SAE Aerospace
An SAE International Group

AEROSPACE INFORMATION REPORT

SAE AIR512 | REV. E

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Superseding AIR512D

Aircraft Cabin Illumination

RATIONALE

Add threshold lighting requirements, stairway lighting requirements and references.

1. SCOPE

This document covers the general recommendations for cabin lighting in order to provide satisfactory illumination for, but not limited to:

a. Boarding and deplaning

b. Movement about the cabin

c. Reading

d. Use of lavatories

e. Use of work areas

f. Exiting under emergency conditions

g. Using stowage compartments, coat rooms, and closets

h. Using interior stairways and elevators (lifts)

1.1 Design Goals - Visual

The designer should strive to provide a comfortable visual environment by proper consideration of:

a. Quantity of Light: The amount of illumination required at each area or location to perform the pertinent visual task.

b. Quality of Lighting: The brightness distribution, including contrasts in the field of view. This includes the surrounding area, that is, seat backs, carpeting, bulkheads, overhead, etc., as well as brightness of light sources and fixtures. The values will be influenced by the color, texture, and finish of the materials. Visual comfort is very much dependent upon the quality of the lighting.

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1. Brightness distribution is affected by glare (excessive brightness in the field of view), both direct and reflected, the source of which can be the light sources in the cabin, or light sources exterior to the cabin, such as the sun. The reflected glare may come from shiny, specular surfaces inside the cabin, or airplane parts, such as the wing on the exterior.

2. By choice of colors and brightness, claustrophobic effects may be reduced.

1.2 Design Goals - Electrical and Mechanical

The designer should strive to accomplish the above with:

a. Adequate hardware design with consideration given to:

   1. Minimal weight

   2. Reliability of equipment and lamps

   3. Ease of maintenance

b. Safety

   1. Electrical

   2. Thermal

   3. Moisture proof, as required

1.2.1 Illumination Design Errors

a. Improper quantity of light - too much as well as too little

b. Inadequate quality of lighting

   1. Improper distribution

   2. Exposed light sources - direct glare

   3. Improper consideration of secondary surfaces that absorb or reflect light - brightness distribution, colors, reflected glare, etc.

c. Difficulty of maintaining lighting systems

1.2.2 Ingredients for Good Lighting

a. Sufficient illumination for task

b. Adequate quality

   1. Adequate brightness control with respect to:

      (a) Direct glare

      (b) Reflected glare

      (c) Contrast between task and surround

      (d) Color of furnishings and light

2. APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications should apply. The applicable issue of other publications should 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.

ARP378 Passenger Reading Lights

ARP5873 LED Passenger Reading Light Assembly

ARP503 Emergency Evacuation Illumination

ARP6253 LEDs and Aircraft Applications

ARP711 Illuminated Signs

ARP712 Galley Lighting

AS4914 Aircraft Fluorescent Lighting Ballast/Fixture Safety Design Standard

2.2 RTCA Publications

Available from RTCA Inc., 1828 L Street, NW, Suite 805, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

DO-160 Environmental Conditions and Test Procedures for Airborne Electronics/Electrical Equipment and Instruments

2.3 Other Publications

Carson D. H., Archea, J.C., Carson, F., Margulis S.T.&Carson,F.E.(1978). Safety on Stairs. NBS Building Science Series 108. Washington, DC: National Bureau of Standards

Templar, J (1995) The Staircase: Studies of Hazards, Falls and Safer Design. MA: The MIT Press

3. SPECIFIC RECOMMENDATIONS

3.1 Cabin Lighting

3.1.1 Cabin Lights

Cabin lights should be provided in the passenger compartments by an indirect, direct, or combination lighting system to provide sufficient illumination of adequate intensity and distribution. Lighting tones or color throughout the passenger areas should be selected for comfort and aesthetic quality. "Walls, window frames, and overhead surfaces of the passenger cabin should have a light-diffusing finish to minimize glare which might be annoying to adjacent passengers."

3.1.2 Cabin Lighting Control

Cabin illumination should be controllable at the attendant’s panel for suitable lighting levels.

3.1.3 Colors

Careful blending of colors of light with the color of the interior decorations will help to minimize the effect of claustrophobia for passengers with sensitivity to space limits. Consideration should be given to the psychological affects of lighting and color for reducing the effects of claustrophopia and creating a comfortable environment.

3.1.4 Boarding Lights

When the passenger is boarding or departing, a temporary condition exists in changing from one environment to another. The entrance way, tops of seats, baggage compartments, steps, ramps, and other potential obstructions (such as partitions) should be brightly illuminated. The entrance area, when not in use, should be illuminated the same as the remainder of the cabin.

3.1.5 Reading Lights

The reading light design should be in accordance with the requirements of ARP378 or ARP5873.

3.1.6 Galley

Galley area should be lighted as recommended in ARP712.

3.1.7 Flood Lights

When sidewall lights are used for aesthetic effects, illumination sources should not be visible. Controls for dimming located on the attendant's panel are recommended.

3.1.8 Signs

Should be in accordance with ARP711.

3.1.9 Sign Control

Should be in accordance with ARP711.

