SAE Aerospace
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AEROSPACE STANDARD

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Superseding AS4914A

(R) Aircraft Fluorescent Lighting Ballast/Fixture Safety Standard

RATIONALE

This document has been revised to provide better guidance in designing failsafe light assemblies. It has also improved defining test requirements along with incorporating lessons learned from industry.

1. SCOPE

The purpose of this standard is to recommend minimum performance requirements to assist the specification writer in establishing a failsafe airplane interior light assembly design. This standard relates to the design of fluorescent lamp ballasts, lampholders, fixtures, and installation of the same.

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 U.S. Government Publications

Available from Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, http://assist.daps.dla.mil/quicksearch/.

MIL-HDBK-454 Department of Defense Handbook, General Guidelines for Electronic Equipment.

MIL-HDBK-1547 Department of Defense Handbook, Electronic Parts, Materials, and Processes for Space Vehicles

MIL-STD-889 Military Standards - Dissimilar Metals

MIL-PRF-27 Military Specifications for Transformers and inductors (Audio, Power and High Power Pulse), General Specification for

NAVSO P-3641 More Power for the Dollar

2.2 FAR Publications from FAA

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

Part 25 of the Federal Aviation Regulations (14CFR 25)

FAA AC 25-10, Guidance for Installation of Miscellaneous, Non-Required Electrical Equipment

FAA AC 25.1309-1A, System, Design and Analysis

2.3 Industry Documents

SAE ARP4761, Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment

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

American Society for Testing Materials (ASTM) ASTM D495-48T, Standard Test Method for High-Voltage, Low-Current Dry Arc Resistance of Electrical Insulation

NEMA_MW-1000, Magnetic Wire Standards

3. GENERAL DESIGN REQUIREMENTS

Equipment supplied under the requirements of this document shall be designed to the following standards and permit operation under the environments and to the performance levels specified. Requirements include applicable Part 25 Federal Aviation Regulations (FARs). Also as a guide Aircraft Circulars AC 25-10 and AC 25.1309-1A can be used.

The design/construction of all equipment shall incorporate features which allow the equipment to be operated safely. Testing shall be conducted to verify the design standards.

3.1 Materials and Finishes

Materials and finishes used in the construction of the ballast/fixture shall be capable of withstanding the airplane environments as specified by RTCA/DO-160 such as Temperature and Altitude, Temperature Variation, Humidity, Operational Shocks and Crash Safety, Vibration, Fungus Resistance, Sand and Dust, Power Input, Voltage Spike, Audio Frequency Conducted Susceptibility – Power Inputs, Induced Signal Susceptibility, Radio Frequency Susceptibility, (Radiated and Conducted), Emission of Radio Frequency Energy, Lightning Induced Transient Susceptibility, and Electrostatic Discharge.

a. Metals: All metals shall be of the corrosion resistant type unless suitably protected to resist corrosion during normal service life. Guidance regarding metals in contact with each other shall be selected and protected as defined in MIL-STD-889.

b. Nonmetallic Materials: Materials which are nutrients for fungi shall not be used.

c. Flammable Materials: All nonmetallic/metallic composite materials shall meet FAR 25.853.

d. Electrical wire shall meet FAR 25.869(a)(4).

3.2 Lampholders

a. The arc resistance time of lampholder insulating materials shall exceed 125 s, when tested per arc resistance test, ASTM designation D495-48T, high-voltage, low current arc resistance of solid electrical insulating materials.

b. The lampholders shall be capable of retaining the fluorescent lamp and permit satisfactory lamp operation throughout the specified airplane environment.

c. Gold plated contacts are recommended.

d. Moisture resistant lampholders shall be specified or the fixture design shall provide protection for the lampholder from condensation and moisture accumulation. In service history has shown that either moisture or condensation dripping onto lampholders may result in an arcing condition during flight which impacts crew workload, operation and even results in an air turn back.

e. Lampholders should mechanically lock or have a means to secure the lamp/lamps contacts into position. Mis-installation of the fluorescent lamp may result in an arcing condition that may damage the light assembly.

f. Electrical contact resistance between the lamp contacts and lampholder contacts (pin or sockets) should be minimized through maximizing surface area and providing appropriate pressure. Lampholders that only depend on spring pressure tend to arc under intermittent contact during vibration. Contacts should engage at least three quarters of the diameter of the lamp contact.

g. The ballast shall not sustain damage if lamps are removed or installed with power applied.

h. Some known lampholder failure modes include:

1. Lamp Mis-Installation
   If the lamps are not fully seated and retained in the lamp holder, an intermittent connection can develop. The resulting electrical arc and associated heating can severely damage the lampholder.

2. Use of Broken Lampholders
   As with a mis-installed lamp, unsecured lamp contacts can result in electrical arcing and lampholder damage.

3. Ground Fault
   The fault occurs on lampholders where the (conductive) lampholder fastener is attached to the airframe and is relatively close to the lampholder contact. Over time, a conductive path develops between the contact and fastener across the lampholder body. Once initiated, the conductive path increases until the short circuit occurs.

