AEROSPACE STANDARD

AS8037™	REV. D
Issued 1986-01 Revised 2022-02 Superseding AS8037C	

Minimum Performance Standard
for Aircraft Position Lights

RATIONALE

This document establishes minimum performance levels for aircraft position lights including chromaticity, and light intensity in support of TSO and system certification. Information contained herein has been expanded from AS8037C in the areas of minimum criteria for showing compliance, continued airworthiness, glare, and specific criteria related to the use of LED technology. Sections related to chromaticity have been merged and simplified. Additional details have been provided on how to show compliance to regulatory requirements as well as practical applications and the rationale behind the regulations. Qualification categories have also been updated.

1. SCOPE

This SAE Aerospace Standard (AS) establishes minimum performance standards for new equipment position lights.

This SAE Aerospace Standard (AS) defines minimum and maximum light intensity in terms of candelas in vertical and horizontal directions about the longitudinal, vertical, and lateral axes of the aircraft. It also defines color tolerances in terms of limiting chromaticities for the light emitted from the position lights. It is not intended that this standard require the use of any particular light source such as quartz-halogen, incandescent, or any other specific design of lamp.

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.

AIR1106 Some Factors Affecting Visibility of Aircraft Navigation and Anticollision Lights

AIR5689 Light Transmitting Glass Covers for Exterior Aircraft Lighting

ARP991 Position and Anticollision Lights - Fixed-Wing Aircraft

ARP5029 Measurement Procedures for Short Pulse Width Strobe Anticollison Lights

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

For more information on this standard, visit
https://www.sae.org/standards/content/AS8037D/

ARP5414	Aircraft Lightning Zoning
ARP5637	Design and Maintenance Considerations for Aircraft Eterior Lighting Plastic Lenses
ARP6161	Flight Compartment Glare
ARP6253	LEDs and Aircraft Applications
AS25050	Colors, Aeronautical Lights and Lighting Equipment, General Requirements for
SAE J1330	Photometry Laboratory Accuracy Guidelines

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	Radio Technical Commission for Aeronautics (RTCA), Environmental Conditions and Test Procedures for Airborne Equipment

2.3 U.S. Government Publications

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

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

2.4 Code of Federal Regulations (CFR) Publications

Available from the United States Government Printing Office, 732 North Capitol Street, NW, Washington, DC 20401, Tel: 202-512-1800, www.gpo.gov.

Code of Federal Regulations Title 14, Part 23, 25, 27, 29

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

§23-.2530	External and Cockpit Lighting
§25, 27, 29-.1385	Position Light System Installation
§25, 27, 29-.1387	Position Light System Dihedral Angles
§25, 27, 29-.1389	Position Light Distribution and Intensities
§25, 27, 29-.1391	Minimum Intensities in the Horizontal Plane of Forward and Rear Position Lights
§25, 27, 29-.1393	Minimum Intensities in Any Vertical Plane of Forward and Rear Position Lights
§25, 27, 29-.1395	Maximum Intensities in Overlapping Beams of Forward and Rear Position Lights
§25, 27, 29-.1397	Color Specifications

2.5 FAA Publications

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

NOTE: EASA CS paragraph numbers match the FAA at the time of this publication.

AC 20-30 Advisory Circular, Aircraft Position Light and Anticollision Light Installations

AC 20-74 Aircraft Position and Anticollision Light Measurements

TSO-C30 Aircraft Position Lights

2.6 ASTM International 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 F3234/F3234M-17 Standard Specification for Exterior Lighting in Small Aircraft

2.7 EUROCAE Publications

Available from EUROCAE Secretariat, 9-23 Rue Paul Lafargue, 93200 Saint-Denis, France, Tel: +33 1 40 92 79 30, https://www.eurocae.net/.

ED-14 Environmental Conditions And Test Procedures For Airborne Equipment

3. GENERAL STANDARDS

3.1 Dihedral Angle Coverage, Forward Position Lights, Types I and II, and Rear Position Lights, Type III

When mounted on the aircraft in accordance with manufacturer's instructions, the forward and rear lights shall show unbroken light within the dihedral angles specified in Table 1 and defined in 3.1.1. Forward position lights must consist of a red and a green light spaced laterally as far apart as practicable. The rear position light(s) must be a white light mounted as far aft as practicable on the tail or on each wing tip. Example system installations include but are not limited to those shown in Figure 1. Position lights are intended to be viewed from a distance and appear as point sources in order to make the individual colors identifiable from one another such that an observer can identify the aircraft's direction of flight.

