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The Engineering Society For Advancing Mobility Land Sea Air and Space

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# AEROSPACE INFORMATION REPORT

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## AIRCRAFT CABIN ILLUMINATION

1. INTRODUCTION: This document provides the aircraft designer, architect, industrial designer and electrical engineer with design criteria to properly illuminate aircraft cabin interior.

2. PURPOSE:

2.1 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)

2.2 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.

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.

2.3 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. Moistureproof, as required

2.3.1 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

2.3.2 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

3. SPECIFIC RECOMMENDATIONS:

3.1 Cabin Lighting:

3.1.1 Cabin Lights: Cabin lighting should be provided in the passenger compartments by an indirect, direct, or combination lighting system to provide sufficient illumination of adequate intensity and distribution. Warm white lighting tones should be used throughout passenger areas for comfort and aesthetic quality unless special applications make cool white or daylight tones necessary.

3.1.2 Cabin Lighting Control: Cabin illumination should be controllable at the attendent'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.

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 ARP 378.

3.1.6 Galley: Galley area should be lighted as recommended in ARP 712.

3.1.7 Flood Lights: When sidewall flood lights are used for aesthetic effects, the illumination sources should not be visible. Provisions for dimming or cut-off should be provided on the attendant's panel.

3.1.8 Signs: "NO SMOKING" and "FASTEN SEAT BELT" signs should be provided in passenger compartments. "RETURN TO CABIN" or "RETURN TO SEAT" and "NO SMOKING" signs should be provided in each lavatory. Signs reading "LAVATORIES-VACANT-OCCUPIED" should be installed and visible to all passengers in respective areas. When illuminated, the signs should be clearly visible to all persons from whatever distance or angle the viewing may occur, even under daylight ambient lighting conditions. Sign design should be as recommended in ARP 711.

3.1.9 Sign Controls: An "ON-OFF" switch should be installed in the pilot's overhead panel to control the "FASTEN SEAT BELT", "RETURN TO CABIN", and "NO SMOKING" signs. "LAVATORIES-VACANT-OCCUPIED" signs should be controlled by the respective lavatory lock latches. The circuitry for "NO SMOKING", "FASTEN SEAT BELT" and "RETURN TO CABIN" should be connected to the call chime circuitry to audibly alert passengers. The signs may flash for 10 seconds after turn on before remaining steady.

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. Incandescent lamps or two level fluorescent 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 shall 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.

3.2 Emergency Lighting: Should be in accordance with ARP 503.

4. OTHER CONSIDERATIONS:

4.1 Incandescent Fixtures: Fixtures should be designed and the lamps selected to avoid overheating, potential deterioration of the fixture, possible fire hazard and shortened lamp life. Lamps should be operated at 90 to 95% of rated voltage.

4.1.1 Fluorescent Ballasts: Ballast should be designed with 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 lamp replacement without special tools or skills.

Each fixture should be marked in such a way that the lamp number is visible during relamping.

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 fixture designs should have adequate heat dissipation and ventilation. Luminaries should be designed and located such that nothing can be put over them which will trap heat. Where this cannot be avoided (as an example, 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 volts or greater should be grounded to protect passengers and maintenance personnel. All parts of the electrical circuit shall 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 I.

5. LIGHT SOURCES: The types of lamps primarily used for lighting aircraft cabins are incandescent filament lamps and fluorescent lamps.

5.1 Incandescent Filament Lamps: In general, incandescent filament lamps used in aircraft cabin lighting comprise a range from 0.3 watt, 0.03 candela to 36 watt, 50 candelas. 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 lumens per watt to 15 lumens per watt, 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 lumens per watt for the 4 watt rapid start lamps to about 85 lumens per watt for the 55 watt warm white 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.

6. ENVIRONMENTAL CONDITIONS: Performance should be determined and testing accomplished in accordance with applicable environmental conditions of Radio Technical Commission for Aeronautics (RTCA) Document NO. DO-160B, "Environmental Conditions and Test Procedures for Airborne Electronics/ Electrical Equipment and Instruments."



Prepared by SAE Subcommittee A-20C, Interior Subcommittee
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# APPENDIX I

## RECOMMENDED MINIMUM LIGHT LEVELS

| | Minimum LUX (Footcandles) average |
|---|---|
| **Boarding and Departing** | |
| Entry Door and Obstructions | 107.64 (10) |
| Entry Floor | 53.82 (5) |
| Aisle | 21.53 (2) |
| Seats | 53.82 (5) |
| Baggage Racks | 53.82 (5) |
| **Flight Conditions - Night - Illuminated** | |
| Aisle | 21.53 (2) |
| Seats | 21.53 (2) |
| Partitions | - |
| Reading Lights at Arm Rest Level | See ARP 378 |
| **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 ARP 712 |