2.3 The recommended minimum illuminance for engine nacelles is 5.3 lux (0.5 ft-c) measured normal to the incident light. See Figure 1.

4.2.4 The recommended minimum illuminance for wing upper surfaces is 107.5 lux (10.0 ft-c) measured normal to the incident light. See Figure 2.

4.2.5 The light beam should be shaped and directed to provide a reasonably uniform illumination of the wing surfaces.

4.3 Color

The color should be aviation white as defined in Part 25.1397. Deviations are acceptable.

Aviation white:

x is not less than 0.300 and not greater than 0.540;
y is not less than x−0.040; or y0−0.010, whichever is the smaller; and
y is not greater than x+0.020 nor 0.636−0.400x;
Where y0 is the y coordinate of the Planckian radiator for the value of x considered.

Or, alternate color definition that has been practiced by other and certification programs:

Aviation White:

Yellow Boundary	x = 0.500
Red Boundary	y = 0.382
Purple Boundary	y = 0.047 + 0.762x
Blue Boundary	x = 0.285
Green Boundary	y = 0.150 + 0.640x and y = 0.440

4.4 Locations

For most aircraft, the primary locations for light fixtures are:

a. The sides of the fuselage forward of the wing leading edges (used to illuminate the wing leading edges) (see Figure 1).

b. The outboard surface of nacelles (used to illuminate the outboard wing leading edges).

c. The sides of the fuselage above the wings (used to illuminate the upper wing surfaces) (see Figure 2).

NOTE: For all locations, the angle between the light beam and the wing surfaces should be as large as possible to optimize the illumination.

4.5 Control

4.5.1 A simple on/off switch is all that is required when the lights are used for wing inspection purposes only.

4.5.2 When wing inspection lights are also used for aerial refueling, intensity should be controlled from full ON to OFF. Continuous dimming or step dimming may be satisfactory.

5. MEASUREMENTS

5.1 Laboratory ambient temperature shall be 25 +/- 10 °C.

5.2 Input power: Intensity measurements should be performed at nominal input voltage. Compliance should be demonstrated by testing or other means at the lower and higher normal voltage limits to show compliance for all normal input voltages.

5.3 Forced air cooling: There should be no external forced air cooling (fans and other drafts) during measurements, except in cases where their use is required to simulate the aircraft's operating environment.

5.4 Warm up and stabilization: For purposes of demonstrating compliance with this specification, all photometric and color measurements for LED sources should be made after a minimum warm up period of 30 minutes or after the light has reached thermal stabilization, whichever is longer. Stabilization should be defined as the point in which light output does not change by more than 3% over a 15 minute period. The minimum warm up period for Halogen or other light sources should be 5 minutes or after the light has reached thermal stabilization, whichever is longer.

5.5 Cover lens: Intensity measurements must comply with the cover lens in place. However, intensity measurements can be performed with or without the aircraft cover lens installed. When measuring without the cover lens, analyses should be used to show compliance.

5.6 Definition of Operating Lifetime

Operating Lifetime is the duration for which the light is expected to meet the minimum intensity requirements when intensities are measured per Section 5.

Environmental and installation conditions affect Operating Lifetime. In the case of LED based lights, lumen maintenance is a function of junction temperature. Lumen maintenance for typical laboratory ambient conditions (T = 25 °C ± 5 °C) and other elevated or lower expected flight test temperatures and their exposure times, (71 °C with a 3 knot wind for 3 hours per day, for example) can be used to help estimate actual Operating Lifetimes for particular flight patterns. This data would be used to define the aircraft's installation environment.

Continuing airworthiness can be achieved by a number of methods, some of which are:

- Limiting Operating Lifetime based on an estimation of component laboratory life with adjustments which take into account actual operating conditions on-the-ground and in-flight, or;
- Limiting on-wing Operating Lifetime based on active feedback from an integrated light sensor or;
- Requiring Aircraft operators to measure intensity levels at requlary scheduled maintenance intervals to insure compliance.

6. PERFORMANCE STANDARDS UNDER ENVIRONMENTAL CONDITIONS

6.1 Unless otherwise specified herein, the test procedures called out in Section 6.2 of this document are those set forth in Radio Technical Commission for Aeronautics (RTCA) Document No. DO-160 (latest applicable revision) entitled "Environmental Conditions and Test Procedures for Airborne Equipment".

6.1.1 Prior to subjecting the Wing Inspection Light to the environmental tests specified in Section 6.2 of this document, performance tests must be conducted to determine that the light meets requirements of paragraphs 4.2 and 4.3 of this document.

6.1.2 During and/or after (as appropriate) these tests, the following parameters should be recorded:

a. Effective intensity measurements complying with paragraph 4.2

b. Color measurements complying with paragraph 4.3

c. Input voltage

d. Input current

6.1.3 Performance tests which must be made after subjection to test environments may be made after exposure to several environmental conditions, and tests to determine effective intensity may be conducted in a single direction only for comparison with initial tests measurements.

6.1.4 The order of tests must be in accordance with DO-160. The test procedures specified or referenced are satisfactory for use in determining the performance of the Wing Inspection Light under normal and extreme environmental conditions. Alternate approved test procedures that provide equivalent results may be used.

6.2 Environmental Tests

In this section, regarding photometric performance, the meaning of "no significant lighting degradation" or "no significant visually detectable change(s)" means that the light may not suffer any significant visual loss of intensity during and following the test, as applicable.

6.2.1 Temperature and Altitude Tests: When components are subjected to the tests of DO-160 as appropriate, the Wing Inspection Light must operate electrically and show no significant changes in the parameters recorded per paragraph 6.1.2 of this document.

