

NASA-TM-87415

NASA-TM-87415 19850012223

Emergency Locator Transmitter (ELT) Batteries Guidance and Recommendations

LIBRARY COPY

JAN 2 1985

LANGLEY RESEARCH CENTER
LIBRARY NASA, HAMPTON, VA.

DOCUMENT NO. RTCA/DO-188

November 1984

Prepared by SC-136 ELT
Battery Subcommittee



RADIO TECHNICAL COMMISSION FOR AERONAUTICS

... DEDICATED TO THE ADVANCEMENT OF AERONAUTICS

RADIO TECHNICAL COMMISSION FOR AERONAUTICS
One McPherson Square
1425 K Street, N.W., Suite 500
Washington, D.C. 20005

Emergency Locator Transmitter (ELT) Batteries
Guidance and Recommendations

RTCA/DO-188
November 13, 1984

Prepared by:
SC-136 ELT
Battery Subcommittee

N85-20533#

Copies of this document may be obtained from

RTCA SECRETARIAT
One McPherson Square
1425 K Street, N. W.
Suite 500
Washington, D. C. 20005
(202) 682-0266

\$25.00

(50% Discount to RTCA Members & International Associates)

NOTE: All orders for RTCA documents shall be accompanied by payment to include shipping and handling fees. These documents will be sent First Class or Priority Mail in the United States, Canada and Mexico. Shipments to other countries will be by International A0 Mail. The fee to be added to the basic cost of each document is \$3.00 for delivery in the United States, Canada and Mexico, and \$6.00 for other countries. Members and International Associates are entitled to a 50% discount on documents, but the full shipping and handling fee is required for each document ordered. Please remit in U.S. funds directly to RTCA.

F O R E W O R D

This report was prepared in response to a request from the Federal Aviation Administration who had indicated a concern about ELT battery-related problems. A subcommittee of RTCA Special Committee 136 was tasked to investigate these problems as specified in the Statement of Work on page v. The RTCA Executive Committee approved the Report of the ELT Battery Subcommittee on November 13, 1984.

RTCA is an association of aeronautical organizations of the United States from both government and industry. Dedicated to the advancement of aeronautics, RTCA seeks sound technical solutions to problems involving the application of electronics and telecommunications to aeronautical operations. Its objective is the resolution of such problems by mutual agreement of concerned organizations.

The findings of RTCA are in the nature of recommendations to all organizations concerned. As RTCA is not an official agency of the United States Government, its recommendations may not be regarded as statements of official government policy unless so enunciated by the federal government organization or agency having statutory jurisdiction over any matters to which the recommendations relate.

Emergency Beacon Corporation submitted a minority view and requested that it be distributed with the report. Accordingly, the Minority Report by Emergency Beacon Corporation is attached.

THIS PAGE INTENTIONALLY LEFT BLANK

T A B L E O F C O N T E N T S

	<u>Page</u>
FOREWORD	i
TABLE OF CONTENTS	iii
STATEMENT OF WORK CONCERNING BATTERY PROBLEMS	v
1.0 Scope	1
2.0 Types of Batteries	1
2.1 Performance and Mechanical Considerations	1
2.1.1 Primary/Secondary Cells	1
2.1.2 Real-time Activation Considerations	1
2.2 New Battery Technology	2
3.0 Potting or Encapsulation of Cells into a Battery Pack	2
3.1 Possible Advantages	2
3.2 Possible Disadvantages	3
3.3 Recommendations	3
4.0 Placing of Batteries in Cold Storage to Extend Shelf Life	4
5.0 Battery Qualifications	4
5.1 General Requirements	4
5.2 Replacement Batteries, General Requirements	5
5.2.1 Qualification By Identicality	5
5.2.2 Qualification By Demonstration of the MOPS	6
MEMBERSHIP	7
APPENDIX A - CONSIDERATIONS FOR DESIGN AND MANUFACTURE OF BATTERIES FOR EMERGENCY LOCATOR TRANSMITTERS (ELTS)	
ATTACHMENT - MINORITY REPORT BY EMERGENCY BEACON CORP.	

THIS PAGE INTENTIONALLY LEFT BLANK

SC-136
STATEMENT OF WORK CONCERNING BATTERY PROBLEMS

SC-136 will establish a subcommittee to review and recommend corrective actions on ELT battery-related problems.

