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AEROSPACE STANDARD

SAE AS4914

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Submitted for recognition as an American National Standard

AIRCRAFT FLUORESCENT LIGHTING BALLAST/FIXTURE SAFETY DESIGN STANDARD

1. SCOPE:

This document does not dictate a specific design approach or technology, but rather it provides design consideration to assist the specification writer in establishing a fail/safe design.

2. APPLICABLE DOCUMENTS:

2.1 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-454
MIL-B-5087B
DO-160C

2.2 FAR Publications from FAA:

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591.

FAR 25.853

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. 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 environment.

a. Metals: All metals shall be of the corrosion resistant type unless suitably protected to resist corrosion during normal service life. Metals in contacts with each other shall be selected and protected as defined in MIL-STD-454, Requirement 16.

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.

3.2 Arc Resistance:

The arc resistance time of 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.

3.3 Lampholders:

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

b. Gold plated contacts are recommended.

c. Moisture resistant lampholders shall be specified or the fixture design shall provide protection for the lampholder from condensation and moisture accumulation.

3.4 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 under any condition.

3.5 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.

3.6 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.

3.7 Connector:

Connectors with gold plated 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.

3.8 Thermal Protection:

The equipment shall be protected against overheating by a thermal protective device. The rated temperature of this thermal protective device must be lower than that of the rated temperature of the material. It is recommended that a test be done to ensure the effectiveness of the thermal protective device and its location.

3.9 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. Electrical grounding and bonding per MIL-B-5087B if applicable to the installation.

3.10 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.

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 DO-160C, Sections 4 and 5. The category shall be defined by the customer specification.

4.1.2 Altitude: The equipment shall be subjected to altitude testing in accordance with DO-160C, Section 4.0. The category shall be defined by the customer specification.

4.1.3 Vibration: The equipment shall be subjected to vibration testing in accordance with DO-160C, Paragraph 8.0, Sine or Random.

4.1.4 Operational Shock: The equipment shall be subjected to operational shock testing in accordance with DO-160C, Paragraph 7.2, 6.0 g's.

4.1.5 Waterproofness Tests: The equipment shall be subjected to the waterproofness test specified in DO-160C, 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. The test solution shall be a 5% NaCl solution.

c. The equipment shall be operated during the test.

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

e. Failure of the article shall consist of flame or smoke emission, arcing, or other signs of catastrophic failure.

4.2 Nonoperational Tests:

4.2.1 Acceleration and Crash Safety: The equipment shall be subjected to crash safety testing in accordance with DO-160C, 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 percent 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 equipments described in DO-160C, 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 VDC minimum (with lamps removed). The minimum insulation resistance shall be 100 MΩ. This test shall be performed prior to and following the dielectric withstanding voltage test.

4.4 Dielectric Withstanding Test:

Apply a test voltage of 1500V rms at 60 Hz for 1 min 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.

4.5 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-160C. The applicable category shall be specified by customer specification. When electrical power with an abnormal steady state and transient characteristic is applied, the article shall meet the following requirements:

Sustain no damage and remain safe.

Reliability and life shall not be affected.

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

4.6 Electromagnetic Interference (EMI):

The location of the equipment in the aircraft and wiring have a major impact on the significance of the EMI. The system level EMI requirements should be considered when writing the equipment EMI specification. It is recommended that the ballast, fixture and lamp be tested to show that they meet the requirements of DO-160C Sections 17 through 21.

4.7 Flammability Test:

All nonmetallic/metallic composite materials shall meet the requirements of FAR Part 25.853.

4.8 Fail/Safe Verification Test:

Catastrophic failure is defined as a failure or malfunction that emits smoke, noxious gas, or causes a flame, arc, fire, explosion, damage to adjacent aircraft structure, components, equipment or system, or interfere with the essential or critical aircraft equipment or system(s).

The ballast and fixture shall be designed so that when a failure occurs due to any normal or abnormal conditions and/or operation, this failure shall not be catastrophic. At least the following fail/safe conditions shall be verified when the unit is powered:

a. Lamp fail conditions such as: Indefinite short filament(s), open filament(s), broken lamp(s), rectifying lamp(s), lamp removal and relamp (Dependent upon the design approach, a reasonable time shall be specified to simulate indefinite short or open filament(s) or indefinite...).

b. Indefinite shorted output: Filaments shorted together and/or shorted to ground (Dependent upon the design approach, a reasonable time shall be specified to simulate indefinite shorted output).