4. End of Life lamps
   As a fluorescent lamp ages, the cathode filaments deteriorate, ultimately failing as an open circuit. The lamp will continue to operate with the failed filament; however, the remaining elements will reach high temperatures. The heat is transferred to the lamp base which in turn damages the light assembly. A periodic check should be recommended by the manufacturer to detect discoloration and prevent light assembly damage. It is highly recommended that ballast with the ability to detect fluorescent lamp failure be used in all aircraft interior light assemblies. This will alleviate all failures associated with the End of Life and mis-installation of flourescent.

5. Overheating Conditions
   Discoloring marks and lampholder melting as a result of a lamp reaching its end of life while the ballast attempts to illuminate the lamp may occur.

   Light assembly damage may occur as a result of using a non compatible ballast.

3.3 Ballast/Fixture

When operating in an ambient of 77 °F (25 °C), the exposed surface shall not exceed 160 °F (71 °C) under any conditions of normal, abnormal, overload operations or failure.

All materials used shall be self-extinguishing per FAR Part 25.853. The ballast shall be designed in such a manner to be smoke and fume free when subjected to the conditions called out in RTCA DO-160 as specified in Paragraph 3.1.

Electrical wire shall meet FAR 25.869(a)(4).

The ballast should be designed to have the capability of containing smoke, flame, explosion and arcing when subjected to the conditions called out in RTCA DO-160 as specified in 3.1. For ballasts that allow some ventilation, the ballast shall:

a. be metallic to provide a barrier for flames to not propagate.

b. have protection features that will not allow hazardous quantities of toxics or smoke to be emitted (see 3.8 and 3.10).

c. have circuit boards contain fire retardants per FAR 25.853 so as not to propagate flame when circuitry has failed.

3.4 Schematic

A schematic shall be affixed to the equipment. The schematic shall clearly show the electrical connections such as input voltage, frequency, dimmer control and lamp load (type or power), and ground plane spacing dimension.

3.5 Ground Plane

If the ballast or integrated light fixture and ballast design approach requires a minimum ground plane spacing, either the airplane lamp installation or the integrated light fixture shall provide a proper ground plane spacing.

3.6 Connector/Contacts

Connectors with gold plated or Berryllium-Copper (BeCu) contacts are recommended for electrical connection. If it is probable that incorrect connection between various light assemblies or ballast could cause a catastrophic failure, keyed connectors, mounting hole or foot print variation or other mechanical means shall be used to prevent incorrect connection.

Plastic shell connectors are preferable to metal shell connectors or terminal boards (open terminals).

Ballasts using open terminals are not preferred due to lack of protection and susceptibility in collecting dust. If open terminals are to be used, the terminals should be covered or sealed.

Moisture resistance level shall be consistent with lampholder, light fixture and ballast design.

Arcing of contacts should not occur because of vibration.

3.7 Thermal Protection

The equipment shall be protected against overheating by thermal protective devices. The rated temperature of these thermal protective devices must be lower than that of the rated temperature of the material. It is recommended that verification tests be conducted to ensure the effectiveness of these thermal protective devices and their locations.

3.8 Electrical Grounding and Bonding

The equipment shall provide a grounding system capability that is compatible with the grounding within the aircraft and all other equipment to be used with or which interfaces with the equipment.

3.9 Electrical Protection

The input power circuit of the electrical equipment shall contain a fuse or circuit breaker with current rating of at least 50% over the maximum current under worst case voltage and environment conditions. The fuse part number shall be marked adjacent to the fuse on external replaceable fuses. External replaceable fuses are optional. Where possible, output short circuit protection is desirable to prevent smoke or fire.

It is recommended that ballast designs contain circuitry that provides overvoltage protection and detects electrical arcing, ground faults, open filaments, and lamp open circuits to prevent overheating and improve safety.

3.10 Standard Parts

Guidance on the selection of electrical/electronic components can be found in MIL-HDBK-454. Particular consideration shall be given to the environmental limits, electrical characteristics, power ratings, and material used. All parts shall be suitably derated to ensure safety. Recommended derating guidelines can be found in NAVSO P-3641 or in MIL-HDBK-1547.

Note that high voltage capacitors and transformers in the ballast, when they fail short, can cause catastrophic failure to the ballast. Circuit designs should therefore have provisions to mitigate such potential failures. Additionally, temperature and voltage ratings must be extremely conservative.

For capacitors, the temperature rating shall be greater than the ambient temperature adjacent to the capacitor when the ballast is operated at a temperature of 71 °C ambient. Oil filled or oil-bath type capacitors should not be used in aircraft ballast designs.

For inductors and transformers, the devices should meet the requirements of MIL-PRF-27, class V, where possible. Magnet wire used in these devices should conform to the requirements of NEMA MW-1000, class MW-35C (heavy) [supersedes J-W-1177/14 and MIL-W-583 Class 200 Type K2].

3.11 Starting

Use of long lamps results in high starting voltage from ballast. The ballast should be located close to the lamps to minimize the high voltage exposure.

Instant start of cold cathode starting systems should be avoided. Rapid Start and Pre-Heat lamps shall be used whenever possible.

