



The European Organisation for Civil Aviation Equipment
L'Organisation Européenne pour l'Équipement de l'Aviation Civile

MINIMUM OPERATIONAL PERFORMANCE SPECIFICATION FOR LIGHTWEIGHT FLIGHT RECORDING SYSTEMS

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FOREWORD

1. This document was prepared by EUROCAE Working Group 77, and was accepted by the Council of EUROCAE on 17 July 2009.
2. EUROCAE is an international non-profit making organisation. Membership is open to manufacturers and users in Europe of equipment for aeronautics, trade associations, national civil aviation administrations and non-European organisations. Its work programme is principally directed to the preparation of performance specifications and guidance documents for civil aviation equipment, for adoption and use at European and world-wide levels.
3. The findings of EUROCAE are resolved after discussion among its members and, where appropriate, in collaboration with RTCA Inc, Washington D.C. USA and/or the Society of Automotive Engineers (SAE), Warrendale, PA, USA through their appropriate committees.
4. This document covers the following areas:
 - Requirements for Cockpit Audio Recording Systems (CARS)
 - Requirements for Aircraft Data Recording Systems (ADRS)
 - Requirements for Airborne Image Recording Systems (AIRS)
 - Requirements for Data-Link Recording Systems (DLRS)
 - Requirements for Automatically Deployable Recorders.
 - Requirements for Combined Recorders
5. This Minimum Operational Performance Specification (MOPS) is arranged in a series of Sections and Parts which allows the selection of the appropriate requirements for any acceptable combination of recording functions within one or more boxes. It is structured such that individual Parts can be revised independently of the others, and without affecting the main body of the document that applies to all Parts.
6. The Performance Specifications detailed in this document are based on the proposed changes to Annex 6 from the ICAO Flight Recorder Panel (FLIRECP). An account has been taken of the regulations issued by various certification authorities together with the advice and recommendations given by accident investigation specialists. The document represents the minimum standards required primarily for the purposes of accident and incident investigation and is expected to become the basis for new equipment and installation standards to be introduced by the certification authorities.
7. EUROCAE performance specifications are recommendations only. EUROCAE is not an official body of the European governments; its recommendations are valid statements of official policy only when adopted by a particular government or conference of governments.
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SECTION 1

GENERAL BACKGROUND

CHAPTER 1-1

INTRODUCTION

1-1.1 PURPOSE AND SCOPE

This document defines the minimum specification to be met for aircraft required to carry lightweight flight recording systems which may record aircraft data, cockpit audio, airborne images or data-link messages in a robust recording medium primarily for the purposes of the investigation of an occurrence (accident or incident). It is applicable to robust on-board recording systems, ancillary equipment and their installation in aircraft.

This document can also be used to give guidance to manufacturers intending to develop or install lightweight flight recording systems which maybe used for or other purposes such as flight training, flight data monitoring.

NOTE: *It is not the intent of this MOPS to provide replacement or acceptable alternatives for the ED-112 specification.*

1-1.1.1 General

This document responds to a need for improved recording of vital information on small aircraft needed for aviation safety investigations. This document defines recording functions (aircraft data, cockpit audio, airborne images and data-link) as individual Parts along with a common section, applicable to all Parts. Parts may be revised independently of each other and independently of the main body of this document.

1-1.1.2 Description of Content

This document is divided in to three sections, and four parts, as shown in Figure 1-1.1.

Section 1 describes typical equipment applications and operational objectives. Background material and accident/incident investigation considerations are included together with a description of the recording systems. Definitions and abbreviations essential to proper understanding of this document are provided.

Section 2 defines the requirements that are common to all robust recording systems.

Section 3 defines the requirements that are specific to deployable recorders.

Part I defines the requirements that are specific to Cockpit Audio Recording Systems.

Part II defines the requirements that are specific to Aircraft Data Recording Systems.

Part III defines the requirements that are specific to Airborne Image Recording Systems.

Part IV defines the requirements that are specific to Data-Link Recording Systems.

All flight recording systems shall be designed to meet the criteria of Sections 1 and 2 plus the relevant function specific section(s) and Parts.