The following items related to ELT batteries have been identified as pertinent to this subject:

1. Types of batteries

Identify the types of batteries practical for use in ELT applications.

2. Potting of cells into a battery pack

Identify advantages and adverse consequences of using this construction method and provide recommendations, with rationale, on its continuance or discontinuance.

3. Placing of batteries in cold storage to extend shelf life

Solicit and assimilate available data on the effectiveness of using cold storage for extending battery shelf life, and recommend the conditions under which such storage may be acceptable and to what extent.

4. Replacement batteries

Identify all technical parameters that must be met by a battery manufacturer to provide an approved (presume FAA TSO) replacement battery. If special requirements are recommended for inclusion in FAA ELT TSOs or Advisory Circulars, they shall be identified and suitable language recommended.

The subcommittee shall prepare a separate report, keeping in mind its possible use for formal governmental action, such as an FAA Advisory Circular and/or a separate FAA TSO on batteries.

THIS PAGE INTENTIONALLY LEFT BLANK

1.0 Scope

This document contains guidance and recommendations which, if uniformly applied as minimum requirements, provide reasonable assurance that the battery problems existing in the ELT environment will be resolved.

2.0 Types of Batteries ^{1/}

2.1 Performance and Mechanical Considerations

There are many types of batteries (cells) with various characteristics that are available for use in ELT applications depending upon the performance requirements of the ELT. Current drain, storage parameters (temperature and cycling) and physical configuration restrictions determine the actual choice of the basic cell. Mechanical design and marketing objectives also dictate system configuration. The original cell chemistry and mechanical design should be determined jointly by the ELT manufacturer and the cell manufacturer. Replacement batteries should demonstrate performance characteristics equal or superior to the original equipment. These batteries should be approved under the current certification system.

2.1.1 Primary/Secondary Cells

A number of battery types have been identified as practical for use in ELTs; however, they are all primary (non-rechargeable) types. The principal deficiency of the secondary (rechargeable) cell is its inability to provide sufficient capacity over the required range of temperatures that would be competitive with primary cells.

2.1.2 Real-Time Activation Considerations

Some types of cells will cause a time delay for the cell to reach its rated output voltage. This time delay may not be tolerable for ELTs that use electronic latching circuits which must latch during the crashpulse (typically less than 0.1 second). However, if the time delay can be tolerated (e.g., ELTs that use a mechanical latch) then the ELT manufacturer may select a cell that does have a time delay.

^{1/} Appendix A provides additional information on this subject.

2.2 New Battery Technology

Since the battery is a significant contributor to ELT performance, aviation electronic manufacturers are encouraged to recognize recent rapid advances in battery technology and consider these new technologies as power sources in their devices. In comparison to any of the battery systems presently in use, some new cells may offer improved characteristics, such as:

- a. Higher energy density (space and weight reductions).
- b. Broader temperature range (high and low temperature).
- c. Lower self-discharge (longer shelf life).

3.0 Potting or Encapsulation of Cells into a Battery Pack

There are both advantages and disadvantages associated with potting and encapsulation; some are listed below. It is essential that long-term effects of any interaction between the potting material/compound and cells, and other components of the ELT, be evaluated and fully understood to ensure mutual compatibility and avoid long-term destructive incompatibilities, such as corrosion effects. This understanding will provide some assurance that consideration of an advantage in one area or parameter will not obscure considerations of disadvantages in another area or parameter. For example, some potting compounds might provide enhanced resistance to fire and heat (relative to non-potted batteries) but may also permit a corrosive environment to be trapped in the package; or some compounds may provide many of the advantages listed below except that the selected compound may decrease the ELT's heat resistance.

3.1 Possible Advantages

- a. Can provide an inexpensive and convenient method of mechanically securing cells into a battery pack that is relatively vibration and shock resistant.
- b. Can protect the cells from physical and environmental damage, which may prevent shorting and corrosion as a result of condensation, particularly in the areas of seals and welded joints.
- c. Allows the battery pack to be shaped in a convenient form which uniquely mates with the ELT and can prevent reversed polarity connections.

- d. Discourages tampering with individual cells and/or unauthorized repair of battery packs.
- e. Can protect ELT electronics and other vital components by containing corrosive or otherwise harmful gaseous, solid or liquid discharges from the cells.
- f. May increase resistance to fire and heat.
- g. Can serve to effectively isolate and protect areas of differing electrovoltaic potentials.