3.12 Flickering

Lamps that flicker or are erratic that are powered by magnetic ballasts should require prompt maintenance.

Flickering light may be the result of:

a. Loose wire in the light assembly installation.

b. Mis-installation of the fluorescent lamp in conjunction with the airplane vibration.

c. Flourescent lamps reaching the end of life.

d. Mismatch of ballast output driving a particular lamp.

A periodic check should be recommended by the manufacturer to inspect for discoloration on the lamp or lamp holders and provide specific detailed corrective action instructions for these conditions.

3.13 Thermal Environment

A good ballast design must consider the thermal environment.

Heat dissipation presents more of a problem in electronic ballasts. Proper thermal management is necessary. Where feasible, maximum heatsinking is required. Mounting on metal surfaces preferred, bonding practices necessary.

3.14 EMI : Electromagnetic Radiation

Any electric arc is a source of EMI. For the operation of any fluorescent lamp, there is an arc at either end of the lamp. These arcs are capable of causing serious interference with radio communication and navigation systems in the airplane.

Extreme care must be taken in design of lamp fixtures, ballasts and interconnecting wiring so that conducted or radiated EMI effects to the airplane electrical system from the lighting systems are minimized.

4. TEST REQUIREMENTS

4.1 Operational Tests

The system shall perform within operational requirements during and after exposure to the following.

4.1.1 Thermal

The equipment shall be subjected to thermal testing as defined in RTCA/DO-160, Sections 4, Category A2 and 5, Category C or as defined by the customer specification.

4.1.2 Altitude

The equipment shall be subjected to altitude testing in accordance with RTCA/DO-160, Section 4.0, Category A2 or as defined by the customer specification.

4.1.3 Vibration

The equipment shall be subjected to vibration testing in accordance with RTCA/DO-160, Paragraph 8.0, Category S or S2, Sine or Random. During the test, any signs of arcing, flame, smoke emission, intermittent contact (lamp flickering) shall constitute failure of the article. After testing inspect the lamp and lampholder contacts for signs of arcing or lampholder contact displacement. Any signs of arcing, lamp or lampholder contact displacement shall constitute failure of the fixture.

4.1.4 Operational Shock

The equipment shall be subjected to operational shock testing in accordance with RTCA/DO-160, Paragraph 7.2, Category A, 6.0 g's. After testing inspect the lamp and lampholder contacts for signs of arcing and lampholder contact displacement. Any signs of arcing , flame, smoke emission, intermittent contact (lamp flickering) shall constitute failure of the article.

4.1.5 Waterproofness Tests

The equipment shall be subjected to the Waterproofness test specified in RTCA/DO-160, Section 10, Category W under the following conditions:

a. The equipment shall be tested in the normal aircraft installation orientation with droplets falling from above.

b. A standing water requirement of 0.2 inches will be imposed.

c. The test solution shall be a 5% NAACO solution.

d. The equipment shall be operated during the test.

e. Fuse opening or temporary shutdown shall not constitute failure or rejection of the article.

f. Failure of the article shall consist of permanent malfunction (not including fuse opening), flame or smoke emission, arcing, or other signs of catastrophic failure.

4.2 Non-operational Tests

4.2.1 Acceleration and Crash Safety

The equipment shall be subjected to crash safety testing in accordance with RTCA/DO-160, Paragraph 7.3 - except the force shall be 9.0 g's in each axis.

4.2.2 Humidity

The equipment shall operate normally after exposure to relative humidity up to 100% with temperature and altitude cycling between 20 to 130 °F (-6.7 to 54.5 °C) and -1000 to 20,000 ft mean sea level (MSL), including conditions where condensation occurs on the equipment's described in RTCA/DO-160, Paragraph 6.3.2 for Category B equipment - Severe Humidity Environment.

4.2.3 Insulation Resistance Test

The insulation resistance between electrically isolated circuit elements and between those elements and the housing shall be measured at 500 V DC minimum (with lamps removed). The minimum insulation resistance shall be 100 MegΩ. This test shall be performed prior to and following the dielectric withstanding voltage test.

4.2.4 Dielectric Withstanding Test

Apply a test voltage of 1500 V rms at 60 Hz for 1 minute between mutually insulated conductive paths. The test voltage shall be applied and removed at a uniform rate of 250 to 500 V/s. Any arcing as evidenced by flashover, sparkover, (or) breakdown, or leakage current exceeding 2 mA shall constitute failure. Capacitors, diodes, and other electronic devices susceptible to damage may be disconnected from the equipment or short circuited for these tests.

4.3 Power Quality

Article shall be tested to verify the compliance with its performance requirements when supplied with power, having normal and abnormal operating characteristic as specified in Section 16 of RTCA/DO-160, Category E. or as specified by customer specification. When electrical power with an abnormal steady state and transient characteristic is applied, the article shall meet the following requirements:

a. Sustain no damage and remain safe.

b. Reliability and life shall not be affected.

c. Automatically recover full performance capability when power with normal characteristics is reestablished.

d. The article shall not cause interference to other aircraft equipment of systems that meet the same requirement as stated.