1-1.2 APPLICATION

1-1.2.1 Cockpit Audio Recording System (Part I of this document)

The Cockpit Audio Recording System (CARS) records the acoustic environment of the cockpit and may include voice communications between pilots, voice communications transmitted from or received in the aircraft by radio, and voice communications of pilots in the cockpit.

1-1.2.2 Aircraft Data Recording System (Part II of this document)

The Aircraft Data Recording System (ADRS) records parameters necessary to accurately determine the aircraft movement. The specific parameters required will depend upon aircraft complexity, data sources available on the aircraft, and the need to record certain essential parameters.

1-1.2.3 Airborne Image Recording System (Part III of this document)

The Airborne Image Recording System (AIRS) records images of the cockpit environment and may include control inputs, external views, instruments and control panels.

1-1.2.4 Data-Link Recording System (Part IV of this document)

The Data-Link Recording System (DLRS) records those messages that are relayed over a digital data-link (rather than by voice communication) and which authorise, or control directly or indirectly, the movement of the aircraft.

1-1.2.5 Multi-Function Recording

It is acceptable to record audio, data, images and data-link, or a combination of two or more of these functions in a single memory module in order to comply with this MOPS.

1-1.3 TECHNICAL BACKGROUND

1-1.3.1 Units of Measurement

The measurements are expressed, where appropriate, in SI units.

1-1.4 “SHALL” AND “SHOULD” PHRASES

a. “Shall”

The use of the word “Shall” indicates a mandatory criterion to comply with this specification and no alternative may be applied.

b. “Should”

The use of the word “Should” indicates that the criterion is recommended but not mandatory to comply with this specification.

1-1.5 COMMON DEFINITIONS AND ABBREVIATIONS

The definitions and abbreviations of ICAO Annex 5, Annex 6 and Annex 10 are applicable.

1-1.5.1 Definition of Terms

The following definitions are provided for the terms that are used in this document.

AAC

The ICAO definition of aeronautical administrative communication (AAC) is communication used by aeronautical operating agencies related to the business aspects of operating their flights and transport services. This communication is used for a variety of purposes, such as flight and ground transportation, bookings, deployment of crew and aircraft or any other logistical purposes that maintain or enhance the efficiency of overall flight operation. (Annex 10, Part III).

NOTE: The airlines use the term airline operational communication (AOC) for this type of communication. ICAO uses the abbreviation “AOC” for different purposes. See below. This document uses the ICAO meanings for these terms.

Airborne Image Recording System

An airborne image recording system (AIRS) is a device that uses an image sensor(s) to collect and record visual information from various parts of the aircraft.

Aircraft Data Recording System

An aircraft data recording system (ADRS) is a device or devices that use a combination of data providers to collect and record parameters that reflect the state and performance of an aircraft.

AOC

The ICAO definition of aeronautical operational control (AOC) is communication required for the exercise of authority over the initiation, continuation, diversion or termination of flight for safety, regularity and efficiency reasons (Annex 10, Part III).