Table 1 - Dihedral angle coverage

Position Light Type	Dihedral Angle
Type I (forward, red)	L (left)
Type II (forward, green)	R (right)
Type III (rear, white)	A (aft)

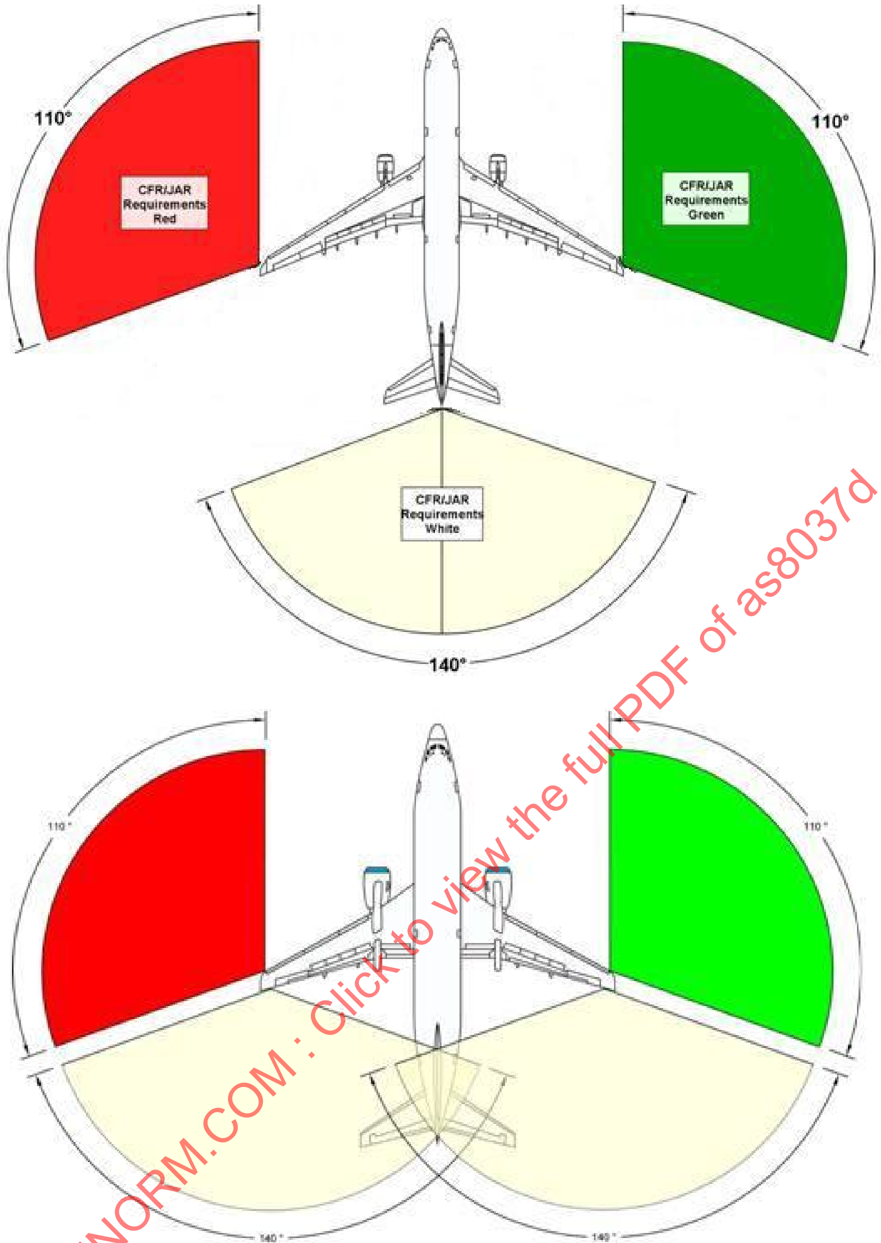


Figure 1 - Dihedral angle coverage, forward and rear position lights, showing both single and dual aft installations

3.1.1 Definitions of Dihedral Angles

a. Dihedral Angle L (Left): The dihedral angle formed by two intersecting vertical planes, one parallel to the longitudinal axis of the airplane, and the other at 110 degrees to the left of the first when looking forward along the longitudinal axis (Figure 2).

b. Dihedral Angle R (Right): The dihedral angle formed by two intersecting vertical planes, one parallel to the longitudinal axis of the airplane, and the other at 110 degrees to the right of the first when looking forward along the longitudinal axis (Figure 2).

c. Dihedral Angle A (Aft): The dihedral angle formed by two intersecting vertical planes making angles of 70 degrees to the right and 70 degrees to the left, respectively, looking aft along the longitudinal axis, to a vertical plane passing through the longitudinal axis (Figure 3).