3.2

Possible Disadvantages

If proper precautions are not considered in the potting method or selection of material, the following problems may be encountered:

- a. Destructive interference may occur with the venting mechanism designed into the cell.
- b. A corrosive environment may be trapped in the package.
- c. Damaging mechanical stresses on the connections may be introduced.
- d. The fire and heat resistance of the ELT may be reduced.

3.3

Recommendations

- a. Potting or encapsulating cells into a battery pack is recommended because sufficient historical data is available which indicates that cells can be potted without being detrimental to the battery's required performance. It can also enhance the battery's capability to survive and/or perform under adverse environmental conditions.
- b. Since there are a variety of potting methods and materials which can be used and since improper methods and/or materials may adversely affect the performance of the battery in an ELT, information and/or data should be provided to the certification authority by the ELT or battery manufacturer in regard to the acceptability of the potted or encapsulated battery. The information may be in the form of historical data or, in the absence of such information relative to the potting methods and material being used, test data should be provided.

NOTE: RTCA/DO-183, paragraph 2.1.11, "Power Supply," does not require tests for gas or liquid seepage, but the ELT or battery manufacturer is expected to determine if this can occur.

- c. It is also recommended that testing programs consider the battery cells, the potting materials, the connection between the battery pack and the transmitter, the weight, strength, shock and vibration characteristics of the proposed total system.

4.0 Placing of Batteries in Cold Storage to Extend Shelf Life

From a technical standpoint there is a shelf-life benefit associated with the storage of batteries at controlled low temperatures. There are potential risks, however, which preclude this procedure from being a recommended practice for anyone but cell manufacturers. Two potential risks are:

- a. Poorly controlled low temperature conditions resulting in temperature cycling.
- b. Poorly controlled procedures in returning the batteries to ambient conditions resulting in condensation on the cells, terminals and insulators which could cause electrical shorting of the battery or cells within the battery package.

Based on the risks involved, it is recommended that low temperature storage be used by no one other than the cell manufacturer.

5.0 Battery Qualifications

5.1 General Requirements

The ELT manufacturer and any alternate battery replacement manufacturer shall provide information and/or data to the certification authority regarding the following:

- a. Acceptability of battery technology and potting/encapsulation materials to be used for original and replacement batteries. This may be in the form of historical data or test data, as appropriate.
- b. The useful shelf life that can be expected from the original or replacement battery, as appropriate. This may include the cell self-discharge characteristics or per cent capacity remaining at the end of the cell's

useful life. (Useful life is the period corresponding to the interim between the date of cell manufacture and the date that the battery must be replaced.)

- c. Assurance that future replacement batteries will interface with any ELT for which they were designed without modification to the original ELT and using no tooling other than that originally required for replacement of the battery by the ELT manufacturer. This shall include production tolerances and a quality assurance program.

5.2 Replacement Batteries, General Requirements

ELTs with replacement batteries shall meet RTCA/DO-183, "Minimum Operational Performance Standards (MOPS) for Emergency Locator Transmitters -- Automatic Fixed - ELT (AF), Automatic Portable - ELT (AP), Automatic Deployable - ELT (AD), Survival - ELT (S) Operating on 121.5 and 243.0 MHz." These requirements shall be met by batteries manufactured by and/or for the ELT manufacturer and by alternate battery sources. The battery package shall be replaceable only as a complete unit. Replacement of individual cells or a group of cells shall not be authorized.

Qualification of replacement batteries shall include one of the following procedures:

- a. By identity with the original equipment battery.
- b. By demonstration of compliance with the ELT MOPS with the replacement battery installed in the ELT for which it is designed.

5.2.1 Qualification By Identity

If qualification is conducted on the basis of identity with the original equipment battery this identity shall be shown by either of the following methods:

- a. Conformance with the ELT manufacturer's battery production, process drawings and instructions.
- b. Engineering such that identity is achieved in -
 - (1) General configuration - form, fit, and function.
 - (2) Dimensional identity in all aspects relating to construction of the battery and interface with the ELT.
 - (3) Battery cells - identical type, voltage, capacity and manufacturer.

- (4) Materials - packaging, contacts/connections, lead wire, solder and encapsulation.
- (5) Tolerances shall be within the ELT manufacturer's tolerances.