APC	Aeronautical passenger communication (APC) is data-link communication relating to the non-safety audio and data services to passengers and crew members for personal communication.
Approval	An act or instance of expressing a favourable opinion or giving formal or official sanction.
ATSC	The ICAO definition of air traffic service communication (ATSC) is communications related to air traffic services including air traffic control, aeronautical and meteorological information, position reporting and services related to safety and regularity of flight. This communication involves one or more air traffic service administrations. This term is used for purposes of address administration. (Annex 10, Part III).
ATC	Air Traffic Control. In this context, the use of safety-related data-link communication for the purpose of: - a Preventing collisions between aircraft and, on the manoeuvring area, between aircraft and obstructions; - b Expediting and maintaining an orderly flow of traffic.
ATM	Air Traffic Management. A system consisting of a ground and air part, to ensure the efficient and safe movement of aircraft during all phases of operation. The system includes equipment, people and procedures.
ATS	Air Traffic Services. A generic term meaning variously, flight information service, alerting service, air traffic advisory service, air traffic control service (area control service, approach control service or aerodrome control service).
Camera	Within this document includes thermal imagers, image sensors and other electronic pick-up devices.
Certification	Legal recognition by a certification authority that a product, service, organisation or person complies with the applicable requirements. Such certification comprises the activity of technically checking the product, service, organisation or person and the formal recognition of compliance with the applicable requirements by issue of a certificate, licence, approval or other documents as required by national laws and procedures. In particular, certification of a product involves: - a the process of assessing the design of a product to ensure that it complies with a set of standards applicable to that type of product so as to demonstrate an acceptable level of safety, - b the process of assessing an individual product to ensure that it conforms with the certificated type design, - c the issue of a certificate required by national laws to declare that compliance or conformity has been found with applicable standards in accordance with items (a) or (b) above.
Certification Authority	The organization or person responsible within the state or country concerned with the certification of compliance with applicable requirements.
Channel	A path that allows a signal to be transmitted or processed in a deterministic manner independently of other signals.
CNS	Communications, Navigation and Surveillance. The way in which enhanced capabilities of satellite-based navigation and digital data-link communication systems will permit the next generation of ATM systems to combine the features of ADS and CPDLC with the conventional ATC functions.
Cockpit Audio Recording System	A Cockpit Audio Recording System (CARS) is a device that uses a combination of microphones and other audio and digital inputs to collect and record the aural environment of the cockpit and communications to, from and between the pilots.

Correlation	The parallel relationship of two or more corresponding events.
Corrupted Data/Record	Any data item or record which has been altered in a way other than the one intended by design.
Crash	Refer to "Reportable Accident".
Crew member	A person assigned to perform duties in an aircraft during flight.
Data-link	Aeronautical two-way data communications.
Data-Link Recording System	A Data-Link Recording System (DLRS) is a device that records those messages whereby the flight path of the aircraft is authorised, controlled directly or indirectly, and which are relayed over a digital data-link rather than by voice communication.
Deployable Recorders	A deployable recorder is any robust recording system (ADRS, CARS or other) which is designed to be automatically separated from the aircraft only in the event of an accident.
Down-link	Transmission from air to ground.
Download	Means of copying the digital data (also known as "raw" data) stored in the robust memory module for replaying at a later time.
Flight Recording System	Any type of recording system installed in the aircraft for the purpose of complementing accident/incident investigation or flight analysis.
Follow-on Installation	A production series installation performed in accordance with a previously certified configuration (e.g. a follow-on from a Type Certificate (TC), Supplemental Type Certificate (STC) or Major Modification).
Incident	Any fortuitous or unexpected event, not being a reportable accident, by which the safety of an aircraft or any person is threatened.
Initial Installation	The installation for initial certification of the recording system.
Interconnection Harness	The electrical wiring that connects one system functional element to another e.g. between a robust memory module and the flight recording system interface electronics.
Interphone	An audio system that enables crew members to communicate with each other in the cockpit or with other personnel elsewhere on the aircraft.
Long term RMS	A signal that remains constant for a period of several seconds.
Maintenance	The ongoing process of inspections, servicing, modification and repair throughout the lifetime of an aircraft needed to ensure that the aircraft remains in compliance with the certificated type design and consistent with a high standard of safety; this includes modifications made mandatory by the authorities.
Memory Device	The smallest separate physical element in which data can be stored and recovered (e.g. chips).
Memory Module	The unprotected assembly containing the memory devices used to retain the recorded data.
Nominal	Value commonly used and considered between the minimal and maximal values.
Operator	A person, organisation or enterprise engaged in or offering to engage in an aircraft operation.
Recording	The act of making certain data persistent, with a view to subsequent replay or analysis.
Replay	The act of reconstructing the recorded situations/scenarios.

