



AEROSPACE RECOMMENDED PRACTICE

ARP6259™

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LED Replacement for Incandescent/Halogen Bulbs or Fluorescent Lamps Transport Category Aircraft and Rotorcraft

RATIONALE

This document establishes guidance for interior aircraft lighting replacement of incandescent, halogen, or fluorescent light fixture with LED lights. Information contained herein has been expanded from other related LED light type AS and ARPs.

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1. SCOPE

This SAE Aerospace Recommended Practice (ARP) establishes design and qualification guidance for interior aircraft lighting replacement of incandescent, halogen, or fluorescent light with LED lights.

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.

AIR512 Aircraft Cabin Illumination

ARP5873 LED Passenger Reading Light Assembly

ARP6253 LEDs and Aircraft Applications

2.1.2 U.S. Government Publications

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

CFR references are available at the Government Printing Office.

CFR AC and special conditions references are also available at the FAA home page at:

http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgWebcomponents.nsf/HomeFrame?OpenFrameSet

14 CFR Part 25 Airworthiness Standards: Transport Category Airplanes

14 CFR Part 29 Airworthiness Standards: Transport Category Rotorcraft

EASA CS 25 Certification Specifications for Large Aeroplanes

AC Advisory Circulars

Special Conditions: Dependent on aircraft models applicable special conditions can be found in the FAA websites:

http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgSC.nsf/MainFrame?OpenFrameset

2.1.3 CIE Publications

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

CIE 13.3 Method of Measuring and Specifying Colour Rendering Properties of Light Sources

CIE S 009/E Photobiological Safety of Lamps and Lamp Systems

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.

IEC 60081-1997 Double-capped fluorescent lamps - Performance Specifications

IEC 62471 Photobiological Safety of Lamps and Lamp Systems

IEC 62402 Obsolescence Management

2.1.5 RTCA Publications

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

RTCA DO-160 Environmental Conditions and Test Procedures for Airborne Equipment

RTCA/DO-178 Software Considerations in Airborne Systems and Equipment Certification

RTCA/DO-254 Design Assurance Guidance for Airborne Electronic Hardware

2.1.6 IES Documents

Available from Illuminating Engineering Society, 120 Wall Street, Floor 17, New York, NY 10005-4001, Tel: 212-248-5000, www.ies.org.

LM79 Approved Method: Electrical and Photometric Measurements of Solid State Lighting Products

LM80 Approved Method: Measuring Lumen Maintenance of LED Light Sources

TM21 Projecting Long Term Lumen Maintenance of LED Light Sources

2.1.7 ANSI Accredited Publications

Copies of these documents are available online at <http://webstore.ansi.org>.

ANSI/IESNA RP-27 Recommended Practice for Photobiological Safety for Lamps - Risk group classification and labeling

2.2 Definitions

AC Advisory Circulars

A/C Aircraft

A/P Airplane

BIT Built in Test

BITE Built in Test Equipment

EMC Electromagnetic Compatibility

EME Electromagnetic Effects

EMI Electromagnetic Interference

eV	Electronvolt
EO	End of Life
ESD	Electrostatic Discharge
FMEA	Failure Mode Effect and Analysis
ICD	Interface Control Drawing
In situ	“in place”
LED	Light Emitting Diode
LF	Light Fixture. It's also referred to as luminaire
LRU	Line Replaceable Unit. LRUs are standalone replaceable units including lighting elements, luminaries, and power supply/conversion units.
MTBF	Mean Time Between Failure. This value shall be expressed in operating hours. A correlation to flight hours can also be provided based upon the aircraft and LRU's specific operating assumptions, mission profile and aircraft design life cycle, and other applicable assumptions.
MTBUR	Mean Time Between Unscheduled Removal. This value shall be expressed as a percentage of the MTBF.
MTTR	Mean Time to Repair. This value shall be expressed in man-hours.
SCD	Specification Control Drawing
Ø	Phase or without
PS	Power Supply
RPS	Remote Power Supply
UV	Ultraviolet (UV) light is <u>electromagnetic radiation</u> with a <u>wavelength</u> shorter than that of <u>visible light</u> , but longer than <u>X-rays</u> , that is, in the range between 100 <u>nm</u> and 400 nm, corresponding to photon energies from 3 <u>eV</u> to 124 eV.
UI	User Interface
VAC	Volts Alternating Current
VDC	Volts Direct Current

