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Emergency Locator Transmitter (ELT) Equipment Installation and Performance

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F O R E W O R D

This document was prepared by Special Committee 136 of the Radio Technical Commission for Aeronautics. It was approved by RTCA on November 17, 1982 and is complementary to RTCA Document DO-183, "Minimum Operational Performance Standards for Emergency Locator Transmitters: Automatic Fixed - ELT (AF), Automatic Portable - ELT (AP), Automatic Deployable - ELT (AD), and Survival - ELT (S)."

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 its member and participating organizations.

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D E D I C A T I O N

This document is dedicated to Mr. Lee Sierp of Piper Aircraft Company for his outstanding contributions to the content of this report before his untimely death in January 1979.

EXECUTIVE SUMMARY

Controversy has surrounded the use of the emergency locator transmitter (ELT) since 1970, when Congress mandated its installation in most general aviation aircraft with the intent of expediting the location of downed aircraft by searchers. The controversy arose because the ELT and its associated equipment has been plagued with many technical problems that severely limit the reliability of these potentially useful devices. A high rate of non-distress activations (over 95%) and failure to activate in crash situations are the two most blatant ELT malfunctions. More than 80% of all located false alarm incidents that were eventually traced to specific aircraft were found at airports. Suspected sources of unwarranted activations and/or failures of ELTs are, among others, improper mounting in the aircraft, short circuits, ELT sensor vibration sensitivity, battery failures and poor antenna location. In response to this, Special Committee 136 was formed to address these technical problems and to develop criteria and guidance information pertaining to the placement and mounting of ELTs within aircraft, so as to assure the effectiveness of the equipment. The three major areas of investigation were:

a. Analysis of field data on ELT performance, which include: False alarms, ELT deactivation and post-crash evaluation of ELT effectiveness.

b. ELT placement, which includes mounting and activation studies.

c. ELT system performance, which includes the crash force sensor, batteries, electronics, antenna and the performance of the search aircraft's receiver.

Specific recommendations resulting from these investigations are contained in Section 6.0 of this document.

The study of ELT false alarm incidents indicates that the problem has not disappeared--only the causes have changed. It is estimated that in 1978 there were approximately 19,300 false alarms, the equivalent of one in every 10 units triggering unnecessarily. The majority of false alarms can be traced to problems with the G-switch or the lithium battery. Most false alarms occur at airports; approximately 40% at towered airports and 37% at non-towered airports. Field reports on incidents of ELT activations are limited in number and do not provide the in-depth data to effectively evaluate ELT performance. An ELT Effectiveness Report form was generated and provided to the aircraft accident investigatory agencies NTSB and FAA, Civil Air Patrol (CAP) and the AFRCC as part of a NASA/Goddard Space Flight Center Study. Other studies were performed by various organizations and they are reported herein (see References 1-12).

The investigation of ELT system performance determined:

a. The most effective antenna locations for typical high-wing and low-wing aircraft.

b. Environmental effects on ELT electronics and batteries.

c. Small search aircraft receiving systems' sensitivities at 121.5 MHz.

The investigation showed that a search aircraft receiver's sensitivity to an ELT signal is enhanced by 8 to 35 dB (depending on the receiver model) by deactivating the squelch circuit. This is equivalent to extending the distance at which the rescue aircraft can detect the signal by factors of 2.5 to 60. In fact, the ability to detect an ELT signal is more dependent on the type of receiver used and whether squelch is used, than antenna location. It is strongly recommended that SAR missions incorporate deactivation of squelch in their search procedures, because some of the newer radios will not receive an ELT signal unless the squelch is deactivated.

ELT antennas are presently mounted in two general areas on aircraft: In the cockpit area (internal) or on top of the tailcone (external). The results of tests performed on full-scale high-wing and low-wing aircraft indicate the tailcone antenna provided the best overall gain when the aircraft were in an upright position. The internal antenna exhibited the best overall gain when the high-wing aircraft was inverted. Both the internal and external antennas exhibited severe attenuation in gain when the low-wing aircraft was inverted and neither antenna location had a significant advantage over the other. The test results did indicate the internal antenna is affected by the volume within the cabin and the presence of passengers. Either condition can cause radiation pattern distortion. To minimize radio frequency interference with external ELT antennas, the minimum recommended spacing between the ELT antenna and other antennas is 0.25 wavelengths. Using a frequency of 121 MHz, the spacing should be not less than 61 cm, or as otherwise specified by the manufacturer.

Ambient temperature tests on ELT units indicate that technology exists for manufacturing inexpensive ELTs that will operate electronically over the -40 degrees C to 55 degrees C temperature region with a 30% tolerance from the rated voltage. The environmental tests indicate, however, that the ELT system will not radiate more than 50 mW Peak Effective Radiated Power (PERP) after 18 hours of operation at -40 degrees C using alkaline cells (not in parallel) if initial current drain is 35 mA or more. In addition, alkaline cells were tested to characterize their capacity as a function of temperature, load, altitude, thermal cycling, shock and venting.