Reportable Accident

As defined by ICAO, an occurrence associated with the operation of an aircraft which takes place between the time when any person boards the aircraft with the intention of flight and such time as all persons have disembarked there from, in which:

- a any person suffers death or serious injury while in or upon the aircraft or by direct contact with any part of the aircraft (including any part which has become detached from the aircraft) or by direct exposure to jet blast, except when the death or serious injury is from natural causes, is self inflicted or is inflicted by other persons or when the death or serious injury is suffered by a stowaway hiding outside the areas normally available in flight to the passengers and crew members of the aircraft; or
- b the aircraft incurs damage or structural failure, other than:
 - 1) engine failure or damage, when the damage is limited to the engine, its cowling or accessories,
 - 2) damage limited to propellers, wing tips, antennae, tyres, brakes, fairings, small dents or punctured holes in the aircraft skin which adversely affects its structural strength, performance or flight characteristics and which would normally require major repair or replacement of the affected component, or
- c the aircraft is missing or is completely inaccessible.

Retrieval

Retrieval of data from the recording medium for the task of presenting the data for analysis purposes.

Robust Memory Module
Robust Recorder

The protected enclosure containing the memory module(s).

The protected part of the flight recording system which comprises an aircraft-mountable enclosure containing the memory module and which may contain other ancillary electronics.

Segregation

The physical separation of memory devices within a recording system robust module.

Sidetone

Output audio level control (through the transceiver and interphone (including the sound of the speaker's voice and background noise as picked up by the microphone and received audio) reproduced in the speaker's own head set.

Simulation

The use of a laboratory-installed system of avionic components ('test bench') representative of the aircraft in which the recording system is to be certified. The test bench may be controlled by a computer-based system including analogue and discrete inputs, to create specific operating conditions, such as 90° pitch up, or other conditions that cannot be tested in flight or are difficult to test on the aircraft. The test bench should be configured such that the computer or analogue inputs to the system drive the instruments and displays in a way representative of the aircraft. All avionic components installed in the test bench should be either of production standard or representative of the final production configuration.

Software

Computer programs and, possibly, associated documentation and data pertaining to the operation of a computer system.

Solid-State

An electronic device that is capable of performing a function without use of moving parts, using semiconductor material or similar.

Sound Pressure Level

In decibels (dB), the Sound Pressure Level is 20 times the logarithm to the base 10 of the ratio of the pressure of this sound to the reference pressure. The reference pressure is 20 µPa, and shall be explicitly stated along with the Sound Pressure Level, such as: _dB above 20 µPa.

Synchronisation

A technique to align two independent events to a common point in time.

Telephone	Audio reception (radio or interphone)
Test	A means of demonstrating compliance, using a test aircraft in a configuration representative of the configuration to be certified, in a ground and/or flight environment.
Timebase	A signal which provides the reference time for other recorded signals.
Timescale	A defined scale to be used in relation to the timebase signal.
Up-link	Transmission from ground to air.
Volume control setting	Channel gain level or equivalent.

1-1.5.2 Abbreviations

AAC	Aeronautical Administrative Communication
AC	Alternating Current/Advisory Circular
ACMS	Aircraft Condition Monitoring System
ADRS	Aircraft Data Recording System
ADS	Automatic Dependent Surveillance
ADS-B	Automatic Dependent Surveillance - Broadcast
ADS-C	Automatic Dependent Surveillance - Contract
AF	Audio Frequency
AFN	ATS Facility Notification
AGC	Automatic Gain Control
AIRS	Airborne Image Recording System
ANSI	American National Standards Institute
AOC	Aeronautical Operational Control
APC	Aeronautical Passenger Communication
ARINC	ARINC (Aeronautical Radio Inc.)
ATC	Air Traffic Control
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
ATS	Air Traffic Services
ATSU	Air Traffic Services Unit
BITE	Built-in Test Equipment
Btu	British Thermal Units
C	Celsius
CARS	Cockpit Audio Recording System
CM	Context Management
CMS	Condition Monitoring System / Central Maintenance System
CMU	Communications Management Unit
CNS	Communications, Navigation and Surveillance
CPDLC	Controller / Pilot Data-Link Communications
D-ATIS	Digital Automatic Terminal Information Services
D-OTIS	Data-link Operational Terminal Information Services
dB	Decibels

