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AEROSPACE STANDARD

SAE AS4914

REV. A

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Superseding AS4914

# Aircraft Fluorescent Lighting Ballast/Fixture Safety 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:

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

MIL-HDBK-454
MIL-HDBK-1547
MIL-STD-464
MIL-STD-889
DO-160

### 2.2 FAR Publications from FM:

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

FAR 25.853



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## 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. 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.

### 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.

The ballast shall be designed to have the capability of containing smoke, flame, explosion and arcing 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.

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

3.8 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.

3.9 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.

3.11 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 NAVMAT P-4855-1, “Navy Power Supply Reliability Guidelines,” or in MIL-HDBK-1547, “Technical Requirements for Parts, Materials, and Processes for Space and Launch Vehicles.”

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 shall meet the requirements of MIL-T-921, class S, or MIL-T-27, class V. Magnet wire used in these devices shall 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].

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. 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 DO-160C, Paragraph 7.2, 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 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. A standing water requirement of 0.2 in 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, 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 DO-1GOC, 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 OO-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 V DC minimum (with lamps removed). The minimum insulation resistance shall be 100 kΩ. This test shall be performed prior to and following the dielectric withstanding voltage test.

4.4 Dielectric Withstanding Test:

Apply a test voltage of 1500 V rms at 60 Hz for 1 mm 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:

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.

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.

When tested to the methods of DO-160C the following shall apply;

The ballast, lamp and fixture shall not be harmed when subjected to the following susceptibility requirements:

Sections 17, 18 and 19, Category A
Section 20, Category U

The ballast, lamp and fixture shall not exhibit degraded performance when subjected to Section 20, Category T conditions.

The ballast, lamp and fixture shall be designed to meet the Radiated Emissions requirements of Section 21, Category B. Compliance to Category Z is a recommended practice.

NOTE: When the installation requires a discrete ballast an light fixture assembly, the Radiated Emissions and susceptibility test be set up with a distance of 1 m between the ballast and light assembly.

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).

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°/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. Indefinite shorted input control lines (ON/)OFF or DIM control lines) shorted to a high power or an AC return line(s) (dependent upon the design approach, a reasonable time shall be specified to simulate indefinite short input).

g. 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.

h. All electronic components shall be subjected to a Failure Mode and Effects and Criticality Analysis (FMECA) per MIL-STD-1629A, Notice 2 along with a verification test conducted on the hardware.

4.9 Acoustical Noise Test:

The variation of the airplane ballast installation has a significant impact on ballast acoustical noise output. The acoustical noise can affect the flightcrew performance and be an annoyance to passengers. For the ballasts installed in the passenger cabin, it is recommended that:

The Sound Power Level (SPL db REF: $10^{-12}$) data be obtained after thermal stabilization of the ballast and the ballast is firmly mounted to a .375 thick Graphite or .375 Nomex panel, which is cut in a rectangle 48 in x 12 in.

The mounting plate be supported only at its corners.

The noise chamber must be noise proof and the wall must be constructed of acoustical noise absorbent material, microphone locations must be one meter radius and at 30° increments in all directions from the ballast. The SPL shall not exceed the tabulated values when the ballast is connected to its normal lamp load and operated until reaching thermal stabilization. The following are the recommended values:

TABLE 1

| Octave Band Center Frequency in Hertz | Sound Power Level db REF: $10^{-12}$ W |
|---|---|
| 250 | 35 |
| 500 | 35 |
| 1000 | 35 |
| 2000 | 35 |
| 4000 | 35 |
| 8000 | 35 |
| 16,000 | 35 |

| Originator | Agree | Partially Agree | Disagree | Comments |
|---|---|---|---|---|
| Avtech<br>D. Lund/ M. Rector | X | | | No. comments |
| Bruce Industries<br>G. Baxter | | X | | If thermal limiter is properly located (touching the ballast coils) with thermal conducting grease response time is adequate. |
| DAC<br>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<br>R. Besdon | X | | | No Comments |
| Grimes<br>C. Roudeski &<br>P. Greenlee | X | | | Limiting impedance in series with the primary would keep fault dissipation low.<br>Keep flammable material away from magnetics. |

FIGURE 1 - 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<br>D. Lund/ M. Rector | X | | | No. comments |
| Bruce Industries<br>G. Baxter | X | | | No. comments |
| DAC<br>H. Klein | X | | | No. comments |
| Grimes<br>R. Besdon | | 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. |
| Grimes<br>C. Roudeski &<br>P. Greenlee | X | | | Flame retardant additives actually encourage tracking problems. Suggest covering terminals or use of sealant to eliminate dust formation. "Siloed" connectors are best. Large spacing between pins. |