4.8 (Continued):

c. No load (no lamp(s): Open circuit voltage with normal, abnormal and transient input power.

d. High temperature: The ballast and fixture shall be operated in a 185 °F [85 °C] ambient for 24 h or until the unit fails. If no failure occurs within 24 h, slowly increase the temperature at a rate of 7 deg/h until failure. Note that the effectiveness of the thermal protective device shall be verified by this test.

e. High voltage: The unit shall be operated at normal input power for 1 h. The input voltage shall be increased at a rate of no more than 5 V/h until the unit fails.

f. High voltage transient in high ambient: The unit shall operate in 185 °F [85 °C] ambient for 3 h then apply 600 V power line spike at a rate of 60 per minute repeat for negative 600 power volt spike. If no failure occurs, slowly increase the voltage spike level at 50 V increments and repeat until the unit fails.

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APPENDIX A
LESSONS LEARNED

A.1 "Lessons Learned" have been provided by the people listed considered by many to be experts in the design and manufacture of ballasts/fluorescent lighting systems for the commercial aircraft industry.

a. Avtech, Seattle Washington

Mr. Dennis Lund and Mr. Mark Rector

b. Bruce Industries

Mr. David Greenblat

c. Douglas Aircraft Company

Mr. Herm Klein

d. Grimes Aerospace Co.

Mr. Ron Bezdon
Mr. Paul Greenlee
Mr. Chuck Roudeski

Item #1. Thermal limiters in magnetic ballasts can be too slow. The smaller size of magnetic components in an electronic unit makes the action faster but not always fast enough.

Originator	Agree	Partially Agree	Disagree	Comments
Avtech D. Lund/M. Rector	X			No comments.
Bruce Industries G. Baxter		X		If thermal limiter is properly located (touching the ballast coils) with thermal conducting grease response time is adequate.
DAC H. Klein			X	Thermal devices shall be used to prevent smoke and/or any conditions of internal or external shorts or overload and not cause nuisance tripping.
Grimes R. Bezdon	X			No comments.
C. Roudeski/P. Greenlee	X			1. Limiting impedance in series with the primary would keep fault dissipation low. 2. Keep flammable material away from magnetics.

FIGURE A1

Item #2. Pins, on terminal block or open terminal ballasts, can short to the case through a carbon path developed over years of service. This is most prevalent on high voltage (200V and above) ballasts. The use of an integral connector is the best cure.

Originator	Agree	Partially Agree	Disagree	Comments
Avtech D. Lund/M. Rector	X			No comments.
Bruce Industries G. Baxter	X			No comments.
DAC H. Klein	X			No comments.
Grimes R. Bezdon		X		Depends on type of connector used. Alternate connector types may be selected which offer resistance to "tracking" which is usually due to moisture ingression.
C. Roudeski/P. Greenlee	X			Flame retardant additives actually encourage tracking problem. Suggest covering terminals or use of sealant to eliminate dust formation. "Siloed" connectors best. Large spacings between pins.

FIGURE A2

Item #3. The ballast should contain active output and input short circuit protection to prevent misfires.

Originator	Agree	Partially Agree	Disagree	Comments
Avtech D. Lund/M. Rector	X			1. Active output short circuit protection --- AGREE. 2. Input short circuit protection --- should be a fuse only.
Bruce Industries G. Baxter	X			This drives us toward electronic ballasts and complexity.
DAC H. Klein		X		Could also be a combination of electrical fuse and thermal protection.
Grimes R. Bezdon		X		Not "misfires" just fires".
C. Roudeski/P. Greenlee	X			Fuse on input is a passive preventative measure. "Active" not necessarily reliable enough but good for output protection.

FIGURE A3

Item #4. Potting material tends to emit flame and smoke in quantities proportional to its use. Higher frequency and lower voltage magnetics have less acoustic noise and electrical stress. Thus they need little or no potting material.

Originator	Agree	Partially Agree	Disagree	Comments
Avtech D. Lund/M. Rector	[ ]	[X]	[ ]	Potting material may or may not be necessary; should be allowed as long as fail safe provisions are met.
Bruce Industries G. Baxter	[X]	[ ]	[ ]	No comments.
DAC H. Klein	[ ]	[X]	[ ]	Potting material is available which will not support combustion and is self-extinguishing - 400 hertz transformers for DAC magnetic ballasts meet required acoustic requirements.
Grimes R. Bezdon	[X]	[ ]	[ ]	No comments.
C. Roudeski/P. Greenlee	[X]	[ ]	[ ]	"No potting" does not preclude the necessity of varnish to protect windings.