DC	Direct Current
DCL	Departure Clearance
DL	Data-Link
DLIC	Data-Link Initiation Capability
DLRS	Data-Link Recording System
EIRP	Effective Isotropic Radiated Power
ELT	Emergency Locator Transmitter
EPR	Engine Pressure Ratio
EUROCAE	European Organisation for Civil Aviation Equipment
FANS 1/A	Future Air Navigation Systems for Boeing and Airbus aircraft
FLIRECP	Flight Recorder Panel (of ICAO)
FMS	Flight Management System
FRED	Flight Recorder Electronic Documentation
ft	Feet
g	Gravitational Acceleration
GPS	Global Positioning System
HF	High Frequency (3-30 MHz)
Hz	Hertz
ICAO	International Civil Aviation Organization
IEC	International Electrotechnical Commission
ILS	Instrument Landing System
in	Inches
kg	Kilograms
kHz	Kilohertz
kN	Kilonewtons
kPa	Kilopascals
kt	Knots
kW	Kilowatts
L	Left
lb	Pounds
LSB	Least Significant Bit
m	Metres
m/s	Metres per second
MASPS	Minimum Aviation System Performance Specification
mb	Millibars
MEMS	Micro Electromechanical Systems
mm	Millimetres
Mode-S	Mode Selective
MOPS	Minimum Operational Performance Specification
ms	Milliseconds

N1	Fan Speed
NF	Free Power Turbine Speed
NG	Gas Generator Speed
NM	Nautical Miles
NP	Propeller Speed
NR	Rotational Speed
OCL	Oceanic Clearances
Pa	Pascal
PA	Public Address
PCM	Pulse Code Modulation
ppm	Parts per million
PTT	Push To Talk
R	Right
rms	Root Mean Square
RPM	Revolutions Per Minute
RTCA	RTCA Inc.
s	Seconds
SAE	Society of Automotive Engineers
SARPs	Standard and Recommended Practices
SATCOM	Satellite Communications
SNR	Signal-to-Noise Ratio
SPL	Sound Pressure Level
TCAS	Traffic Collision Avoidance System
THD	Total Harmonic Distortion
UTC	Universal Time Co-ordinated
V	Volts
VHF	Very High Frequency (30-300 MHz)

1-1.6

LIST OF REFERENCE DOCUMENTS

ARINC Specification 647A - Flight Recorder Electronic Documentation (FRED)

EUROCAE ED-12B/RTCA DO-178B - Software Considerations in Airborne Systems and Equipment Certification

EUROCAE ED-14F/RTCA DO-160F - Environmental Conditions and Test Procedures for Airborne Equipment

EUROCAE ED-62 - Minimum Operational Performance Specification for Emergency Locator Transmitter

EUROCAE ED-78A/RTCA DO-264 - Guidance Material for the Establishment of Data Link supported ATS Services

EUROCAE ED-93 - Minimum Aviation Systems Performance Specification for CNS/ATM Message Recorder Systems

EUROCAE ED-112 - Minimum Operational Performance Specification for crash protected airborne recorder systems

ICAO International Standards and Recommended Practices - Operation of Aircraft, ANNEX 6, Parts I, II and III

ICAO SARPS - CNS/ATM Package 1 "Manual of Technical Provisions for the ATN" - ICAO Doc 9705 - AN956 - 1998

IEC 225 - 3rd Octave Filters (1966)

IEC 225 - Octave, Half Octave and Third Octave Band Filters Intended For The Analysis Of Sounds And Vibrations (1966)

IEC 651- Sound Level Meters (1979)

RTCA DO-214 - Audio Systems Characteristics and Minimum Operational Performance Standards for Aircraft Audio Systems and Equipment