5.2.2 Qualification By Demonstration of the MOPS

If qualification is conducted on the basis of conforming to the MOPS that was required for the ELT's TSO authorization, the following procedures shall apply:

- a. Demonstrate that the replacement battery will interface with the unmodified ELT for which it is designed using no tooling other than that required for replacement of the original ELT battery.
- b. Unmodified ELTs mated with unused replacement batteries shall be subjected to and meet the requirements of the tests specified in DO-183, Section 2.0.

S. Green	General Aviation Manufacturers Association
G. Griffin	NASA Goddard Space Flight Center
D. Gutman	NARCO Avionics, Inc.
D. Hall	Robertson Research, Inc.
D. Haykin	NASA Goddard Space Flight Center
B. Huret	Panasonic Industrial Company
F. Kissel	Westinghouse Electric Co.
L. Langdon	U. S. Department of Interior
G. Leegate	DME Corporation
J. Lepage	Canadian Marconi Company
D. Linden	Duracell U. S. A.
B. Loeb	National Transportation Safety Board
J. Longshore	McDonnell Douglas Corporation
G. Lynn	Van Dusen Aircraft Supply Company
N. Marincic	Battery Engineering, Inc.
D. Marling	Orion Electronics Limited
T. Martin	Battelle Columbus Laboratories
D. McSmith	NASA Langley Research Center
M. H. Merliss	MERL, Inc.
M. R. Merliss	MERL, Inc.
L. Miller	Aviation Consumer Magazine
R. Monroe	Aircraft Owners & Pilots Association
T. Moody	Cessna Aircraft Company
A. Murfin	Canadian Marconi Company
C. Naab	Conax Corporation
A. Norwood	Consultant
T. Oneto	Aircraft Owners and Pilots Association
C. Phipps	Aeronautical Radio, Inc.
G. Robinson	NASA Goddard Space Flight Center
D. Schacher	Tel-Instrument Electronics
D. Sieminski	Electrochem Industries
C. Sturm	Federal Aviation Administration
R. Taylor	Beech Aircraft
T. Telzrow	Union Carbide Corporation
R. Thomson	NASA Langley Research Center
B. Trudell	NASA Goddard Space Flight Center
J. Turkiewicz	NASA Goddard Space Flight Center
R. Vago	Deft Laboratories, Inc.
J. Van Houten	Duracell U. S. A.
M. Vermij	Aviation Safety Bureau (Canada)
D. Wassom	Van Dusen Aircraft Supply Company
H. Waterman	Federal Aviation Administration
D. Wilberg	Ray-O-Vac Corporation
F. Williams	Servo Corporation of America
R. Wissoker	GTE Power Systems
R. Wrenn	Federal Aviation Administration
C. Wright	Aircraft Owners & Pilots Association
D. Yates	Federal Communications Commission
J. Young	Federal Communications Commission

A P P E N D I X A

CONSIDERATIONS FOR DESIGN AND MANUFACTURE OF
BATTERIES FOR EMERGENCY LOCATOR TRANSMITTERS (ELTS)

THIS PAGE INTENTIONALLY LEFT BLANK

1.0 INTRODUCTION

This appendix provides reference information which may be applied in the design and manufacture of batteries and battery packs for emergency locator transmitters. The information provided herein was gathered in a 1983 survey of a number of battery cell manufacturers, domestic and foreign, under the auspices of RTCA Special Committee 136. This information is not represented as being inclusive of all significant design and fabrication considerations relating to ELT batteries, nor does this information necessarily represent a consensus industry opinion.

2.0 COLD STORAGE FOR SHELF LIFE EXTENSION

It is generally agreed that cold storage retards cell deterioration by impeding (1) self-discharge and (2) chemical reactions that tend to debilitate the cells over time. Industry feeling is mixed regarding the use of cold storage to prolong cell shelf life due to a combination of one or both of the following: (1) Risks associated with cold storage itself, (2) net economic value of cold storage costs versus shelf life saved.

2.1 Risks of Cold Storage

The risks associated with cold storage are (1) dangers relating to the freezing of the electrolyte, (2) short circuits due to moisture/condensation, (3) growth of a "passivation" layer in certain lithium chemistries, (4) mechanical expansion/contraction of the cell associated with cycling from high to low temperatures.

The risk of freezing of the electrolyte was suggested by a lithium cell manufacturer.

The risk associated with condensation relates to moisture formed internally or externally to the cell or battery pack while the unit is cycled between a cold and warmer temperature. Such moisture could result in an electrically conductive path or corrosion, particularly within an encapsulation medium. This is not thought to be a problem in cells that are hermetically sealed.