3.1.10 Aisle Lights

Light sources should be provided to illuminate aisles and entry ways in the passenger compartments when general illumination is reduced or off. The light should be controlled to provide aisle lighting without annoying the passengers.

3.1.11 Lavatory Lighting

Each lavatory should be provided with light fixtures which will illuminate the area. Lighting equipment at the mirror should direct light toward the user and not onto the mirror. Dimmable lights may be used for low level illumination that will not interfere with passenger comfort during night operations when the door is opened. High intensity illumination for each lavatory should be controlled by a "BRIGHT-DIM" switch integral with the respective lavatory door lock. Opening the lavatory door should change the lighting from bright to dim. Provisions should be made to maintain the lights in the "BRIGHT" position for servicing and maintenance purposes with the lavatory door open.

3.1.12 Coat Compartment Lighting

Illumination should be provided in the fixed coat (garment bag) storage areas. The lighting fixtures should be designed such that they do not come in contact with the garments. Control switches should be conveniently located in the coat rack area.

3.1.13 Stairway Lighting

The nosing of the stairs tread is the key feature and should be highly visible. The nosing area is two inches from the edge of the tread and entire width of the stair. This area should be illuminated as uniformally as possible with a minimum.of 8fc. It should be acknowledged surface reflectances of the stair covering material can affect visibility of the stairs. Mounting of the luminaire(s) should be designed to produce minimum glare and installed in the optimum position to meet the above illumination requirements. Light blockage by passengers using the stairs and any other interior structure should be considered.

Nosings shall be emphasized whenever stairway illumination, under either normal or emergency conditions, is expected to be less than 8 footcandles (86.4 lux). Emphasis shall be attained by having a different light reflectance (either in brightness or hue) on the nosing than on the remainder of the tread. Illumination is to be measured with a photometer placed within 2 inches (50 mm) of the edge of the nosing at any point along the width of the tread. One approach would be for a contrasting stripe 1 to 2 inches (25 - 50 mm) wide to be placed on the top surface of each nosing. Another approach would be for alternating treads to have different reflectance characteristics.

3.1.14 Threshold Lighting

The threshold area should be illuminated uniformly as possibly with a minimum of 8fc for an area centered on the doorway, 8 inches inside and outside the passenger cabin. Mounting of the luminaire(s) should be designed to produce minimum glare and mounted in the optimum position to meet the above illumination requirements. Light blockage by passengers entering and exiting the airplane should be considered.

3.2 Emergency Lighting

Should be in accordance with ARP503.

4. OTHER CONSIDERATIONS

4.1 Light Fixtures

Fixtures should be designed and the light sources selected to avoid overheating, potential deterioration of the fixture, possible fire hazard, and shortened service life.

4.1.1 Fluorescent Ballasts

Ballasts should be designed in accordance AS4914. Ample margins for the known conditions of voltage, frequency, heat, and vibration. Ballast design should be such that no smoke can be emitted under any failure condition. The selection of the wire and wire size and insulation in the ballast windings should be capable of continuous duty for many thousands of hours under the known conditions. Ballasts should be readily accessible and easily detached with terminal strip, electrical connector, or other electrical junction device for ease of maintenance.

4.2 Reliability and Maintenance

Reliability and simplicity of maintenance are important design goals. Fixture installations should be readily accessible for inspection, removal, and replacement without special tools or skills.

If the light fixture requires lamp replacement, it should be marked in such a way that the lamp number is visible during lamp replacement.

Selection of components for design reliability is a criteria for reduction in maintenance cost. Adequate instructions should be provided in the maintenance and overhaul manual.

4.3 Safety

Lighting fixtures, as installed in the airplane, should dissipate heat such that fire hazards and/or heat damage does not occur. Luminaire designs should have adequate heat dissipation and ventilation for proper operation.. Luminaries should be designed and located such that nothing can be put over them which will trap heat. Where this cannot be avoided (e.g., overhead stowage compartment), then means must be taken to prevent fire hazard and heat damage to the articles in these compartments. This protection should insure physical separation and methods of conducting, convecting, or radiating the heat elsewhere. All fixtures which have 40 V or greater should be grounded to protect passengers and maintenance personnel. All parts of the electrical circuit should be shielded in such a way as to preclude contact by personnel and foreign objects. Thermal and electrical fuses should be provided in the secondary circuit of each transformer and ballast to prevent overheating should the primary circuit protector fail to clear secondary circuit faults.

4.4 Recommended Minimum Light Levels

See Appendix A.

5. LIGHT SOURCES

The types of lamps primarily used for lighting aircraft cabins are currently incandescent filament lamps, fluorescent lamps and LEDs (Light Emitting Diodes).

5.1 Incandescent Filament Lamps

In general, incandescent filament lamps used in aircraft cabin lighting comprise a range from 0.3 W, 0.03 cd to 36 W, 50 cd. They are used in every facet of cabin lighting, including indications, signs, area, reading, and decorative. Their efficacy of light production ranges from approximately 1.2 to 15 lm/W, depending on size, wattage, and design life.