FIGURE 2 - 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 (200 V and above) ballasts. The use of an integral connector is the best cure.

| Originator | Agree | Partially Agree | Disagree | Comments |
|---|---|---|---|---|
| Avtech<br>D. Lund/ M. Rector | X | | | Active output short circuit protection--------Agree<br>Input short circuit protection-----should be fuse only. |
| Bruce Industries<br>G. Baxter | X | | | This drives us toward electronic ballasts and complexity. |
| DAC<br>H. Klein | | X | | Could be a combination of electrical fuses and thermal protection. |
| Grimes<br>R. Besdon | | X | | Not “misfires” just “fires”. |
| Grimes<br>C. Roudeski &<br>P. Greenlee | X | | | Fuse on input is a passive preventative measure. “Active “ not necessarily reliable enough but good for output protection. |
| Grimes<br>G. Mortimer | | | | Why is <u>active</u> short circuit protection required? This would effectively eliminate all magnetic ballasts from use. Passive short circuit protection such as peak current limiting should be adequate without the use of active foldback or cutout circuits |

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

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

FIGURE 4 - 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<br>D. Lund/ M. Rector | X | | | No comments. |
| Bruce Industries<br>G. Baxter | X | | | No comments |
| DAC<br>H. Klein | X | | | No comments |
| Grimes<br>R. Besdon | X | | | Even warm start lamps have high strike voltages. |
| Grimes<br>C. Roudeski &<br>P. Greenlee | X | | | No comments |
| Grimes<br>G. Mortimer | | X | | Cold-cathode Lamps -- agree.<br>Instant-start operation of conventional hot-cathode lamps have been proven for years in commercial and residential lighting applications. |

FIGURE 5 - 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.

| Comments | Agree | Partially Agree | Disagree | Comments |
|---|---|---|---|---|
| Avtech<br>D. Lund/ M. Rector | X | | | No comment. |
| Bruce Industries<br>G. Baxter | X | | | No comment. |
| DAC<br>H. Klein | | X | | No comment. |
| Grimes<br>R. Besdon | X | | | Also magnetics can have a much higher operating temperature compared to a capacitive. |
| Grimes<br>C. Roudeski &<br>P. Greenlee | | | X | Proper design is all that is required. |
| Grimes<br>G. Mortimer | | | X | Capacitive ballasting is the preferred method of high-frequency ballasting due to the small size and off-the-shelf availability of film capacitors in the ranges required. |

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

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

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

| Comments | Agree | Partially Agree | Disagree | Comments |
|---|---|---|---|---|
| Avtech<br>D. Lund/ M. Rector | | | | Generally agree. Gold contacts may not be necessary; lampholder must meet the vibration requirements. Locking is generally a good idea. |
| Bruce Industries<br>G. Baxter | X | | | No comments. |
| DAC<br>H. Klein | X | | | No comments. |
| Grimes<br>R. Besdon | | | | 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 poor on, there is no reason to prohibit hot relamping. |
| Grimes<br>C. Roudeski &<br>P. Greenlee | X | | | 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 <u>not</u> compatible. What are lamp pins plated with? |
| Grimes<br>G. Mortimer | | X | | Circuits have been designed which are capable of hot relamping without damage to the lamps, lampholders, or ballasting circuits.<br>BeCu is preferable to gold-plated contacts for arcing, corrosion resistance, and resistance to electrolysis between the contact and the lamp pin.<br>Use of lamp pins only to provide positive mechanical engagement and support for the lamp is impractical when using longer lamps. |

FIGURE 8 - Item #8 - Luminaries (Fixtures)

Lampholders -- Lampholders 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.

| Comments | Agree | Partially Agree | Disagree | Comments |
|---|---|---|---|---|
| Avtech<br>D. Lund/ M. Rector | X | | | Moisture Proofness level must be established. |
| Bruce Industries<br>G. Baxter | X | | | No comments. |
| DAC<br>H. Klein | X | | | No comments. |
| Grimes<br>R. Besdon | X | | | No comments. |
| Grimes<br>C. Roudeski &<br>P. Greenlee | X | | | No comments. |
| Grimes<br>G. Mortimer | | | | Item #9, Moisture-resistant lampholders -- The use of sealed lampholders or moisture-resistant luminaries should be based on the luminaire orientation and location. It may be possible to install the fixture such that condensation would be drained away from the lampholders without the use of some exotic lampholder scheme. |

FIGURE 9 - 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.