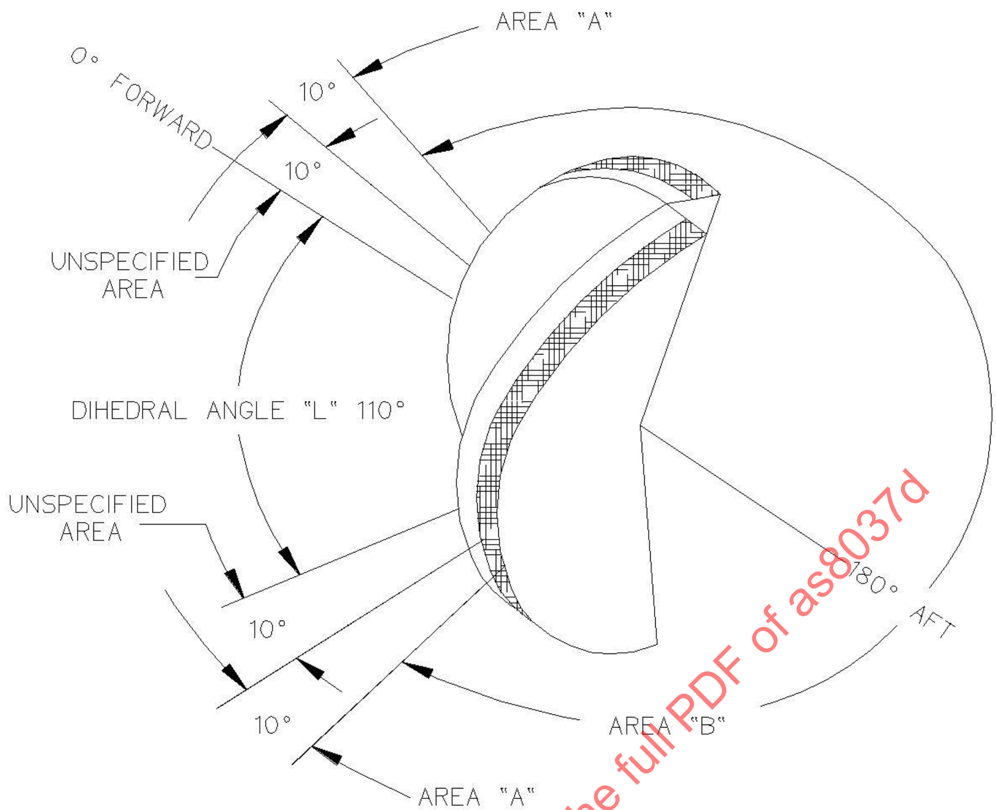


Figure 2 - Representation of angles for left forward position light

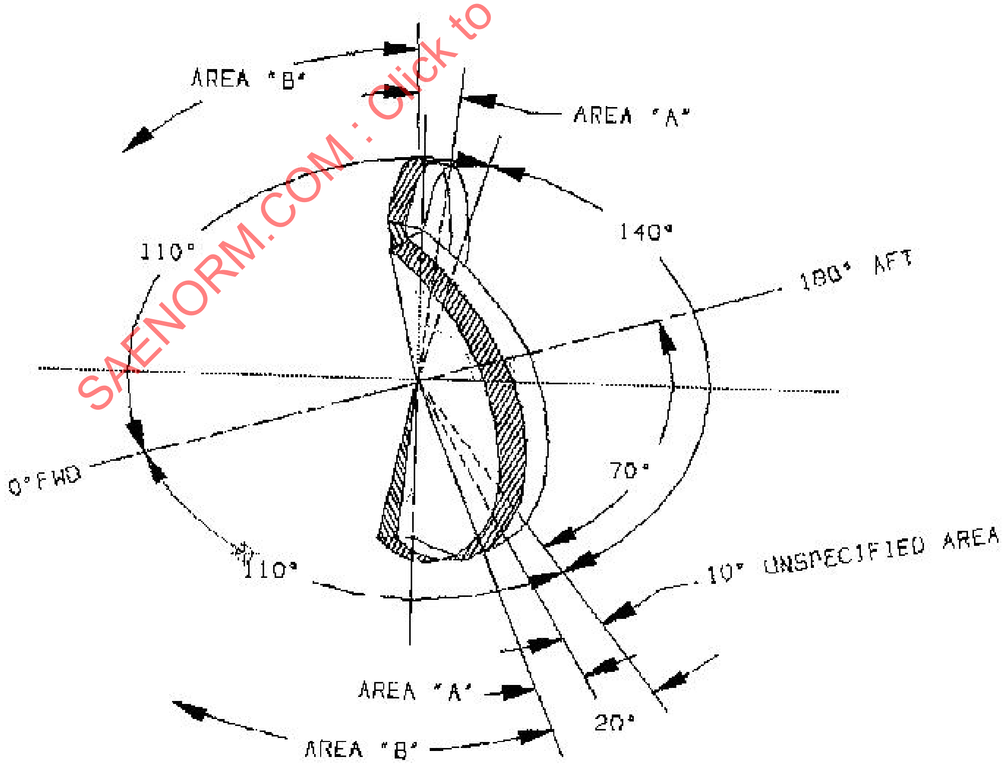


Figure 3 - Representation of angles for aft position light

3.2 Position Light Intensity Distribution

3.2.1 General

The intensities specified in this section shall be provided with all light covers and color filters in place, when mounted on aircraft in accordance with the manufacturer's instructions. Luminous intensity can be measured at nominal input voltage. If the luminous intensity varies with the input voltage, it should be shown that the light assembly meets the minimum and maximum intensity requirements throughout the rated (assembly) input voltage range.

3.2.2 Minimum Intensities in the Horizontal Plane

The intensities in the horizontal plane shall not be less than the values given in Table 2. The horizontal plane is defined as the plane containing the longitudinal axis of the airplane in the normal flying position and is perpendicular to the plane of symmetry of the aircraft.