5.2 Fluorescent Lamps

In general, fluorescent lamps are used for area lighting, including cabin, galley and lavatory and decorative lighting. The fluorescent lamp is an electric discharge light source, in which light is predominantly produced by fluorescent powders activated by ultraviolet energy generated by a mercury arc. There are two basic types of fluorescent lamps, hot cathode and cold cathode.

5.2.1 Hot Cathode Fluorescent Lamps

Hot cathode fluorescent lamps employ coiled tungsten filaments as electrodes. These are coated with one or more of the alkaline earth oxides. This electron- emissive coating provides an abundance of free electrons when hot. By suitable circuit arrangements, these cathodes can be heated to a satisfactory electron emitting temperature before the arc is struck (preheat, trigger, or rapid start) or they may be required to act momentarily as cold cathodes until heated by the electron stream after starting (instant start or slimline). The efficacy of light production of the hot cathode lamps used on aircraft varies from about 16 lm/W for the 4 W rapid start lamps to about 85 lm/W for the 55 W warm white (Color Temperature of 3000 K) lamp. These figures are for the lamp only and do not include ballast losses.

5.2.2 Cold Cathode Fluorescent Lamps

Cold cathode fluorescent lamps are similar in design and construction to hot cathode lamps except that no filaments are provided in the electrode ends of the lamps. To start conduction or “Strike the Arc” in a cold cathode lamp, a minimum voltage is required of 2 to 4 times greater than that required for starting a hot cathode tube. The electrode in each end is shaped with a cavity and is coated with a special barium oxide compound to optimize conduction and minimize impedance. The ballast for the cold cathode lamp performs a similar function to the ballast for the hot cathode lamp, except for the higher output voltage and the absence of a separate filament drive circuit. The ballast functions to provide an elevated starting voltage for striking the initial arc, and immediately afterwards providing a reduced voltage for limiting the average current. While lamp efficacy for hot and cold cathode lamps for light production are comparable, cold cathode lamps have significantly longer service life due to the absence of filaments.

5.3 Light Emitting Diodes

LEDs are electronic semiconductor devices that emit light when an electric current passes through it. They are considerably more efficient than incandescent bulbs, and rarely burn out. LEDs are used in many applications such as flat-screen video displays, and increasingly as general sources of light. Considerations for LED selection and elements affecting perfomance are listed in ARP 6253, LEDs and Aircraft Applications.

6. ENVIRONMENTAL CONDITION

Luminaires shall meet the RTCA DO-160 environmental requirements of Table 1 or as defined by the aircraft engineering authority.

TABLE 1 - RTCA DO-160 ENVIRONMENTAL REQUIREMENTS EXAMPLE

Requirement	*Test Level
Temperature and Altitude	Category A1
Temperature Variation	Category C
Humidity	Category A
Operational Shocks and Crash Safety	Category A
Vibration	Category S or S2 test curves B or B2
Waterproofness	Category W. Use 5% NaCl in water sample for this test.
Power Input	Category B (for 28 VDC applications) Category A(CF) (for VAC applications; single phase). Category A(WF) (for 115 VAC variable frequency, single phase). For voltages other than 115 VAC, the tests shall scale the RTCA 115 VAC voltage requirements by the same proportion as the nominal operating voltage to 115 VAC (for example, 28 VAC would scale the RTCA requirements for maximum voltages, voltage surges, etc by a factor of 28/115.
Voltage Spike	Category A
Audio Frequency Conducted – Power Inputs	Category B (for 28 VDC applications Category R(NF) (for 28 VAC applications. Test shall scale the 115 VAC to 28 VAC or use a 115 VAC to 28 VAC transformer).
Induced Signal Susceptibility	Category B
Radio Frequency Susceptibilty (Radiated & Conducted)	Category S
Emission of Radio Frequency Energy	Category B
Electrostatic Discharge	Category A

*Note: The categories and paragraphs noted in this table were specified from RTCA DO-160. Light assemblies are recommended to meet the environmental requirements of RTCA DO-160 latest revision. Test levels will depend on each aircraft installation.

7. NOTES

7.1 A change bar (l) 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.

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APPENDIX A - RECOMMENDED MINIMUM LIGHT LEVELS

TABLE A1 - RECOMMENDED MINIMUM LIGHT LEVELS

Boarding and Departing	Minimum LUX (Footcandles) Average
Entry Door and Obstructions	107.64 (10)
Threshold Area	86.08 (8)
Entry Floor	53.82 (5)
Aisle	21.53 (2)
Seat Cushion	53.82 (5)
Stairway	86.08 (8)
Baggage Racks	53.82 (5)
Flight Conditions - Night - Illuminated	
Aisle	21.53 (2)
Seat Cushion	21.53 (2)
Stairway	86.08 (8)
Partitions	–
Reading Lights at Arm Rest Level	See ARP378/ARP5873
Flight Conditions - Night - Sleeping	
Aisle	1.08 (0.1)
Floors at Lavatory Doors	10.76 (1)
Lavatories	
Task Area	215.28-322.92 (20-30)
Floor	21.53 (2)
Galley	See ARP712