FIGURE A4

Item #5. Avoid instant start of cold cathode lighting systems because of the high ballast output voltage necessary to strike the arc. The electrical stress is transferred to wiring terminations and lamp sockets.

Originator	Agree	Partially Agree	Disagree	Comments
Avtech D. Lund/M. Rector	X			No comments.
Bruce Industries G. Baxter	X			No comments.
DAC H. Klein	X			No comments.
Grimes R. Bezdon	X			Even warm start lamps have high strike voltages.
C. Roudeski/P. Greenlee	X			"No potting" does not preclude the necessity of varnish to protect windings.

FIGURE A5

Item #6. Capacitive ballasts should be avoided because of the high electrical stress on the capacitor which is difficult to manage.

Originator	Agree	Partially Agree	Disagree	Comments
Avtech D. Lund/M. Rector	X			No comments.
Bruce Industries G. Baxter	X			No comments.
DAC H. Klein		X		No comments.
Grimes R. Bezdon				Also magnetics can have a much higher operating temperature compared to a capacitive ballast.
C. Roudeski/P. Greenlee			X	Proper design is all that is required.

FIGURE A6

Item #7. Prompt maintenance of erratic or flickering lamps in magnetic ballast systems will reduce the duration of the ballast stress.

Originator	Agree	Partially Agree	Disagree	Comments
Avtech D. Lund/M. Rector		X		Sophisticated ballasts may survive this indefinitely.
Bruce Industries G. Baxter	X			No comments.
DAC H. Klein		X		DAC requires ballast and lamp not be damaged or degraded by distortion of input waveform or loss of lamp filament power which may cause a distortion of waveform resulting in a DC component of lamp current.
Grimes R. Bezdon	X			As well as electrical stress.
C. Roudeski/P. Greenlee	X			If tube end is burned out, lamp rectifies current putting "DC" load on ballast, causing magnetic core to heat up.

FIGURE A7

Item #8. LUMINAIRES (FIXTURES)

Lampholders - Lampholder must mechanically lock the lamp pins positively. 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 pins. Contacts should be gold plated to provide corrosion resistance. The lampholders should be protected from condensation moisture accumulation. Hot relamping should be prohibited.

Originator	Agree	Partially Agree	Disagree	Comments
Avtech D. Lund/M. Rector	☐	☐	☐	Generally agree. Gold contacts may not be necessary; lampholder must meet vibration requirements. Locking is generally a good idea.
Bruce Industries G. Baxter	☒	☐	☐	No comments.
DAC H. Klein	☒	☐	☐	No comments.
Grimes R. Bezdon	☐	☐	☐	Extensive moisture could be a cost and weight driver. Other than the obvious risk of a service person being able to intentionally touch lamp contacts with power on, there is no reason to prohibit hot relamping.
C. Roudeski/P. Greenlee	☒	☐	☐	Gold will burn through if hot relamping is tried. Suggest beryllium copper series materials for superior spring life under high temperature. Gold and tin are not compatible. What are lamp pins plated with?

FIGURE A8

Item #9. Condensation/moisture dripping onto/into lampholders causes arcing. Moisture proof/resistant lampholder or special lampholder protection features should be incorporated into the luminaire design.

Originator	Agree	Partially Agree	Disagree	Comments
Avtech D. Lund/M. Rector	X			Moisture proofness level must be established.
Bruce Industries G. Baxter	X			No comments.
DAC H. Klein	X			No comments.
Grimes R. Bezdon	X			No comments.
C. Roudeski/P. Greenlee	X			No comments.

FIGURE A9

Item #10. Good ballast design will provide the maximum heat sinking, consistent with weight considerations, however, this is negated if mounted in tight unventilated places. Maximum air flow is a must.

Originator	Agree	Partially Agree	Disagree	Comments
Avtech D. Lund/M. Rector				Mounting areas may not have any air flow; they must work in unventilated spaces.
Bruce Industries G. Baxter	X			No comments.
DAC H. Klein		X		Attention should be given to the design for adequate cooling without resorting to forced air convection.
Grimes R. Bezdon		X		This is purely a design trade issue. Good air flow will bring down size and weight and improve reliability.
Roudeski/P. Greenlee	X			Limit rise to 30°C above ambient (hot spot) - Heat sinking does work. An IR is a desirable thing however.