The test results indicate:

a. All cells can be expected to perform in the same manner as fresh cells after being subjected to 100 G shock forces and 50,000 feet altitude.

b. Thermal stress adversely affects the capacity of many cells and in some cases causes leaks that result in a significant loss in capacity.

c. Operations at temperatures as low as -40 degrees C for 50 hours may be possible using alkaline cells, if future designs carefully balance the desired PERP with a relatively low current drain.

The investigation of ELT placement, mounting and activation within an aircraft identified probable causes of excessive false alarm activation and non-activations of ELTs during crash situations. In addition, guidelines for specific integrity tests for ELT units were defined.

ELT activation problems were investigated in a sampling of ELT units in full-scale aircraft crash tests and in a vertical drop test apparatus which simulated longitudinal crash pulses with superimposed local structural resonances. Data from these tests indicate that the longitudinal crash environment imposed on ELTs is basically a low frequency loading pulse well below 10 Hz with high amplitude, local structural resonances (between 35 to 200 Hz) superimposed on the loading pulse. Many ELT units did not operate within their specified activation thresholds. Other ELTs and typical ELT impact sensors were found to be too sensitive to local structural resonances. The vibration sensitivity of the ELT impact sensor is undesirable since local structural vibrations during normal aircraft operations could cause unwarranted activations or prevent the sensor from properly activating (and latching) the ELT in a crash situation. A low frequency switch design was demonstrated to possess desirable response characteristics by being sensitive to low frequency crash pulses and nonresponsive to higher frequency structural vibrations.

The components of the ELT system must meet several goals of structural attachment and crashworthiness. The recommended goals for attachment are specified as:

a. The ELT components must not come loose from their attachment points.

b. All components necessary to transmit a signal must remain properly connected to each other after the crash.

c. System components and their installation must not degrade existing aircraft structural capability.

d. The structural attachments must provide a load path from the primary structure directly to the activation system.

e. The structural attachment must be designed to minimize vibration of the various components, and in particular, those activation systems which sense crash forces must not be permitted to vibrate so that the crash force pulse is masked by local resonances.

f. The components must have some degree of fire protection.

g. The ELT location shall optimize the likelihood of survival in a crash, consistent with other installation constraints.

To accomplish the crashworthiness goals, specific integrity tests for the ELT system are contained in Section 4.0 of this document.

With the implementation of the recommendations proposed in this document and the adoption of the ELT MOPS contained in RTCA DO-183, the effectiveness of the total ELT, including the search aircraft system, will be greatly enhanced. The controversy that has plagued these devices and limited their usefulness as search and rescue tools will, in the course of time, diminish as non-distress activations decrease and distress signals are more clearly discerned. The goal of improved ELT effectiveness will only be realized if:

a. Proper attention is given to correct placement and mounting.

b. Electronic components and antennas are improved.

c. Search and rescue aircraft receiver utilization and performance are enhanced.

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1.0 INTRODUCTION

Controversy has surrounded the use of the emergency locator transmitter (ELT) since 1970 when Congress mandated its installation in most general aviation aircraft. Normally, ELTs are crash activated and intended to expedite the location of downed aircraft by searchers. However, the ELT has been plagued with many technical problems that severely limit the usefulness of these potentially life-saving devices. A high rate of non-distress activations and failure to activate in crash situations are the two most blatant ELT malfunctions. Data from the National Transportation Safety Board (Reference 1), indicate that the majority of ELT signals originate from the vicinity of airports and most of these are non-distress activations. Suspected sources of unwarranted ELT activations and/or failures are, among others, improper mounting and location in the aircraft, short circuits, ELT sensor vibration sensitivity, battery failures and antenna location. The two broad ELT malfunction problems can be further categorized as indicated in the following paragraphs.

1.1 ELT Activation in Non-Distress Situations

a. Poor G-Switch Specifications: A G-switch designed to meet the specifications contained in Federal Aviation Administration (FAA) Technical Standard Order (TSO) C-91 is, in essence, a vibration sensor. 1/ Slamming doors, rough landings, etc., can and will cause vibrations in the aircraft that provide excursions large enough and of sufficient duration to break the activation threshold and set off the ELT.

A new specification for an ELT crash sensor is contained in RTCA/DO-168 (Reference 2). This specification was derived without extensive experimental verification. Therefore, some of the same problems experienced with the G-switch specifications contained in DO-147 could be inherent in the DO-168 specifications.

b. Improper Handling and Installation Practices: For example, ELTs have been mounted in baggage compartments and other locations where they could be bumped and inadvertently activated. Additional activations have occurred when ELTs were removed from the aircraft and mishandled or stored improperly.

1/ RTCA/DO-147 is incorporated by reference in TSO C-91.