AEROSPACE RECOMMENDED PRACTICE

ARP1798™	REV. B
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Portable Emergency Lighting Systems
for Flight Crew Members

RATIONALE

This document is being updated to correct typos and provide additional recommendations on batteries.

1. SCOPE

1.1 The purpose of this SAE Aerospace Recommended Practice (ARP) is to recommend general design and performance characteristics for hand-held portable, emergency lighting systems (note: the portable portion of this system that contains the lamp and reflector will be identified throughout the remainder of this document simply as a "flashlight") intended for use by crew members of commercial aircraft during any emergency situation, within or outside of the aircraft cabin, where emergency lighting is required.

1.2 It is not the intention of this document to recommend specific designs, materials, or technology to meet the recommendations contained herein, but rather to establish general guidelines in these areas. Where specificity is apparent, such may be overruled in the design when it can be demonstrated that the intent of the recommendation has been met with an equivalent level of performance.

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 examption has been obtained.

2.1 FAA Publications

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

14 CFR Part 25 Airworthiness Standards: Transport Category Airplanes, Code of Federal Regulations

AC 20-115 Airborne Software Development Assurance Using EUROCAE ED-12( ) and RTCA DO-178( )

AC 20-168 FAA Advisory Circular, Certification Guidance for Installation of Non-Essential, Non-Required Aircraft Cabin Systems & Equipment (CS&E)

2.2 RTCA Publications

Available from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

For more information on this standard, visit
https://www.sae.org/standards/content/ARP1798B/

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

RTCA/DO-227 Minimum Operational Performance Standards for Lithium Batteries

RTCA/DO-311 Minimum Operational Performance Standards for Rechargeable Lithium Batteries and Battery Systems

RTCA/DO-293 Minimum Operational Performance Standards (MOPS) for Nickel-Cadmium, Nickel Metal-Hydride and Lead-Acid Batteries

2.3 U.S. Government Publications

Copies of these documents are available online at https://quicksearch.dla.mil.

MIL-HDBK-217 Reliability Prediction of Electronic Equipment

MIL-STD-810 Environmental Engineering Considerations And Test Methods

3. GENERAL DESCRIPTION

Equipment intended to comply with the requirements of this document shall conform to the following design standards and provide the proper performance under the environmental test conditions specified.

Requirements include applicable 14 CFR Part 25 Federal Aviation Regulations as referenced in later sections. As a guide, Advisory Circulars AC 20-168 should be consulted regarding the use of lithium batteries, flammability for small parts, glass in the cabin, etc. Specific sections of this document are referenced to in later sections of this document.

The design/construction of equipment should incorporate features that allow the equipment to be operated safely. Testing should be conducted to verify compliance with the applicable performance standards in this document.

3.1 The portable emergency lighting system for flight crew members is intended to be classified the same as the other cabin emergency equipment, and should be accorded the same emphasis in its design, performance, reliability, maintenance, handling, installation, and use.

3.2 The flashlight should provide the portability and ease of use typical of designs based on standard D-cell batteries, without necessarily having to conform to that particular type of package design.

3.3 The flashlight should be designed to provide a high degree of reliability in an aircraft cabin environment, which can exhibit extreme temperature fluctuations, vibration/shock, and abusive handling.

3.4 The flashlight should provide a high-intensity, directional beam both as general illumination and as a directional indicator.

4. SPECIFIC RECOMMENDATIONS

4.1 General Configuration

4.1.1 The flashlight, as configured for use after removal from its retention system, should be easily and comfortably held and controlled by a single hand.

4.1.2 The flashlight grip or handle should provide for both utility and security. The grip or handle should be at least 10 cm (3.94 inches) long and have an overall circumference between 7.85 cm (3.14 inches) and 15.7 cm (6.28 inches).

4.1.3 A flashlight with the head mounted on other than either of its two ends should be designed to minimize the probability of injury to the user, should the device be allowed to rotate in the holding hand.

4.1.4 The flashlight, as configured for use after removal from its retention device, should weigh less than 0.9 kg (1.98 pounds).

4.1.5 The flashlight should incorporate a wrist lanyard which can be used to secure the flashlight to the user's wrist while the flashlight is in use. The lanyard should be secure enough to retain the flashlight if inadvertently dropped, while still designed to break-away without injuring the wrist when the flashlight is intentionally released or forcibly separated from the user.

4.1.6 The flashlight and its retention device should not have sharp edges or protrusions that could result in injury to the user or others.