FIGURE A10

Item #11. Capacitors, especially high voltage power factor capacitors must be of the metal enclosed, glass seal type.

Originator	Agree	Partially Agree	Disagree	Comments
Avtech D. Lund/M. Rector	X			Mandating type of capacitor is specifying design and potentially ruling out new technologies. Document must specify "safe" failure mode but not design approach.
Bruce Industries G. Baxter	X			No comments.
DAC H. Klein	X			No comments.
Grimes R. Bezdon		X		This depends on the ballast type used. Most electronic ballasts do not need this type of connector.
C. Roudeski/P. Greenlee	X			Why metal enclosed? Why glass seal?

FIGURE A11

Item #12. Input current fuse should be mandatory.

Originator	Agree	Partially Agree	Disagree	Comments
Avtech D. Lund/M. Rector	X			Input fuse is good idea; internal fuse should be allowed (and perhaps preferred).
Bruce Industries G. Baxter	X			No comments.
DAC H. Klein	X			No comments.
Grimes R. Bezdon	X			No comments.
C. Roudeski/P. Greenlee	X			No comments.

FIGURE A12

Item #13. A thermal protector adjacent to the ballast coil windings should be mandatory, either re-setting or single action.

Originator	Agree	Partially Agree	Disagree	Comments
Avtech D. Lund/M. Rector	☐	☐	☐	Thermal connectors may be too slow; more sophisticated electrical protection may be desired.
Bruce Industries G. Baxter	X	☐	☐	There may not be a ballast coil in an electronic ballast. Electronic ballasts have better protection capabilities.
DAC H. Klein	X	☐	☐	No comments.
Grimes R. Bezdon	X	☐	☐	No comments.
C. Roudeski/P. Greenlee	X	☐	☐	Self-resetting not a good idea! Single action - Yes!

FIGURE A13

Item #14. Plastic shell connectors are preferable to metal shell connectors or open terminal boards.

Originator	Agree	Partially Agree	Disagree	Comments
Avtech D. Lund/M. Rector	☐	☐	☐	Plastic shell connectors are preferable for cost and weight but not necessarily safety.
Bruce Industries G. Baxter	☒	☐	☐	No comments.
DAC H. Klein	☐	☐	☐	No comments.
Grimes R. Bezdon	☒	☐	☐	No comments.
C. Roudeski/P. Greenlee	☒	☐	☐	No comments.

FIGURE A14

BALLASTS - ELECTRONIC

The safety points regarding megnetic ballasts above mentioned likewise apply to electronic ballasts.

Item #15. Heat dissipation presents a more serious problem in electronic ballasts. Mounting on metal structure preferred, bonding practices mandatory. Thermal management to be given high priority. Proper bonding also enhances EMI filter "y" cap safety.

Originator	Agree	Partially Agree	Disagree	Comments
Avtech D. Lund/M. Rector	☐	☐	☐	Ballasts may not have metal surfaces available for mounting and must be able to operate without external heat sinking.
Bruce Industries G. Baxter	☒	☐	☐	No comments.
DAC H. Klein	☒	☐	☐	No comments.
Grimes R. Bezdon	☒	☐	☐	But it may not be more serious as most electronic ballast. May offer efficiency improvements.
C. Roudeski/P. Greenlee	☒	☐	☐	No comments.

FIGURE A15

Item #16. EMI audio susceptibility requirements should be more pragmatic.

Originator	Agree	Partially Agree	Disagree	Comments
Avtech D. Lund/M. Rector	[ ]	[ ]	[ ]	Yes to more pragmatic EMI requirements; in particular AFCS, RS (electric field) and lightning.
Bruce Industries G. Baxter	[X]	[ ]	[ ]	No comments.
DAC H. Klein	[ ]	[X]	[ ]	No comments.
Grimes R. Bezdon	[X]	[ ]	[ ]	No comments.
C. Roudeski/P. Greenlee	[X]	[ ]	[ ]	No comments.

FIGURE A16

Item #17. Power derating of components and materials are of serious consideration and standards should be established.

Originator	Agree	Partially Agree	Disagree	Comments
Avtech D. Lund/M. Rector	X			Derating should be encouraged/ required.
Bruce Industries G. Baxter	X			No comments.
DAC H. Klein	X			No comments.
Grimes R. Bezdon			X	No comments.
C. Roudeski/P. Greenlee	X			No comments.

FIGURE A17