Lithium-thionyl chloride systems generate a passivation layer; too much growth of the passivation layer is not desirable

because it can affect the "time delay" of the cell in reaching rated voltage (this may not be an important consideration in some ELT systems). The worst condition for growth of the passivation layer in one system is around 50 degrees C. A temperature above or below is a better storage condition. Cells with excessive growth of the passivation layer can be recovered through partial discharge under load; such recovery process would result only in a loss of approximately 1% of capacity.

While there exists a potential for mechanical problems associated with expansion/contraction under temperature cycles, most manufacturers felt that their products were essentially impervious to such problems.

2.2

Economic Considerations of Cold Storage

There is general consensus that the economic costs of maintaining cold storage for cells and batteries would not justify the associated shelf life extension. One manufacturer indicated that cold storage in the six to twelve month range was certainly not worth the cost. Although it is understood that shelf loss rates vary within chemistries among manufacturers, the following were offered as general rules that apply to specific types of chemistries.

- a. One manufacturer indicates that tests with alkaline cells have shown capacity retention rates of 89% after four years at room ambient conditions, and states that a reasonable shelf life under those conditions is five years. Shelf loss rates increase dramatically at the 60-80% capacity level.
- b. One manufacturer of alkaline cells indicates that such systems can lose 7-10% of capacity per year at ambient room temperatures, with each increase or decrease of 10 degrees C speeding or retarding, respectively, the shelf loss rate by 50%. This same manufacturer indicated that storage of alkaline cells at 0 degrees C would result in an insignificant shelf loss over a six to twelve month period.
- c. Another alkaline cell manufacturer's published data indicates a 5% capacity loss per year over four years at ambient room temperatures.
- d. Lithium-thionyl chloride system manufacturers variously indicated that shelf loss rates vary from 1-2% per year at ambient room conditions with a total shelf life of 10 years. Cold storage for such systems for less than a year would thus have marginal economic benefit.

3.0 PACKAGING/POTTING CONSIDERATIONS

3.1 Potting/Encapsulation

It is consensus opinion that potting materials should be electrical insulators. In some cases, it is important that such materials not have high exotherm characteristics, to minimize heat generation during the curing process. In some cases, it was recommended that the potting materials either react chemically with cell effluent in such a way that volume of effluent is reduced chemically, or that such potting materials be permeable to hydrogen.

It is generally agreed that the package design and any encapsulation materials should allow for expansion of internal cells.

Most manufacturers favor full encapsulation, but one alkaline manufacturer specifically recommends against it in published literature. This manufacturer informally acknowledges that its cells are used regularly with full encapsulation with few if any detrimental effects.

Another alkaline cell manufacturer recommends full encapsulation as a prevention for external leakage and cites no known problems with this type of packaging.

3.2 Provisions for Venting and Out-Gassing

Internal accommodation for venting with "free volume" which could be provided with open cell foams is not practical in some chemistries. For instance, 50-100 cc of free volume would be required to contain effluent gases when one existing type of lithium-sulfur dioxide "D" cell vented.

Some lithium systems are designed with hermetic seals and are not designed to vent or out-gas under normal operating conditions. Some manufacturers of those systems do not see the need for venting or outgassing provisions. Another lithium cell manufacturer specifically recommends against external venting provisions because the effluent, if any, is toxic and harmful to electronic components. This manufacturer holds that the internal design of the cells and the packaging should obviate the need for external venting.

Another Lithium cell manufacturer allows that venting provisions should be built in to accommodate extreme conditions beyond the expected operating environment.

One alkaline manufacturer feels that external venting provisions are not necessary for alkaline battery packs.

Lithium-thionyl chloride and alkaline cells are not fabricated with an internal pressure whereas lithium-sulfur dioxide systems do have a positive internal pressure at ambient room conditions.

4.0 HAZARDS

The types of hazards with which battery assemblers and operators must concern themselves in ELT batteries vary considerably with the chemistry involved. The following paragraphs contain the main areas of concern as provided by the cell manufacturers.

4.1 Leakage

Leakage can be a problem with virtually any cell chemistry, if the cell, by the nature of its construction or by mechanical deformation, is allowed to leak. Most lithium systems are hermetically sealed and the manufacturers discount the leakage problem because the integrity of the cell casing and seals are said to be essentially inviolate under normal operating conditions within the operating temperature limits established by the manufacturer. Most alkaline systems are crimp sealed and susceptible to leakage under adverse operating conditions. Hazards from leakage include toxic effluent which can be harmful to persons and equipment.