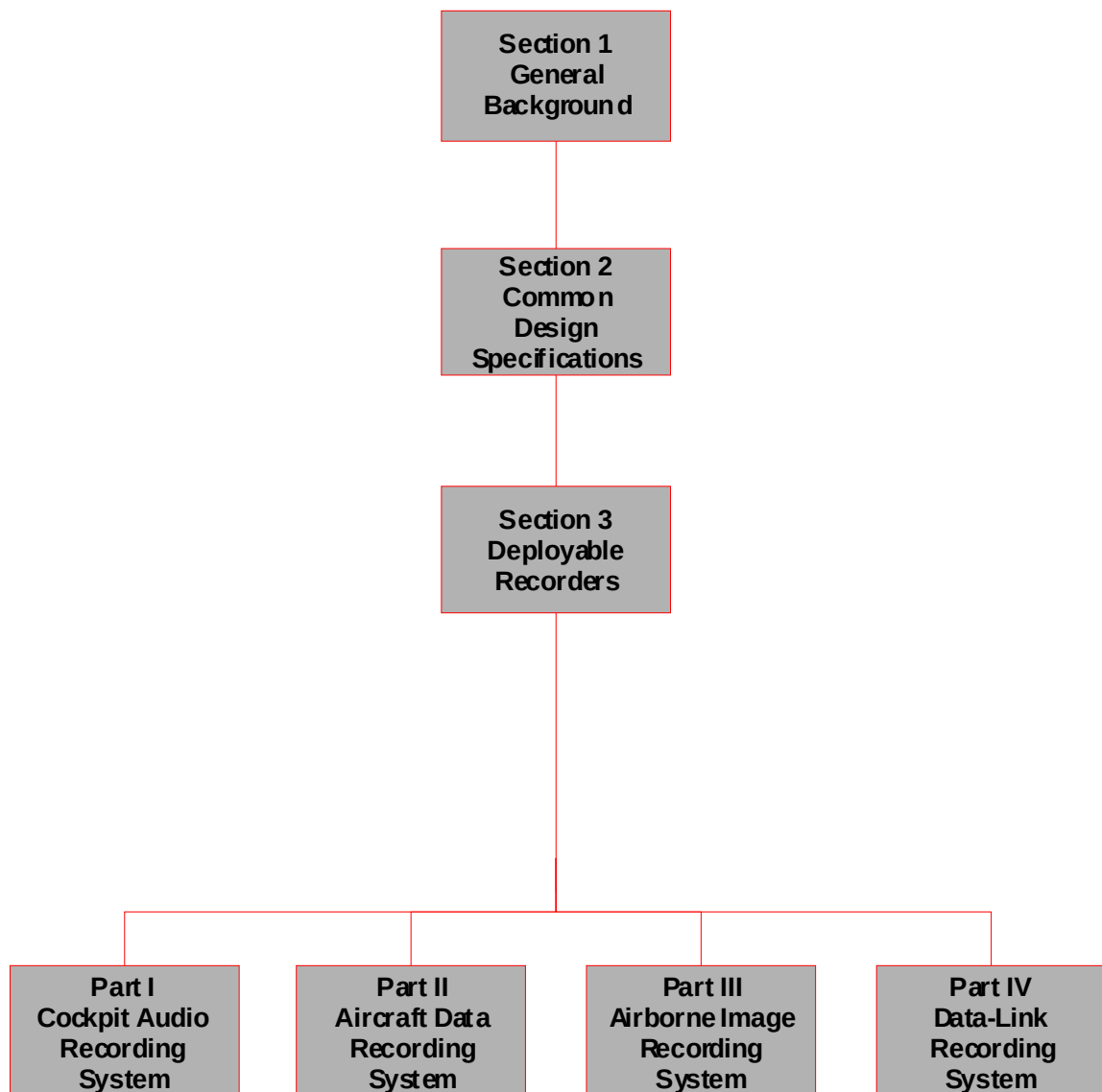


FIGURE 1-1.1: ORGANISATION OF DOCUMENT

SECTION 2

COMMON DESIGN SPECIFICATIONS

CHAPTER 2-1

GENERAL

2-1.1 INTRODUCTION

This chapter establishes the design considerations and general specifications for the equipment specific to lightweight flight recording systems.

2-1.2 RECORDING SYSTEM TECHNOLOGY

The flight recording system shall use a digital method of recording. Magnetic tape, wire and photographic methods shall not be used.

Compliance with this section will ensure that recording systems will perform their function under the conditions encountered in aircraft operations.

2-1.3 AIRWORTHINESS AND CERTIFICATION

2-1.3.1 Safety

The flight recording system equipment shall not, under normal or fault conditions, impair the airworthiness of the aircraft in which it is installed. Particular attention shall be directed to the needs of flight critical systems to ensure appropriate physical and electrical segregation of the information sources at the recording system interface.