3. GENERAL CONSIDERATIONS

Based on the objectives, whether customer demand, power savings, performance, or enhancement in other perceptive values when substituting an existing light source or a luminaire with an LED light, the compatibilities must be addressed to ensure that it meets the intended function and does not have an adverse effect on the airplane in a foreseeable operational condition. There are many benefits as well as challenges of LED technology; therefore, the implementation of LED lighting requires a complete audit for compatibility of the design, manufacture, function, qualification, and maintenance to ensure its airworthiness. The following several technical aspects should be addressed:

- Functional objectives
- Electrical characteristics, power quality, and electrical interface

- Mechanical interface from installation to optic
- Photometric performance
- Software
- Environmental
- Reliability and maintainability
- Life - light source and luminaire light
- Flammability
- Safety
- Part obsolescence
- Qualification
 - o Electrical - power quality
 - o Interferences - EMC, electromagnetic compatibility
 - o Environmental conditions
 - o Flammability
 - o Others: photometric performance, service life, fail-safe, and component, etc.

3.1 Functional Objectives

With each type of light targeted for replacement the integrity of both direct and indirect functions must be considered. For an example, a direct function of a light could be to provide general illumination or illuminate a specific target. But the same light may also provide indirect functions such as:

Providing a coordinated scene to enhance the aesthetic ambient.

Charging the photo-luminescent light strips to provide emergency escape path marking - To establish photo-luminescent strips' operational limit and proper charging regimen, the following must be taken into consideration: photo-luminescent light strip type, aircraft interior lighting operational routine, flight duration, and interior arrangement.

Providing lighting for donning an oxygen mask - To establish a minimum light level to don an oxygen mask, due to the subjective judgment of the adequate light level for this task, it is recommended to coordinate with the proper oxygen system and cabin safety groups for a guidance light level or to conduct a subjective evaluation.

Providing lighting for maintenance purposes - To establish the illumination level for aircraft maintenance purposes, it is recommended that accessibility, maintenance task required, and system capacity be taken into consideration.

Providing other enhanced functions (dimming, color gamut).

Light sources that are to be replaced by LEDs function in a number of different ways either in isolation or within their luminaire/assemblies that must be considered in the design/specification of the LED replacement. For example:

- **Direct Light:** Direct lighting is defined as task lights or flood light type of lights such as reading lights, work lights, dome light, cargo lights, etc., generally the source (not necessary the bulb) can be seen.
- **Indirect Light:** Indirect lighting is defined as a type of light that provides illumination via a secondary target such as a light that illuminates a surface which then reflects the light to illuminate the desired area. Generally, with these types of lights the source cannot be seen. Examples would be a sidewall and ceiling wash light or a light that illuminates the aircraft structure.
- **Signage or Indication Light:** Light sources within signage such as that in PSUs or information or emergency escape signs where requirements/specifications for luminance, color and uniformity must be considered and maintained when the LED replacement is fitted.
 - **Emergency Escape Path Lighting** - Lights that illuminate the escape path or provide escape path marking and guidance to a usable exit location for emergency evacuation purpose.

3.2 Electrical and Thermal Considerations

3.2.1 Electrical Considerations

The power input and control must be compatible to the existing interface to ensure proper electrical and control interface, airplane protection and power budget. The required power input as defined in 3.11.2 shall be validated. It depends on the substituted configuration- see an example of the configuration variations in Figure 1.