Table 2 - Minimum intensities in the horizontal plane, forward and rear position lights

Position Light Considered	Angle (x) from Right or Left of Longitudinal Axis Measured from Dead Ahead (0 degrees)	Minimum Intensity (candelas)
Type I (forward, red) Type II (forward, green)	0 degrees ≤ x ≤ 10 degrees	40
	10 degrees ≤ x ≤ 20 degrees	30
	20 degrees ≤ x ≤ 110 degrees	5
Type III (rear, white)	110 degrees ≤ x ≤ 180 degrees	20

3.2.2.1 Minimum Intensities Above and Below the Horizontal Plane

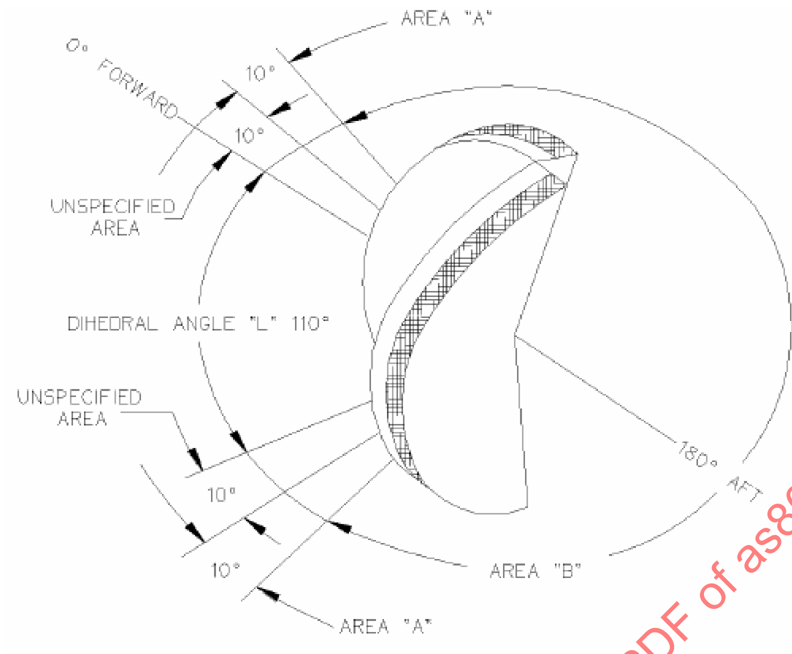
The intensities in any vertical plane shall not be less than the appropriate value given in Table 3, where I is the minimum intensity specified in Table 2 for the corresponding angles in the horizontal plane. Vertical planes are defined as planes perpendicular to the horizontal plane.

