SAE INTERNATIONAL

AEROSPACE RECOMMENDED PRACTICE

ARP4087™ REV. D

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Superseding ARP4087C

(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 +1 724-776-4970 (outside USA), www.sae.org.

ARP5414 Aircraft Lightning Zone

ARP6253 LEDs and Aircraft Applications

SAE J1330 Photometry Laboratory Accuracy Guidelines

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

For more information on this standard, visit
https://www.sae.org/standards/content/ARP4087D/

2.2 RTCA Publications

Available from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

DO-160 Environmental Conditions and Test Procedures for Airborne Equipment (latest applicable revision)

2.3 U.S. Government Publications

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

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

Code of Federal Regulations Title 14, Part 25 and 121 Available electronically from the Federal Register at http://www.gpoaccess.gov/fr/advanced.html and by paper from the Government Printing Office at http://bookstore.gpo.gov. Some applicable sections may include, but are not limited to the following:

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

3. GENERAL PROVISIONS

3.1 Wing inspection lights are used to illuminate the wing leading edges, engine nacelles, upper wing surfaces so that they may be visually inspected for ice accumulation or any other critical conditions at night or daytime (such as during low light ambient conditions). Note: If required to operate during daytime, the effects of solar loading regarding the light's operating temperature environment should be considered for survivability (if applicable). 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.

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 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 14 CFR Part 121.629.

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

3.5 For aircraft with wing geometry located so far back the pilot cannot see them from the cockpit to check for icing, the anti-icing function should be operational in weather conditions that are conducive for icing. Light function check must be accomplished on ground for these aircraft or able to visually inspect the wing and nacelle surfaces from fuselage windows.

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 shall vary. Consideration shall 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.

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 shall be shaped and directed to maximize the illumination uniformity of wing surfaces. Designers should consider dividing the illuminated surfaces of the wing into zones or regularly spaced test points and developing a light beam with a low illuminance ratio (<3:1) between any adjacent zones or points, with a maximum ratio of 10:1 across the entire surface. These ratios are guidelines and may be modified depending on wing geometry and light mounting position. Basically, the beam spread should be wide and not narrow in terms of intensity. Recommend that the light beam not immediately illuminate wing structure near the installation source to reduce differences in the illuminance uniformity.