4.1.7 Switching to activate the flashlight may either be automatic (upon removal of the flashlight from its retention device) or manual. A manual switch must be capable of being operated by the holding hand while the hand is on the handle or grip.

4.1.8 If the flashlight design includes software, the design should follow the guidance of AC 20-115.

4.2 Material

4.2.1 The material used in the flashlight and its retention device shall meet the applicable requirements for aircraft cabin material specified in 14 CFR Part 25.853.

4.2.2 Material used in construction of the flashlight should minimize the absorption and conduction of radiated heat, so as to minimize the probability of injury to the user when the flashlight is operated in an environment of extreme heat and/or fire.

4.2.3 The material and chemistry of the integral battery shall be such that amounts and/or relative toxicity of vented gases do not pose a hazard to occupants, equipment, or aircraft. The material, cell chemistry, and battery construction shall also be such that explosive venting of these gases is not possible when exposed to any of the environmental conditions described in this document.

4.2.4 The lamp lens should not cloud or degrade such that the intensity of the light emitted by the flashlight is reduced from exposure to the environmental conditions outlined in the subsequent sections. Glass used in the lens should have high impact resistance.

NOTE: The meaning elsewhere herein of "no significant lighting degradation" or "no significant change(s) in illumination" (including flickering) means that any loss of intensity does not result in a perceptible reduction in intensity.

4.2.5 Flammable Materials

4.2.5.1 All nonmetallic/metallic composite materials should meet 14 CFR Part 25.853, except that the hard wall surface of the equipment that contains the battery shall be free of fragments/debris that could be liberated by an explosion of the battery. Refer to AC 20-168, paragraph 6.d.

4.2.5.2 No explosive or toxic gasses emitted by any battery during normal operation or as the result of any failure of the battery charging or monitoring system (unless the system's probability of failure per MIL-HDBK-217 is shown to be ≤1E-5) may accumulate in hazardous quantities within the aircraft. In addition, no flammable fluids that may escape from any battery may accumulate in hazardous quantities in the aircraft. Further, corrosive fluids or gases that may escape from any battery should not damage surrounding airplane structure or any adjacent essential equipment.

NOTE: These potential failure modes should be considered when products are tested per the methods shown in Table 1. Refer to AC 20-168, paragraph 6.c.(2)(a), regarding the use of lithium batteries.

4.2.5.3 It shall be demonstrated by testing that each battery, as installed, has provisions to preclude hazardous effects on the aircraft structure or any essential systems that could be caused by maximum battery heat dissipation (including fire and explosion) generated during a short circuit of the battery or its individual cells.

4.2.6 Electrical wiring shall meet the applicable sections of 14 CFR Part 25.1703(a) and (b), 25.1713(c), 25.1721(a)(2),(b) and (c), and 25.1729 for Electronic Wiring Interconnection Systems (EWIS).

4.3 Environmental Performance

4.3.1 The RTCA DO-160 test conditions for use in evaluating the flashlight are provided in Table 1. In addition, the flashlight should be capable of delivering usable light (see 3.4) in an ambient temperature range of -40 to +70 °C (-40 to +160 °F).

4.3.2 The flashlight shall operate normally for the rated discharge life of a new battery after submersion in water at a depth of 3 m (9.84 feet) for 10 minutes.

4.3.3 In addition to the test requirements shown in Table 1, the flashlight and its retention system should be operable after having been subjected to inertia (i.e., acceleration) forces of 20 g upward, forward, and downward, and 10 g sideward, per the test method described in MIL-STD-810, Method 513.5, Procedure II, or equivalent.

Table 1 - RTCA DO-160 environmental conditions

#	Requirement	DO-160 Requirements		Comments
		Chap.	Category/Proced.	
1	**Temperature & Altitude**	**4.0**	A1	
2	**In-Flight Loss of Cooling**	**4.5.4**	X	
3	**Temperature Variation**	**5.0**	C	
4	**Humidity**	**6.0**	A	
5	**Operational Shock & Crash Safety**	**7.0**	B	See 4.4.7 and 4.5.1
6	**Vibration (Standard)**	**8.0**	Cat. S, Curve B3	See 4.4.7 and 4.5.1
7	**Explosion Proofness**	**9.0**	A, Environment I	See 4.3.5
8	**Waterproofness**	**10.0**	X	
9	**Fluids Susceptibility**	**11.0**	F	See 4.3.4
10	**Sand and Dust**	**12.0**	X	
11	**Fungus**	**13.0**	F	
12	**Salt Fog Test**	**14.0**	X	
13	**Magnetic Effect**	**15.0**	A	
14	**Power Input**	**16.0**	A(CF) for 115 VAC or A for DC	See 4.4.8.6
15	**Voltage Spike**	**17.0**	A	
16	**Audio Frequency Susceptibility**	**18.0**	R(CF) for 115 VAC or B for DC	See 4.4.9
17	**Induced Signal Susceptibility**	**19.0**	ZC	See 4.4.9
18	**Radio Frequency Susceptibility**	**20.0**	S	See 4.4.9
19	**Radio Frequency Emissions**	**21.0**	B	See 4.4.9
20	**Lightning-Induced Transient Susceptibility**	**22.0**	XXXXX	
21	**Lightning-Direct Effect**	**23.0**	XXXX	
22	**Icing**	**24.0**	X	
23	**Electro Static Discharge**	**25.0**	A	
24	**Fire, Flammability**	**26.0**	C	