4.2 Short Circuit Conditions

External or internal short circuits are of particular concern in the lithium system in general. External shorts can be obviated with the use of fusing, and this is recommended by most manufacturers for lithium battery packs. One manufacturer recommends that fusing should be designed at double the maximum current requirement with slow-blow type fuses.

One lithium cell manufacturer discourages the use of fuses because (1) they are not usually replaceable (2) a battery pack with a blown fuse could be mistaken as a "dud" or depleted unit and discarded as such with potential disposal-associated problems. This manufacturer suggests the use of conductive plastics that increase in resistance as temperature rises.

Short circuits internal to a battery pack can be obviated with careful attention to internal construction, isolation of lead wires, careful selection of the potting medium, and protection

from the introduction of moisture or other conductive materials inside the battery pack.

In some high rate discharge cells, such as one manufacturer's "D" and "DD" size lithium systems, the leads will burn out under short circuit conditions, effectively stopping the short circuit condition.

One manufacturer of high-rate lithium systems cautions that care should be taken to preclude the internal contact of cathode leads and the anode, such as could happen under shock/vibration -- volatile reaction could ensue.

One alkaline cell manufacturer indicated that fusing and short circuit protection is not necessary for such systems. Tests involving dead shorts at full capacity at 200 degrees F have not resulted in ignition or explosive venting.

4.3 Polarity Reversal/Reverse Charging

These hazards relate generally only to lithium systems and can be obviated with diode protection for the battery pack and individual cells. One manufacturer of lithium-thionyl chloride cells indicates that though diode protection is recommended as a fail-safe measure, its design precludes the problem because excess electrolyte is built into the system to ensure full depletion of the lithium, rendering the cell inert following full discharge. Low rate cells are less susceptible to problems in this area than high rate cells.

4.4 Physical Abuse

The primary concern with abuse of alkaline cells relates to leakage.

Some lithium systems are sensitive to physical abuse. As previously indicated, shock/vibration may result in internal shorts in poor designs.

Most lithium cell manufacturers put their cells through exhaustive mechanical testing and indicate that their designs are essentially impervious to physical abuse.

One manufacturer indicates that some lithium-sulfur dioxide cells have shown evidence of shock sensitivity when subjected to significant temperature fluctuations. According to this respondent, the passivation layer formed on the lithium anode, which helps retard shelf loss, can be volatile under conditions where first a thick passivation layer is formed at higher temperatures, the cell is then held at extreme low storage

temperatures (-40 degrees C) and then subsequently returned to ambient conditions.

4.5 Other Hazards

Hazards relating to venting, out-gassing, and encapsulation are covered in previous sections.

All manufacturers stressed the importance of remaining within the manufacturer's specified operating temperature ranges.

All manufacturers warned against the hazards of cell incineration.

One manufacturer of lithium systems indicated that heat build up within the cell should be considered, and that battery packs should provide a heat sink or heat conductive path to obviate this type of problem.

5.0 TESTING

One of the questions presented in the survey related to testing methods to determine the efficacy of venting or out-gassing provisions in extreme conditions. The worst test conditions for venting would include an unfused short circuit condition at elevated temperatures, such testing being conducted at various capacity levels from full charge to full depletion. Another artificial test that would likely not be duplicated in real usage would be a forced overdischarge at elevated voltages. One lithium manufacturer indicated that cells should not vent within the specified operating temperature range, and if they vented beyond that range, the venting should be safely contained. Standard Department of Transportation tests are required. Most manufacturers go well beyond the requirement of these tests.

6.0 BATTERY DESIGN AND FABRICATION HINTS

The following hints for the design and fabrication of ELT batteries were gleaned from the survey. This is not intended to be an exhaustive listing of all considerations.

- a. Carefully consider the need for venting or out-gassing provisions and design to accommodate these needs.
- b. Allow for the expansion of cells within the battery pack.
- c. Consider the implications of leakage to ELT components and inter-cell solder connections.