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

FIGURE 10 - 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.

| Comments | Agree | Partially Agree | Disagree | Comments |
|---|---|---|---|---|
| Avtech<br>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 specify design approach. |
| Bruce Industries<br>G. Baxter | X | | | No comment. |
| DAC<br>H. Klein | X | | | No comment. |
| Grimes<br>R. Besdon | | X | | This depends on the ballast type used. Most electronic ballasts do not need this type of capacitor. |
| Grimes<br>C. Roudeski &<br>P. Greenlee | X | | | Why metal enclosed? Why glass seal? |
| Grimes<br>G. Mortimer | | X | | Relatively few designs use high-voltage liquid-filled capacitors. Where electrolytics are used, they are usually of the MIL-C-39018 (CU/CUR) type or similar commercial grade aluminum electrolytics. Requiring certain types of component exclusively is detrimental to advancing technology. |

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

| Comments | Agree | Partially Agree | Disagree | Comments |
|---|---|---|---|---|
| Avtech<br>D. Lund/ M. Rector | X | | | Input fuse is good idea; internal fuse should be allowed (and perhaps preferred). |
| Bruce Industries<br>G. Baxter | X | | | No comment. |
| DAC<br>H. Klein | X | | | No comment. |
| Grimes<br>R. Besdon | X | | | No comment. |
| Grimes<br>C. Roudeski &<br>P. Greenlee | X | | | No comment. |

FIGURE 12 - Item #12 - Input current fuse should mandatory.

| Comments | Agree | Partially Agree | Disagree | Comments |
|---|---|---|---|---|
| Avtech<br>D. Lund/ M. Rector | | | | Thermal connectors may be too slow; more sophisticated electrical protection may be desired. |
| Bruce Industries<br>G. Baxter | X | | | There may not be a ballast coil in an electronic ballast. Electronic ballasts have a better protection capabilities. |
| DAC<br>H. Klein | X | | | No comment. |
| Grimes<br>R. Besdon | X | | | No comment. |
| Grimes<br>C. Roudeski &<br>P. Greenlee | X | | | Self-resetting not good ides! Single action- Yes! |
| Grimes<br>G. Mortimer | | X | | Better methods of thermal protection are available especially for high-frequency ballasting. |

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

| Comments | Agree | Partially Agree | Disagree | Comments |
|---|---|---|---|---|
| Avtech<br>D. Lund/ M. Rector | | | | Plastic shell connectors are preferable for cost and weight but, not necessarily safety. |
| Bruce Industries<br>G. Baxter | X | | | No comment. |
| DAC<br>H. Klein | | | | No comment. |
| Grimes<br>R. Besdon | X | | | No comment. |
| Grimes<br>C. Roudeski &<br>P. Greenlee | X | | | No comment. |

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

| Comments | Agree | Partially Agree | Disagree | Comments |
|---|---|---|---|---|
| Avtech<br>D. Lund/ M. Rector | | | | Ballasts may non have metal surfaces available for mounting and must be able to operate without external heat sinking. |
| Bruce Industries<br>G. Baxter | X | | | No comment. |
| DAC<br>H. Klein | X | | | No comment. |
| Grimes<br>R. Besdon | X | | | But may not be more serious as most electronic ballast may offer efficiency improvements. |
| Grimes<br>C. Roudeski &<br>P. Greenlee | X | | | No comments. |

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

| Comments | Agree | Partially Agree | Disagree | Comments |
|---|---|---|---|---|
| Avtech<br>D. Lund/ M. Rector | | | | Yes to more pragmatic EMI requirements; in particular AFCS, RS (electric field) and lightning. |
| Bruce Industries<br>G. Baxter | X | | | No comment. |
| DAC<br>H. Klein | | X | | No comment. |
| Grimes<br>R. Besdon | X | | | No comment. |
| Grimes<br>C. Roudeski &<br>P. Greenlee | X | | | No comment. |

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

| Comments | Agree | Partially Agree | Disagree | Comments |
|---|---|---|---|---|
| Avtech<br>D. Lund/ M. Rector | X | | | Over -voltage protection may not be necessary to prevent overheating, depending on the nature of the design. |
| Bruce Industries<br>G. Baxter | X | | | No comment. |
| DAC<br>H. Klein | X | | | No comment. |
| Grimes<br>R. Besdon | | | | Voltage protection is more to provide safety than to prevent overheating particularly in electronic ballasts. |
| Grimes<br>C. Roudeski &<br>P. Greenlee | X | | | No comment. |
| Grimes<br>G. Mortimer | | | | The requirement for the ballast to operate under a sustained open-circuit condition is already covered in Paragraph 4.8c. |