4.3.4 Flashlight components should be capable of operation after exposure to fluid classes typically encountered in the cabin. Consideration for international aircraft operators may affect which classes are appropriate.

NOTE: Flashlights used by the flight crew for pre-flight inspections or similar tasks should be additionally tested with fluids typically encountered outside the aircraft cabin.

4.3.5 The flashlight shall be tested to demonstrate that breakage of its lamp or lens does not result in a spark/fire hazard in the presence of flammable vapors.

4.3.6 The flashlight should be shown to float lens up when placed in fresh water.

4.3.7 The flashlight should be shown to withstand without damage three successive drop tests, one on each of its two major ends and faces when dropped from a distance of 0.91 m (3 feet) above a hardwood floor.

4.3.8 The portable emergency lighting system should also comply with the aircraft's cabin overpresure test conditions (if specified by the customer). This may be required because cabin fuselage leakage due to the use of this product may not be desired.

4.4 Battery

4.4.1 The flashlight should have an integral, replaceable battery, of either primary or secondary (rechargeable) cells.

4.4.2 The battery shall be designed and installed such that it complies with the applicable portions of 14 CFR 25.1353(b).

4.4.3 Lead acid, nickel cadmium, and nickel metal hydride chemistries should follow the guidance of DO-293.

4.4.4 Both rechargeable and non-rechargeable lithium batteries are on the FAA Transport Airplane Issues List. This requires contacting the Aircraft Certification Service office for Special Conditions if none already exist. RTCA DO-311 and RTCA DO-227 contain both requirements and guidance covering chemical composition, quantity of potentially hazardous substances, cell size, cell construction, interconnection of cells into batteries, fusing, venting, current limiting, operational and storage environments, packaging, handling, tests, and disposal which affect the use of these articles in aircraft.

NOTE: Due to in service events it is recommended for the designer to use at least RTCA DO-311A and RTCA DO-227A. These RTCA document revisions also correspond to TSO-179b and TSO-142b respectively.

4.4.5 The battery, in combination with an appropriately rated lamp, should be capable of delivering the minimum illumination specified herein, when connected to its charging system after inactive storage for 2 years at +21 °C (+69.8 °F). The individual cell(s) comprising the battery should incorporate a positive, mechanical means of venting internally generated gases. Any battery packaging should also incorporate a means of venting gases generated by the individual cells. In cases where the total possible amount of vented gases from cells in the battery is much greater than the free volume inside the flashlight so that pressurization may occur, the flashlight should incorporate a means of venting such gases and still meet the water resistant requirements of 4.3.2.

4.4.6 Multi-cell batteries shall be protected from shorting and the effects of cell leakage.

NOTE: The internal resistance of most secondary cells is small and a short circuit of any cell(s) will produce very high current (equivalent to 30 to 50 times the rated capacity of the cell). This will result in very high heat generation that can damage the cell(s) and surrounding parts. Use of both a thermal fuse and a resettable thermostat in the battery charging circuit is strongly recommended!

NOTE: A thermostat failure can be undetected (i.e., a latent failure). Therefore relying only on a thermostat for thermal control without a backup can result in a safety issue (especially, of a concern when this product is used in the flight crew compartment). For this reason, a combination of both a thermal fuse and a thermostat is highly recommended.

In addition, there should be a fail-safe design practice such that:

a. Control circuit failure shall not cause the battery to discharge back to the fault.

b. Control-circuit house-keeping power demand should be kept at a minimum level (i.e., less than 25% of capacity, or as otherwise determined by the application). Note the self-discharge threshold value is typically determined by the size of the battery and required "housekeeping" circuit such that the circuit will not drain the batteries to an unusable state within 1 month.

c. Control circuit design shall prevent thermal runaway.

d. Electrical failure shall not result in smoke, fire, out-gasing, explosion, etc.