- d. Potting materials, if used, should be electrical insulators. Consideration should be given to their permeability to effluent gases and the chemical reactions that could occur with effluent material.
- e. Use fusing and circuit protection where required.
- f. Properly isolate and insulate lead wires to preclude short circuits.
- g. Carefully design inter-cell and battery connections. Preference is to use weld tabs rather than solder straight to cell casings. Preferred materials for connections include brass, beryllium copper, or steel plated with nickel, silver or gold.
- h. Avoid storage of cells and batteries at high temperatures.
- i. Handle cells carefully to avoid inadvertent short circuit and discharge.
- j. Avoid use of heat gun and high exotherm epoxies in fabrication.

7.0

DISPOSAL CONSIDERATIONS

The survey included questions regarding disposal considerations for cells, especially those of a potentially toxic or volatile nature. This is considered a problem area by most manufacturers, particularly from a logistics point of view.

As ELTs are for the most part a consumer product, the question of disposal logistics becomes more complex. It is possible that lithium battery packs in various states of depletion and condition will be disposed of locally by consumers, with a possibility of hazards that could be associated with other than special handling of these cells.

Consideration should be given for battery replacement programs that would provide incentives for consumers to return depleted battery packs to manufacturers or distributors for credit against the purchase of replacement units. With such a program, there would necessarily have to be a system for returning depleted battery packs to the manufacturer or to disposal centers for processing. Battery disposal centers do exist at this time.

THIS PAGE INTENTIONALLY LEFT BLANK

MINORITY REPORT
by
EMERGENCY BEACON CORP.
on
RTCA SC-136 ELT BATTERY SUBCOMMITTEE REPORT

As an active participant on SC-136 and its subcommittee on batteries, Emergency Beacon Corporation wishes to have a minority report included in the report of the SC-136 Subcommittee on Battery Problems. This minority report is deemed necessary because Emergency Beacon Corporation believes the majority report fails to adequately address the considerations in the STATEMENT OF WORK, paragraph 4., namely:

"Replacement batteries: Identify all technical parameters that must be met by a battery manufacturer to provide an approved (presumed FAA TSO) replacement battery. If special requirements are recommended for inclusion in FAA ELT TSOs or Advisory Circulars, they shall be identified and suitable language recommended."

The subject is covered in Section 5, where two methods are proposed - (1) Qualification by Identicality and (2) Qualification by Demonstration of the MOPS. The qualification by identicality section is complete and the minority agrees with it. Its intent is clear, i.e., that the replacement battery pack be identical and within the same tolerances as the original manufacturer's battery. Emergency Beacon Corporation, however, considers the report to be deficient in the area of "Qualification by Demonstration of the MOPS" because it does not identify all technical parameters that must be met.

The inclusion of additional sub-paragraphs in Section 5, paragraph 5.2.2 would, in the opinion of the minority, correct these deficiencies. The recommended language for each of the additional sub-paragraphs with brief rationale statements, follows:

Add to 5.2.2: (c) The FAA shall furnish to the ELT manufacturer the data on the performance of his ELT and the applicant battery pack. The ELT manufacturer may inform the FAA of any areas it thinks warrant more detailed testing and the FAA shall determine whether such critique is valid and require such further testing, if any, as it believes is necessary after reviewing the ELT manufacturer's critique.

Rationale: It is evident from readily available statistical information (presented to SC-136) that the major problem with replacement ELT batteries stems from manufacturers' attempting to do so-called "backward engineering" to produce a battery pack that will perform compatibly with an ELT. This "backward engineering" is done without knowledge of all the tolerances involved in the ELT and all of its eccentricities. By providing the ELT manufacturer with a copy of the test data of the proposed replacement battery pack, the ELT manufacturer can review the data and if some of the data is not accurate or may be in error, he can advise the FAA of this fact, which may place the FAA in a better position to closely scrutinize the tests of the applicant. We feel that the absence of such a provision at the present time is one of the major

reasons for the battery problems that we have had and the 40:1 ratio of battery failures between those manufactured by battery-pack manufacturers and those manufactured by the ELT manufacturer.

Add to 5.2.2: (d) Number of samples for qualification. A minimum of two new fresh ELTs and ELT replacement battery packs certified by the ELT manufacturer will be required for testing. Where tolerances are involved, such as the size of the battery compartment, the batteries will be designed to have a tolerance to fit within the maximum difference between the samples. If a replacement battery manufacturer wishes larger tolerances he must then produce additional samples and demonstrate that the tolerances he has chosen fall between the limits of the smallest and largest of his sample population.