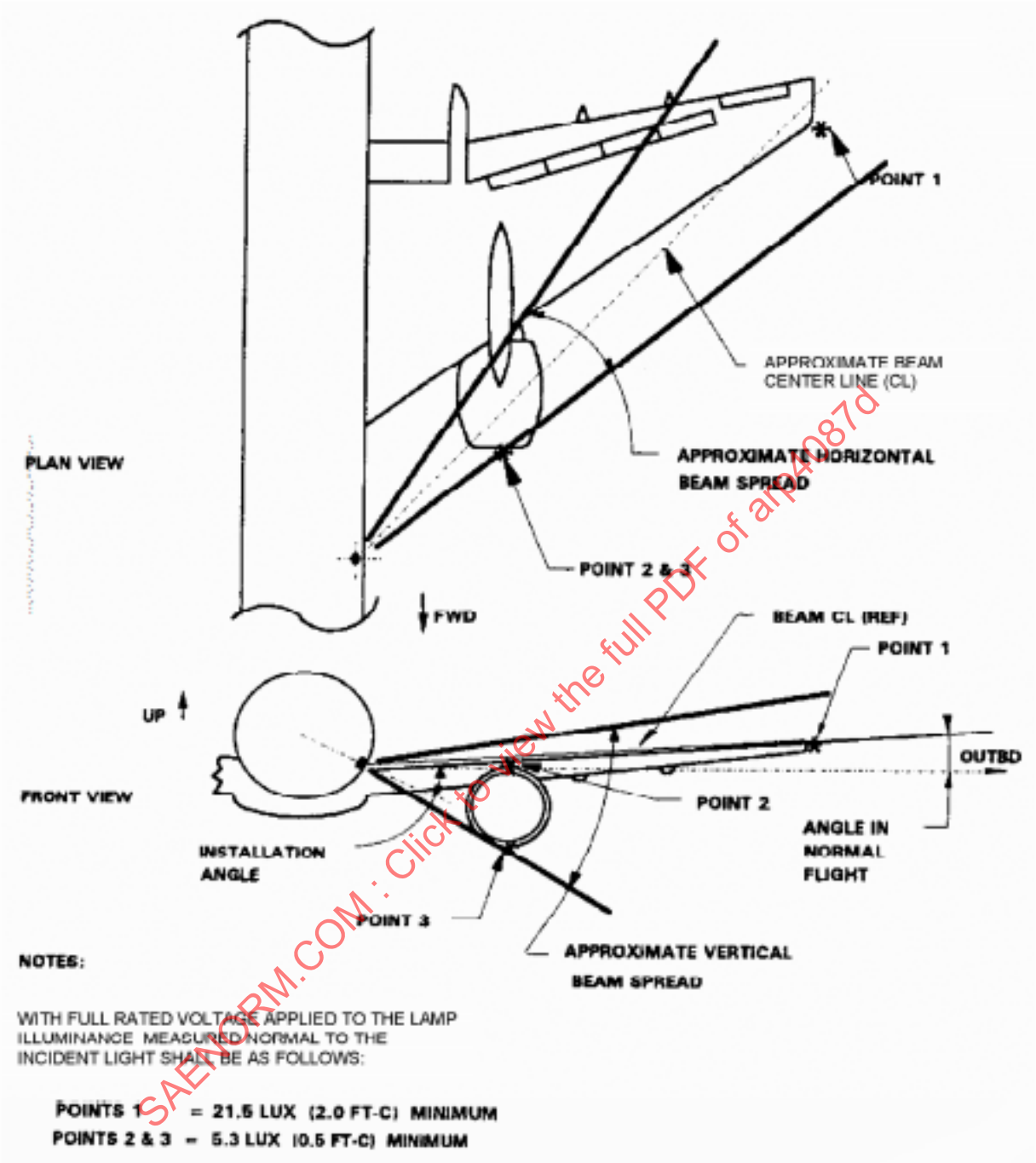

Figure 1 - Wing illumination pattern wing leading edge

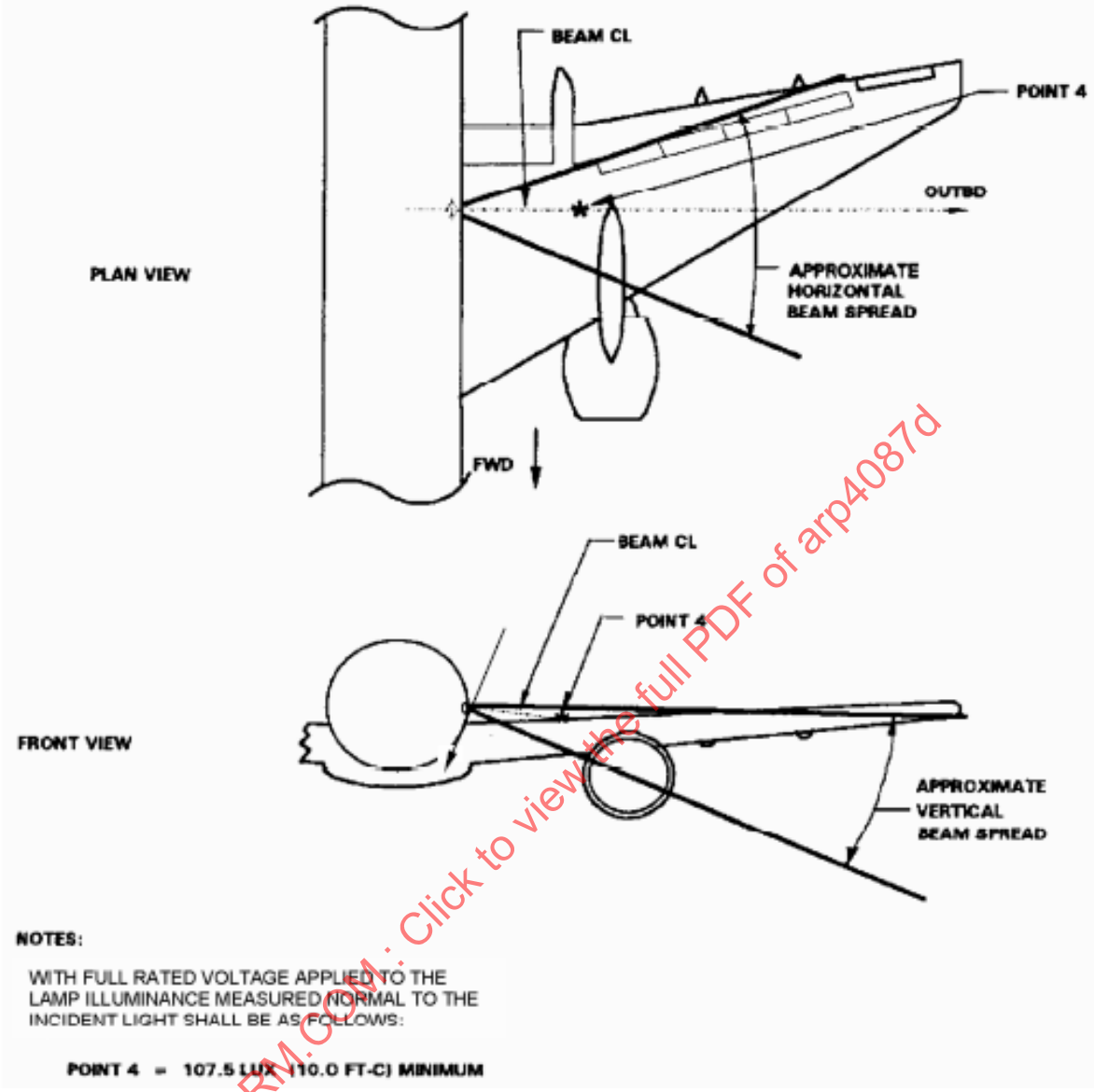

Figure 2 - Wing illumination pattern upper surface

4.3 Color

The color should be aviation white as defined in 14 CFR Part 25.1397.

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.

Figures 3 and 4 detail the color coordinates for both CIE 1931 and 1976.

Aviation White Calculations			
System of Equations			
Corner points are the	Point Label	x	y
intersections of the equation lines	1	0.430	0.392
	2	0.300	0.260
x = 0.3	3	0.300	0.320
x = 0.54	4	0.441	0.461
y = x-.04	5	0.540	0.420
$y = y_o$ -.010	6	0.540	0.402
y = x +.02	7	0.538	0.401