4.4.7 The individual cells, and the battery as a whole, should be of the quick-acting type, generating its full rated voltages and full drain capacity within 5 seconds of activation at +20 °C (+69.8 °F).

4.4.8 Battery connections between the battery and the lamp assembly should be of the positive locking type, capable of separation without tools.

4.4.9 Multi-cell batteries shall be designed such that the failure of a single cell should have a minimal effect on the overall function of the flashlight. Protection from "back charging" should be built into parallel cell designs.

4.4.10 Multi-cell batteries shall be positively protected against rotation or vibration within the battery package to the extent that electrical connections between the cells do not fail under the shock, vibration, and inertial loading conditions of Table 1 and 4.3.7.

4.4.11 Secondary Battery Charging Circuit

4.4.11.1 The term "C rate" applies to the charging rate applicable to a secondary battery used as a power source. The C rate is defined as the rated charging current flow per cell, which is equal to the rated capacity of the cell. Thus, the C rate for a 1 A·h capacity cell is 1 A, and the C rate for a 2.5 A·h cell is 2.5 A.

NOTE: Standard charge cells are typically designed to be continuously charged at C rates up to 0.1, and standard C rates for sealed nickel-cadmium and sealed lead-acid batteries are typically 0.1 A.

4.4.11.2 Sealed batteries should not be charged in parallel, as a slight imbalance in charge acceptance among cells can result in one cell receiving overcharge current at a level significantly greater than its cell specification rating.

4.4.11.3 Overcharge is the continued application of charging current to a battery after the battery has reached its maximum state of charge. It impacts the steady-state values of battery pressure, temperature, voltage, and is therefore abusive to sealed rechargeable batteries.

4.4.11.4 No matter what type of cell is involved, overcharging at rates above the C rate should be avoided to preclude potentially excessive temperatures and venting.

NOTE: In most cases, if the charge current is low enough (e.g., 0.1 C) the cell will be undamaged, even with years of uninterrupted overcharge.

4.4.11.5 Charge Control

4.4.11.5.1 The charging circuit used for charging cells at higher C rates (fast charge cells) shall incorporate a means of preventing overcharging (charge control).

a. Without Feedback Control

Charging without feedback control should be done with care to ensure that the cells and the charge rate are suited to the flashlight's operational environment. For example, diminished oxygen recombination capability at the negative electrode inside the cell in low ambient temperatures can cause the internal pressure of the cell to rise too high in overcharge mode. Consequently, lack of feedback control could allow potentially destructive effects on battery structural integrity, leading to explosion, etc.

b. With Feedback Control

Charging at the 1 C or greater rate (with fast charge cells) permits the battery to be fully charged in 1 hour or less. Fast charging circuits require terminating the high rate charge before the battery is fully charged or nearly fully charged, lowering the charging rate to the 0.1 C rate or to a lower trickle rate. Fast charge circuits should incorporate a feedback control mechanism, such as:

- Coulometric control
- Time control
- Temperature sensing control
- Voltage sensing control
- Voltage and temperature sensing control (most reliable)

The most straightforward approach to charge control is to use a timer control circuit as part of the charger.

NOTE: Any charging method that depends solely on voltage magnitude to terminate fast charge may lose control if a cell shorts. Internal shorting is a primary failure mode of nickel cadmium cells, when they reach the end of their lives.

4.4.11.6 Charger Power Sources

Secondary batteries may be charged from either a direct current (DC) power source or a rectified alternating current (AC) power source.

The AC charging current may contain significant ripple content when using either half wave or full wave rectification. Half wave rectification is the most economical for low power levels, but has the most significant ripple current.

4.4.11.7 Charging and monitoring circuits should be demonstrated to operate without harm at the normal operating characteristics of aircraft power, per the methods shown in Table 1.

4.4.11.8 Charging circuits should be demonstrated to regulate charging power and current level so as to preclude over- and under-charging of the battery for applicable voltage ranges, per the methods shown in Table 1.

4.4.12 Electromagnetic Interference (EMI)

The flashlight should be designed to prevent damage to associated components, such as the charging and monitoring circuits, when exposed to the electromagnetic radiation (EMI) levels per the methods shown in Table 1.

The flashlight should not be harmed or experience significant degradation of its light output after testing per the methods shown in Table 1.