6.2.2 Humidity: After being subjected to the Humidity tests of DO-160, standard humidity environment (or more stringent, if required), there should be no significant changes in the parameters recorded per paragraph 6.1.2 of this document. Optical parts such as Lens assemblies (external surfaces only) may be cleaned if necessary.

6.2.3 Vibration: When the light is tested in accordance with DO-160, standard vibration environment (or more stringent, if required), there should be no significant change in the parameters recorded per paragraph 6.1.2 of this document.

6.2.4 Explosive Atmosphere: Lights which are to be marked with an Explosive Atmosphere category must be tested in accordance with DO-160.

6.2.5 Waterproofness: Lights which are to be marked with a Waterproofness Category must be tested in accordance with DO-160. Following this test the light should show no significant change in the parameters recorded per paragraph 6.1.2 of this document.

6.2.6 Fluids Susceptibility: Lights which are to be marked Category F must be tested in accordance with DO-160. For Category D testing, following this test the light should show no significant changes in the parameters recorded per paragraph 6.1.2 of this document. For Category S testing, following this test, the degree of damage or performance degradation should be as specified by the manufacturer. Optical parts such as Lens Assemblies (external surfaces only) may be cleaned if necessary.

6.2.7 Sand and Dust: Lights which are to be marked Sand and Dust Category D or S must be tested in accordance with DO-160. Following this test the light should show no significant change in the parameters recorded per paragraph 6.1.2 of this document. Optical parts such as Lens Assemblies (external surfaces only) may be cleaned if necessary.

6.2.8 Fungus Resistance: Lights which are to be marked Fungus Resistance Category F must be tested or an analysis performed in accordance with DO-160. Following testing the light should show no significant change in the parameters recorded per paragraph 6.1.2 of this document.

6.2.9 Salt Fog: Lights which are to be marked Salt Fog Category S (or more stringent) must be tested in accordance with DO-160. Following this test, the light should show no significant changes in the parameters recorded per paragraph 6.1.2 of this document. Optical parts such as Lens Assemblies (external surfaces only) may be cleaned if necessary.

6.2.10 Power Input Tests

6.2.10.1 Lights should be subjected to tests for normal power input operating conditions of DO-160. Lights should meet performance standards of paragraph 6.1.2 of this document. During and after testing, the light must operate electrically and show no significant lighting degradation.

6.2.10.2 When the light is subjected to the abnormal power input operating conditions of DO-160, the light should sustain no damage and the degree of performance degradation shall be specified by the manufacturer.

6.2.11 Voltage Spike: The light should be subjected to voltage spikes conducted to the tests of DO-160. During testing and after testing, this test should cause no significant change in the parameters recorded per paragraph 6.1.2.

6.2.12 Audio Frequency Conducted Susceptibility: The light should be subjected to the Audio Frequency Conducted Susceptibility tests of DO-160. During testing and after testing, there should be no significant changes in the parameters recorded per paragraph 6.1.2.

6.2.13 Induced Signal Susceptibility: The Light should be subjected to the Induced Signal Susceptibility tests of DO-160. During testing and after testing, there should be no significant changes in the parameters recorded per paragraph 6.1.2.

6.2.14 Radio Frequency Susceptibility: The Light should be subjected to the Radio Frequency Susceptibility tests of DO-160. During testing and after testing, there should be no significant changes in the parameters recorded per paragraph 6.1.2.

6.2.15 Emission of Radio Frequency Energy: The Light should comply with the Emission of Radio Frequency Energy test limits of DO-160.

6.2.16 Electrostatic Discharge (ESD): The Light should be tested in accordance with the electrostatic discharge requirements of DO-160, for lights that use lighting sources other than incandescent.

6.2.17 Lightning Induced Transient Susceptibility: because Wing Inspection Lights are installed in lightning susceptible locations of the aircraft, it is recommended that the light be tested in accordance with the Lightning Induced Transient Susceptibility and Lightning Direct Effects requirements of DO-160 per the categories specified in ARP5414. After testing, the degree of damage or performance degradation should be specified by the manufacturer.

6.2.18 Lightning Direct Effects: because Wing Inspection Lights are installed in lightning susceptible locations of the aircraft, it is recommended that the light be tested in accordance with the Lightning Direct Effects requirements of DO-160 per the categories specified in ARP5414. During testing, there should be no harmfull voltages or currents passed through the Wing Inspection Light wiring to the aircraft power bus. After testing, the degree of damage or performance degradation should be specified by the manufacturer.

6.2.19 Fire, Flammability: Lights which are to be marked with a Fire, Flammability category must be tested and/or analyzed to show compliance with DO-160 requirements. Following testing, the degree of damage or performance degradation should be specified by the manufacturer.

6.2.20 Thermal Shock: The light assembly's lenses should be able to withstand the thermal shock requirement as described below (Reference MIL-DTL-7989) without any cracks or breakage.

The Wing Inspection Light should be operated at its rated voltage, in still air at 20 to 25 °C for 1 hour, in a manner simulating aircraft installation, after which, the lens is to be sprayed with water at a temperature of 10 °C in a manner simulating rainfall.

7. SYSTEM INFORMATION

The following information should be supplied with each light.

7.1 Manufacturer's operating instructions and equipment limitations.

7.2 Installation procedures with applicable schematic drawings, wiring diagrams, and specifications. Any limitations, restrictions, or other conditions pertinent to the installation must be defined.

7.3 List of components (by part number) that make up the equipment light complying with the standards prescribed.

7.4 Equipment data sheets specifying, within the prescribed ranges of environmental conditions, the actual performance of the equipment.

7.5 Maximum and minimum voltage which must be supplied to the equipment after installation, to meet the minimum performance standards.

7.6 Wire size length limitations between components.

8. NOTES

8.1 A change bar (|) 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.