FIGURE 17 - Item #18 - Over-voltage protection of the open-circuit voltage should be considered to prevent overheating and improve safety.

| Comments | Agree | Partially Agree | Disagree | Comments |
|---|---|---|---|---|
| Avtech<br>D. Lund/ M. Rector | | | | Ground plane for starting usually a good idea and is often recommended/required by lamp manufacturers. |
| Bruce Industries<br>G. Baxter | X | | | No comment. |
| DAC<br>H. Klein | X | | | No comment. |
| Grimes<br>R. Besdon | X | | | Area doesn't have to be large for starting purposes. |
| Grimes<br>C. Roudeski &<br>P. Greenlee | X | | | No comment. |

FIGURE 18 - Item #19 - Starting: Need ground plane near bulb wall to facilitate starting.

| Comments | Agree | Partially Agree | Disagree | Comments |
|---|---|---|---|---|
| Avtech<br>D. Lund/ M. Rector | | | | Arcing of pins and socket contacts should not occur because of vibration.. |
| Bruce Industries<br>G. Baxter | X | | | No comment. |
| DAC<br>H. Klein | X | | | No comment. |
| Grimes<br>R. Besdon | | | X | No comment. |
| Grimes<br>C. Roudeski &<br>P. Greenlee | X | | | No comment. |

FIGURE 19 - Item #20 - Vibration: Arcing of pins and socket contacts.

| Comments | Agree | Partially Agree | Disagree | Comments |
|---|---|---|---|---|
| Avtech<br>D. Lund/ M. Rector | | | | Rectifying lamp condition should not cause ballast damage. Power factor and or inrush current requirements should prevent the described "series capacitor" problem.. |
| Bruce Industries<br>G. Baxter | X | | | No comment. |
| DAC<br>H. Klein | | | X | Poor ballast design! |
| Grimes<br>R. Besdon | | | X | No comment. |
| Grimes<br>C. Roudeski &<br>P. Greenlee | X | | | No comment. |
| Grimes<br>G. Mortimer | | | | Power quality is an issue and will become more so as passenger convenience items in the cabin become more prevalent. A power factor specification along the lines of ANSI C82.1 and C82.11, requiring a minimum power factor of 90% and a maximum THD of 32%, should be incorporated. |

FIGURE 20 - Item #21 - Ballast: Overheating, some magnetic type ballasts used minimum iron for weight reduction. Lamp filaments coated with electron emitting material. During operation, more loss of material at one end than other caused a difference in impedance in two directions. This resulted in a "DC" component in the current causing core saturation. Results overheating, smoke even fire. Series capacitor ballasts at least one early installation, two foot (20 watt) lamps were operated directly form a 3-phase line to line electrical system with a capacitor in series for ballast. While this provided very light weight ballast, the resulting large positive power factor resulted in main alternator failures.

| Comments | Agree | Partially Agree | Disagree | Comments |
|---|---|---|---|---|
| Avtech<br>D. Lund/ M. Rector | | | | Generally locating the ballast close to the lamps is desirable but not always feasible; maximum distance may be specified for EMI or voltage drop reasons. |
| Bruce Industries<br>G. Baxter | X | | | No comment. |
| DAC<br>H. Klein | X | | | Don't understand-"long life"? Rapid start? |
| Grimes<br>R. Besdon | X | | | No comment. |
| Grimes<br>C. Roudeski &<br>P. Greenlee | X | | | No comment. |

FIGURE 21 - Item #22 - High voltage: Use of long lamps results in high starting voltage from ballast. Ballast should be located close to lamps to minimize high voltage exposure.

| Comments | Agree | Partially Agree | Disagree | Comments |
|---|---|---|---|---|
| Avtech<br>D. Lund/ M. Rector | | | | Generally careful design is necessary to meet EMI requirements. Arcing of pins and socket contacts should not occur because of vibration.. |
| Bruce Industries<br>G. Baxter | X | | | No comment. |
| DAC<br>H. Klein | X | | | No comment. |
| Grimes<br>R. Besdon | X | | | All parts must operate within worst case conditions. Derating beyond this is a reliability issue. |
| Grimes<br>C. Roudeski &<br>P. Greenlee | X | | | No comment. |

FIGURE 22 - Item #23 - EMI: Electromagnetic Radiation: Any electric arc is a source of EMI. Any fluorescent lamp is an arc between electrodes 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 there is no significant conducted or radiated EMI from the fluorescent system into the airplane electrical system.