Table 3- Minimum intensities in any vertical plane, forward and rear position lights

Angle (y) Above or Below Horizontal, in Any Vertical Plane	Minimum Intensity (I)
0 degrees	1.00 x I
0 degrees ≤ y ≤ 5 degrees	0.90 x I
5 degrees ≤ y ≤ 10 degrees	0.80 x I
10 degrees ≤ y ≤ 15 degrees	0.70 x I
15 degrees ≤ y ≤ 20 degrees	0.50 x I
20 degrees ≤ y ≤ 30 degrees	0.30 x I
30 degrees ≤ y ≤ 40 degrees	0.10 x I
40 degrees ≤ y ≤ 90 degrees	0.05 x I

3.2.3 Maximum Intensities in Overlap Regions, Forward Position Lights, Types I and II, and Rear Position Lights, Type III

The intensities in the overlap regions between any forward or rear position lights shall not exceed the values given in Figure 4 and Table 4, except as noted in 3.2.3.1. Area A includes all directions in the adjacent dihedral angle which pass through the light source and which intercept the common boundary plane at more than 10 degrees but less than 20 degrees. Area B includes all directions in the adjacent dihedral angle which pass through the light source and which intercept the common boundary plane at more than 20 degrees (Figures 2 and 3).



OVERLAP INTENSITIES
LEFT FORWARD POSITION LIGHT

Area “A” if peak intensity is greater than 100 cd maximum intensity in Area “A” may be 10 % of this peak.

Area “B” is all directions more than 20 ° from the boundary planes in dihedral angles “L” and “R”. Maximum intensity in area “B” is 2.5% of the peak.

Figure 4 - Maximum intensities in overlaps between forward and rear position lights

Table 4 - Maximum intensities in overlaps between forward and rear position lights

Dihedral Angle	Maximum Intensity (candelas)	
	Area A	**Area B**
Type I (fwd, red) in dihedral angle R	10	1
Type I (fwd, red) in dihedral angle A	5	1
Type II (fwd, green) in dihedral angle L	10	1
Type II (fwd, green) in dihedral angle A	5	1
Type III (rear, white) in dihedral angle L	5	1
Type III (rear, white) in dihedral angle R	5	1

3.2.3.1 Maximum Intensities in Overlap Regions with High Main Beam Peak Intensity

If the peak position light intensity is substantially greater than minimum intensity levels defined in 3.2.2, a higher maximum overlapping intensity is permitted due to the improved signal clarity of a brighter main beam compared to the overlapping beam. When the peak intensity of the main beam is greater than 100 cd, the maximum overlapping beam intensity may exceed the values given in Table 4, provided the overlapping beam intensity in Area A is not greater than 10% of the peak main beam position light intensity and the overlapping beam intensity in Area B is not greater than 2.5% of the peak main beam position light intensity.

So, for a rear position light, the scaling on the right side is driven by the right forward position light peak intensity, and the scaling on the left side is driven by the left forward position light peak intensity. For the forward position lights, the overlaps to the rear are scaled by the rear position light peak intensity. The concept is that as the correct color light intensity increases in its prescribed area, the tolerance of the incorrect color invading light from the adjacent areas increases. For example, if a green position light has a peak intensity of 150 cd, the adjacent red position light and the rear position light are permitted a maximum of 15 cd (10% of 150) into Area A of dihedral angle L.

3.3 Position Light Color Specifications

The colors of the position light shall be in accordance with Table 5 and shall conform to 3.3.

Table 5 - Position light colors

Type	Color
Type I (forward, red)	Aviation red
Type II (forward, green)	Aviation green
Type III (rear, white)	Aviation white

Each position light color must have the (CIE 1931, 2 degrees observer) International Commission on Illumination chromaticity coordinates preferably as per CFR, or per alternate color definitions reported in 3.3.1.