y = .636-0.400x	8	0.527	0.403
	9	0.516	0.405
	10	0.506	0.405
	11	0.496	0.405
	12	0.486	0.405
	13	0.477	0.404
	14	0.468	0.402
	15	0.460	0.401
	16	0.452	0.399
	17	0.444	0.397
	18	0.437	0.394
	19	0.430	0.392

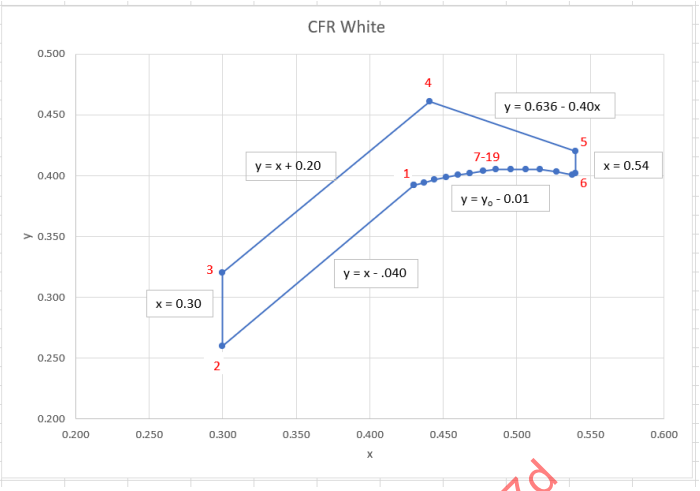

Figure 3 - 1931 CIE for aviation white

Aviation White Calculations			
System of Equations	1	0.251	0.515
Corner points are the	2	0.217	0.424
intersections of the equation lines	3	0.192	0.462
	4	0.231	0.542
	5	0.310	0.543
	6	0.320	0.536
	7	0.319	0.536
	8	0.311	0.535
	9	0.302	0.534
	10	0.296	0.532
	11	0.289	0.531
	12	0.282	0.529
	13	0.277	0.527
	14	0.272	0.525
	15	0.267	0.524
	16	0.263	0.522
	17	0.258	0.520
	18	0.255	0.517
	19	0.251	0.515