Rationale: The subject of ELT battery testing is treated in the report only in a general way. The current report requires only that when the manufacturer's information is not available, the applicant must purchase an ELT and make tests. Since ELTs may vary in efficiency by as much as 2 or 3 to 1, such tests using a single ELT are inadequate to qualify a replacement battery pack. This issue was discussed at length in various committee meetings and finally agreed that a minimum of two ELTs be used and that a tolerance be derived from those 2 ELTs and that all battery packs manufactured shall be required to fall within that tolerance. It was discussed and recognized that if a battery pack manufacturer felt that the tolerance was too tight he could purchase additional ELTs which presumably would increase that tolerance band but still assure acceptable performance with all ELTs in the field.

The language proposed is simply the inclusion of a requirement agreed to in principle during the last subcommittee meeting.

Add to 5.2.2: (e) Voltage and current tests. To insure proper ELT operation and avoid over-stressing critical components the applicant battery pack shall have an open circuit voltage within 5% of that of the manufacturer's battery pack and shall cause a current to be drawn within 5% of that drawn by the manufacturer's battery pack. During the discharge test the voltage of the replacement battery pack will remain within 5% of the highest voltage reading and above the lowest voltage reading of the ELT manufacturer's battery pack. The current drawn by the ELT will be within 1% of the current drawn for an identical voltage when comparing the ELT manufacturer's battery pack to the replacement battery pack. In addition, the output spectrum will be within 1% of that observed with the ELT manufacturer's battery pack. This helps insure that there's no detuning or other electrical effect of the battery pack due to non-static conditions, such as impedance changes and proximity effects.

Rationale: This requirement is needed to add specificity to the battery test and insure that the ELT is powered by the voltage it was designed for.

Add to 5.2.2: (f) Marking. If the performance of the ELT with the replacement battery pack is different from the original battery pack, the change in performance shall be marked on the applicant's battery pack or expressed in a data sheet that accompanies the battery pack. This shall

be required whether the performance is increased or decreased. Additionally, if limits are not known they shall be expressed as a qualification for the battery pack. [NOTE: If the testing is done with ELTs and the maximum current required at the starting voltage and room temperature is, for example, 35 milliamperes the battery shall be suitably marked to indicate that it may only be used on ELTs that draw 35 milliamperes or less and the method of measuring the current or other parameter shall be clearly and succinctly stated in the data sheet accompanying the battery so that the user or installer may quickly and easily confirm whether the battery pack is compatible with his ELT. Further, if the consumer's ELT draws, for example, 55 milliamperes the battery pack would not be suitable for use, but if his ELT draws 35 milliamperes or less he would be assured that the battery pack would have enough energy.]

Rationale: The consumer needs some way to make an informed choice as to what type battery he wishes to buy. He needs to be able to look at the available choices and be able to weigh the price against performance. The consumer needs to know if the battery is not "identical" and if it may change the performance of the ELT. This information should be on the battery label or attached to the battery to permit the consumer to make an informed choice of a battery that would give less, equal or better performance for his ELT. The label will also warn the consumer if a particular battery pack is not compatible with his particular ELT.

Add to 5.2.2: (g) Use of old batteries for qualification tests. One complete set of tests as required in RTCA/DO-183 shall be performed with a battery pack made of cells that are as old as the maximum rated shelf life (these can usually be obtained from the cell manufacturer).

Rationale: This would insure that there are no adverse time storage effects on ELT performance and prevent a repeat of the situation that developed with the early lithium cells which were not tested using old cells and developed corrosion and explosion characteristics after a period of several years in storage in the ELTs, resulting in numerous Airworthiness Directives.

Add to 5.2.2: (h) Prominent marking labels. Prominent marking labels for the ELT shall be provided indicating any important parameters that have been changed by the new battery pack where it is significantly different from the old battery pack. If a description is too lengthy to be placed on the battery pack, a label should be conspicuously placed on the battery pack and the ELT stating, "Important characteristics have been changed on this ELT. It is mandatory to review them on the accompanying data sheet." Examples of conditions that would require prominent marking labels are: (a) A replacement battery pack that would change the flotation characteristics of the ELT; (b) a change in weight that could affect the ELT mounting location; (c) a change in the operating life of the ELT, particularly if it is reduced; and/or (d) a change which could give false or inaccurate self-test readings.

Rationale: This procedure is needed to assure the integrity of ELT performance with non-identical replacement batteries.

End of Document