CFR Title 14, Part 25,27,29 § 2-.1397 aviation color definitions:

a. Aviation red

y is not greater than 0.335; and
z is not greater than 0.002.

b. Aviation green

x is not greater than 0.440-0.320y;
x is not greater than y-0.170; and
y is not less than 0.390-0.170x.

c. 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 y_0 is the y coordinate of the Planckian radiator for the value of x considered.

See Table 6 for x,y color envelope vertex coordinates of CFR color definitions.

Table 6 - CFR x,y vertex coordinates

Color	CFR Color Definition	x, y CFR Vertex Coordinates
Aviation Red	y is not greater than 0.335 z is not greater than 0.002	0.664, 0.335 0.663, 0.335 0.7333, 0.2647
Aviation Green	x is not greater than 0.440-0.320y x is not greater than y-0.170 y is not less than 0.390-0.170x	0.190, 0.781 0.292, 0.462 0.188, 0.358 0.027, 0.385
Aviation White	Aviation White	0.300, 0.260 0.300, 0.320 0.440, 0.460 0.540, 0.420 0.540, 0.400 0.520, 0.404* 0.500, 0.405* 0.480, 0.404* 0.460, 0.401* 0.440, 0.395* 0.433, 0.393 0.300, 0.260

*Representative points have been chosen to approximate a smooth curve.

3.3.1 Alternate color definition that has been practiced by industry's TSO and certification programs:

a. Aviation Red

Purple Boundary y = 0.980 - x
Yellow Boundary y = 0.335

b. Aviation Green

Yellow Boundary x = 0.360 - 0.080y
White Boundary x = 0.650y
Blue Boundary y = 0.390 - 0.171x

c. 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

A visual representation of the color definitions is shown in Figure 5. Refer to AS25050 for xy and u'v' color envelope vertex coordinates of SAE alternate color definitions.

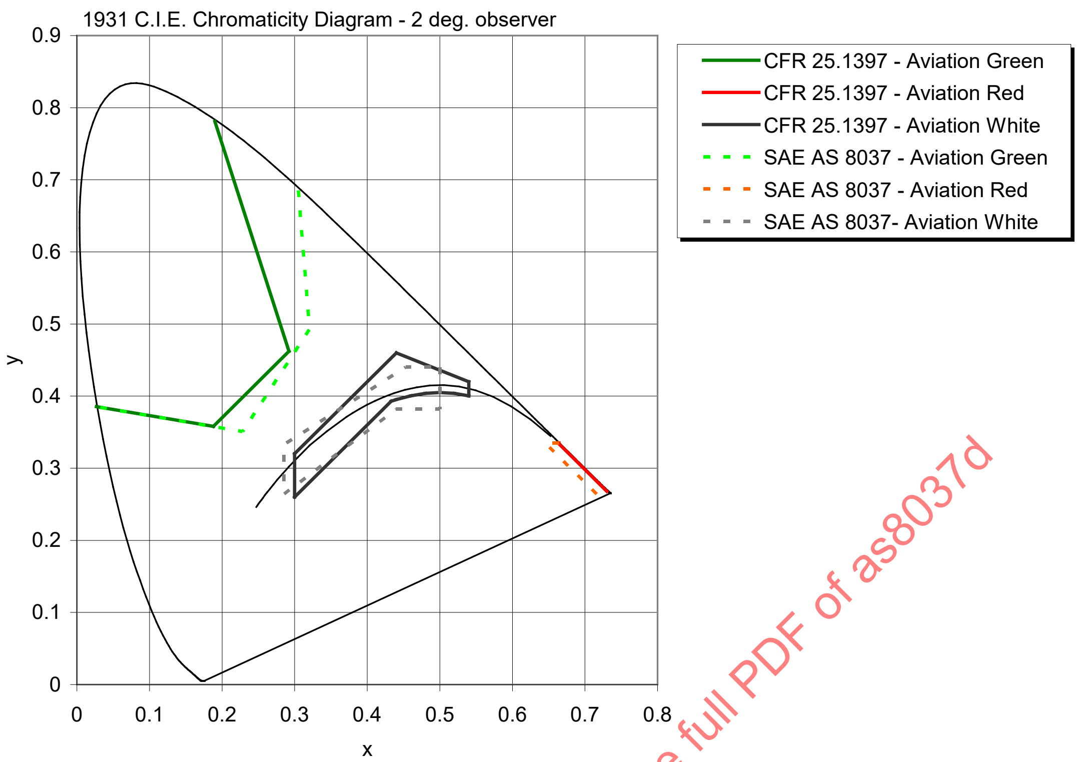


Figure 5 - Aviation color definitions in CIE1931 color diagram

Caution: Compliance only to the alternate color definitions detailed in 3.3.1 (without compliance to the CFR requirements) will require an equivalent level of safety finding by the Federal Aviation Administration in order to allow installation of the lights on certified aircraft.