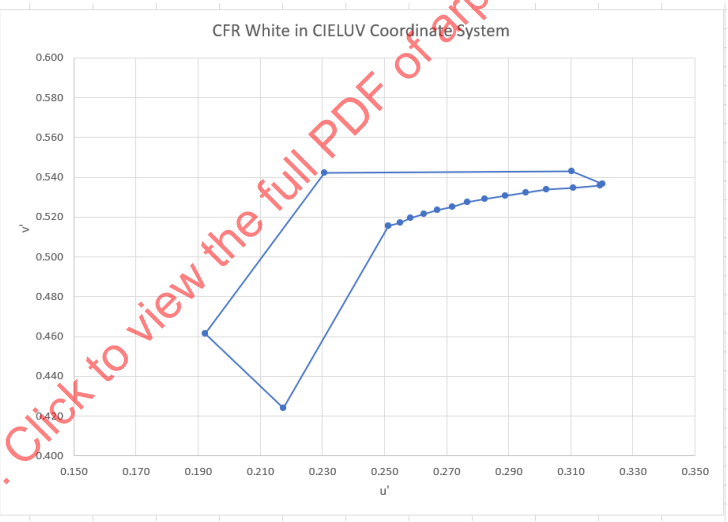

Figure 4 - 1976 CIE for aviation white

4.4 Locations

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

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

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

3. 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 shall be controlled from full ON to OFF. Continuous dimming or step dimming may be satisfactory.

5. CODE OF FEDERAL REGULATIONS

5.1 14 CFR Parts 25.1403 and 121.341(b) state that -- “means shall be provided for illumination or otherwise determining the formation of ice on the parts of the wings that are critical from the standpoint of ice accumulation” -- and “Any illumination that is used must be of a type that will not cause glare or reflection that would handicap crewmembers in the performance of their duties.”

6. MEASUREMENTS

6.1 Laboratory ambient temperature shall be 25 °C ± 10 °C.

6.2 Input Power

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

6.3 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.

6.4 Warm Up and Stabilization

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

6.5 Cover Lens

Intensity measurements must comply with the cover lens in place.

6.6 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 4.2.

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. To overcome the loss of luminance due to both environmental and other maintenance issues, the initial performance of the light assemblies must be a factor higher than the minimum luminance levels of 4.2. The factor higher (25%, 50%, or 100% higher than the minimum) should be based on results of the environmental tests detailed in 7.2. Refer to ARP6621 for predicting photometric degradation of exterior aircraft lights.

7. PERFORMANCE STANDARDS UNDER ENVIRONMENTAL CONDITIONS

7.1 Unless otherwise specified herein, the test procedures called out in Section 7 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."

7.1.1 Prior to subjecting the wing inspection light to the environmental tests specified in 7.2 of this document, performance tests must be conducted to determine that the light meets requirements of 4.2 and 4.3 of this document.

7.1.2 The following parameters should be recorded:

a. Illumination measurements complying with 4.2. During tests where illumination measurements are not possible, visual assessments during the test can help to identify potential test failures.

b. Color measurements complying with 4.3. During tests measurements are not possible, visual assessments during the test can help to identify potential test failures.

c. Input voltage

d. Input current

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

7.1.4 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.

7.2 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.

7.2.1 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 7.1.2 of this document.

7.2.2 Humidity

After being subjected to the humidity tests of DO-160, standard humidity environment (or more stringent, if required), there shall be no significant changes in the parameters recorded per 7.1.2 of this document. Optical parts such as lens assemblies (external surfaces only) may be cleaned if necessary.

7.2.3 Vibration

When the light is tested in accordance with DO-160, standard vibration environment (or more stringent, if required), there shall be no significant change in the parameters recorded per 7.1.2 of this document.

7.2.4 Explosive Atmosphere

Lights which are to be marked with an explosive atmosphere category must be tested in accordance with DO-160.

7.2.5 Waterproofness

Lights which are to be marked with a waterproofness category must be tested in accordance with DO-160. Following this test, the light shall show no significant change in the parameters recorded per 7.1.2 of this document.

7.2.6 Fluids Susceptibility

Lights which are to be marked Category F must be tested in accordance with DO-160. Following this test, the light shall show no significant changes in the parameters recorded per 7.1.2 of this document. Optical parts such as lens assemblies (external surfaces only) may be cleaned if necessary.