3.4 Light Covers, Color Filters, and Light Emitting Diodes (LED)

For all position lights, the light covers or color filters used shall not readily support combustion and shall be constructed so that they will not change shape or permanently change color or shape or suffer any appreciable loss of light transmission during normal use.

3.4.1 Red Filters

Red color filters commonly used have a characteristic where the color changes and luminous transmission decreases with temperature rise. Therefore, both the color and intensity distribution testing shall be performed under standard ambient temperature conditions of 25 °C ± 5 °C. This requirement is intended to produce results which will be more representative of actual aircraft installation and in-flight temperature environment.

3.4.2 LEDs

LEDs commonly used have a characteristic where the color chromaticity coordinates change with temperature. In addition, luminous intensity decreases with temperature rise. Therefore, both the color and intensity distribution testing shall be performed under standard ambient temperature conditions of 25 °C ± 5 °C. This requirement is intended to produce results which will be more representative of actual aircraft installation and in-flight temperature environment. However, the impacts of temperature on color and intensity should be understood to verify that compliance is met under the expected range of in-flight environments. This requirement is applicable to any lighting technology, not just LEDs.

3.5 Multiple Installations

If the lighting distribution for any one type of position light is supplied by two or more lights which are located immediately adjacent to each other (generally 2 feet or less), the intensity distribution shall be determined with both lights operating and mounted in the same relationship to each other as they would be on the aircraft. If the lights are not located immediately adjacent to each other, intensity distributions shall be determined individually for each light and the minimum intensity in any direction shall be provided by either one or the other light. Additive intensity in the same direction cannot be used to demonstrate compliance with the minimum required intensity for non-adjacent lights.

3.6 Measurements

3.6.1 Laboratory ambient temperature shall be 25 °C ± 5 °C.

3.6.2 Input Power

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.

3.6.3 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.

3.6.4 Warm Up and Stabilization

For purposes of demonstrating compliance with this specification, all photometric and color measurements for LED sources shall be made after a minimum of warm up period of 30 minutes, or after the light has reached thermal stabilization, whichever is longer. Stabilization shall 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 incandescent/tungsten halogen light sources is 90 seconds.

3.6.5 Cover Lens

Intensity measurements must comply with any integrated or external cover lenses in place.

NOTE: This includes effects such as color shift, light reflection and/or refraction which may impact compliance to the minimum and maximum intensity requirements. It is not acceptable to only consider the natural light transmission loss of the cover lens material.

3.6.6 Measurement Points

A minimum number of test points is required to show compliance with this specification. Test point increments should be taken at a minimum of 5 degrees apart. In addition to the scans identified below, a visual inspection shall be conducted through the entire area to identify any shadows, reflections, color shifts or areas which indicate questionable compliance. If such areas are identified, further testing shall be made to ensure compliance in each area.

3.6.6.1 Forward Red and Green Position Light Test Data

At a minimum, the following photometric scans must be made to show compliance to minimum intensity levels:

- A horizontal distribution curve in the zero degree vertical plane from directly forward outboard through 110 degrees horizontal.
- Vertical distribution curves from 90 degrees up to 90 degrees down at: 0 degree, 10 degree, 20 degree, and 110 degree horizontal points.

At a minimum, the following photometric scans must be made to show compliance to maximum intensity levels:

- Vertical distribution curves from 90 degrees up to 90 degrees down at: -20 degree, -10 degree, 120 degree, and 130 degree horizontal points to cover Area A and Area B of the adjacent forward and rear position lights.

3.6.6.2 Rear White Position Light Test Data

At a minimum, the following photometric scans must be made to show compliance to minimum intensity levels:

- A horizontal distribution curve in the zero degree vertical plane from 70 degrees right to 70 degrees left of the the rear direction.
- Vertical distribution curves from 90 degrees up to 90 degrees down at the following horizontal points: directly rear, 70 degrees right of the rear direction and 70 degrees left of the the rear direction.

At a minimum, the following photometric scans must be made to show compliance to maximum intensity levels:

- Vertical distribution curves from 90 degrees up to 90 degrees down at the following horizontal points: 80 degree left of the rear direction, 80 degrees right of the rear direction, 90 degree left of the rear direction, and 90 degrees right of the rear direction to cover Area A and Area B of the adjacent forward and rear position lights.

3.6.6.3 Color Test Data

At a minimum, color test points must be collected in the directly forward direction for the forward position lights and the directly aft direction for the rear position light(s).

3.6.7 Photometric Testing Orientation

For purposes of demonstrating compliance with this specification, all photometric measurements shall be performed with the horizontal and vertical planes aligned with the expected orientation of the light as installed on the aircraft in the normal flying position.

Different fixture and light orientations may be used in testing as long as measured data is reported with respect to the expected flight orientation of the light. Care should be taken to ensure that the test stand does not impact the results. For example, reflected light on the test stand might make an impact when measuring dim areas such as the overlap regions.

3.6.8 Glare

Each light must not impair the crew's vision due to direct or reflected glare in its intended installation. For example, wingtip mounted forward navigation lights which on their own meet the maximum overlap criteria may create reflected glare once installed behind a wingtip cover lens. Wingtip mounted rear navigation lights may shine directly into the aft part of the cabin.

3.7 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 3.6.

Environmental and installation conditions affect operating lifetime. In the case of LED based lights, lumen maintenance is a function of LED junction temperature and drive current. 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 (50 °C, 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 on-wing 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 regularly scheduled maintenance intervals to ensure compliance.

Failure modes where a light continues to operate at a degraded level of performance should be identified and addressed. The probability and effects of these failure modes must be considered, including how an operator can determine when a light no longer meets regulatory performance requirements. For example, in LED based systems the light may continue to illuminate even if one or more individual LEDs no longer illuminate. This analysis also includes driver circuitry, flash controllers or other integrated electronics.

As LED technology improves, the duration of time for an LED light to degrade to a level of non-compliance may exceed the MTBF of the remaining electronics in the system. To ensure proper functionality, integrated continued airworthiness features shall reliably perform its function throughout the expected LED life. This should be considered when identifying the method of continued airworthiness.

4. PERFORMANCE STANDARD UNDER ENVIRONMENTAL CONDITIONS

4.1 Unless otherwise specified herein, the test procedures called out in Section 4 are those set forth in Radio Technical Commission for Aeronautics (RTCA) Document No. 160.

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

4.1.2 Certain tests require the equipment to be tested with consideration to the intended equipment installation. For example, lightning direct effects testing must consider the equipment installation mounting and electrical bonding. For a light under development which is not intended for a specific installation, such as a TSO applicant, the intended installation must be taken into account when establishing the testing protocol.

4.2 Environmental Tests

In this section, the meaning of "no significant lighting degradation or degradation in lighting" is that the light must stay lit without flickering or flashing during the test, and following the test, lights shall not suffer any significant loss of intensity.

4.2.1 Temperature and Altitude Tests

When lights are subjected to the appropriate category tests of DO-160 Sections 4 and 5, they must operate electrically and show no significant lighting degradation. Test category is dependant on the intended aircraft operating parameters and installation location.

4.2.2 Humidity

After being subjected to the tests of DO-160 Section 6 Category C (or more stringent) humidity environment, the system must operate electrically and show no significant lighting degradation. Optical parts may be cleaned if necessary. Test category is dependent on the intended installation aircraft zone.

4.2.3 Vibration

When the system is tested in accordance with DO-160 Section 8 Category S (or more stringent) vibration environment, the system must operate electrically and show no significant lighting degradation. Test category is dependant on the intended installation aircraft zone. For incandescent light sources, some bulb failures are acceptable so long as the minimum and maximum intensity requirements are met.

4.2.4 Explosive Atmosphere

Systems which are to be marked with an explosion-proof category shall meet appropriate category explosive atmosphere requirements of DO-160 Section 9. Test category is dependant on the intended installation aircraft environment and equipment construction. All components containing a light source and intended for installation in fuel vapor zones (examples may include mounting within wing tip or tail enclosures) shall meet the explosion containment requirements of DO-160 (latest applicable revision) for Category A equipment.