2-1.3.2 Maintenance

The maintenance tasks required to ensure the serviceability and continued airworthiness of the flight recording systems shall be established by the equipment manufacturers and the equipment installers. The maintenance requirements for specific types of flight recording system are discussed in the relevant chapters of this document.

2-1.3.3 Flammability

Except for small quantities of materials used for heat insulation or dissipation (such as ablative paints and thermo-chemical compounds) and small parts (such as knobs, fasteners, seals, grommets and small electrical parts) that would not contribute significantly to the propagation of a fire, all materials used shall be self-extinguishing.

2-1.3.4 Documents for Compliance with this Specification

The following documents shall be made available to the accident investigation authority:

To establish compliance of the recorder with this specification:

- a Instructions which would enable an accident investigation authority to obtain or manufacture any special tools or interface equipment required for the retrieval of the recorded information,
- b Details of the procedures to be followed for retrieval of the recorded information from an undamaged recording system,
- c Details of the procedures to be followed for retrieval of the recorded information from any memory device used within the robust memory module removed from a crash damaged recording system, including details on how data is organised in the memory,

To establish compliance of the installation with this specification:

- d Interface documentation, including conversion and logic data for reproduction of the original information.

The certification authority should involve the relevant accident investigation authority in the assessment of the above documents. The assessment should confirm that

suitable equipment and information will be readily available to the accident investigation specialist to allow retrieval of the recorded information in a timely manner.

The information provided should enable the accident investigators to produce, within 24 hours of receipt of an undamaged recording medium, the material necessary to support their investigations.

2-1.4 MONITORING OF PROPER OPERATION

There shall be aural or visual means for pre-flight checking the flight recording system(s) for proper recording of the information in the recording medium.

The monitor(s) shall operate throughout the flight. However, an indication of in-flight failure may be suppressed until the aircraft has completed its flight.

NOTE: *An acceptable means of compliance would be to provide system status monitor(s) and built-in test functions which would detect and indicate a failure of the flight recording system due to any of the following:*

- a. *Loss of system electrical power,*
- b. *Failure of the acquisition and processing equipment,*
- c. *Failure of the recording medium,*
- d. *Failure of the recording system to store the information in the recording medium as shown by checks of the recorded material including, if reasonably practicable, correct correspondence with the inputs,*
- e. *The absence of the recording system and/or the acquisition equipment.*

2-1.5 RECORDER OPERATION

The flight recording systems shall start to record prior to the aircraft moving under its own power and record continuously, in accordance with the requirements of this MOPS, until the termination of the flight when the aircraft is no longer capable of moving under its own power. In addition, depending on the availability of electrical power, the recording system should start to record as early as possible during the cockpit checks prior to engine start at the beginning of the flight until the cockpit checks immediately following engine shutdown at the end of the flight.

2-1.6 BIT ERROR RATE

The bit error rate arising from differences between the input and the retrieved data caused by corruption of the data during processing, recording and retrieval shall not exceed one error in 10^5 bits.

2-1.7 SOFTWARE MANAGEMENT

Where equipment uses digital computer techniques the software practices shall follow the applicable guidelines specified in document EUROCAE ED-12B / RTCA DO-178B or subsequent issue. Software for recording functions shall be shown to comply with the guidelines applicable to at least Level E.

2-1.8 EQUIPMENT DESIGN SPECIFICATIONS

The design specifications for each recording system type are detailed in Parts I to IV.

2-1.9 RECORDING SYSTEMS SYNCHRONISATION

Correlation between onboard flight recording systems is recommended.

NOTE: *As far as reasonably practicable, all airborne recordings should be related to a single time reference such as GPS time. This helps establish an absolute time reference for recordings or partially recovered recordings.*

2-1.10 TIME BASE STABILITY

A stable time base or reference signal shall be used having an average accuracy of at least 0.1% (1000 ppm) obtained during information retrieval.

The recorded time base shall be reproducible with an accuracy of 0.1% (1000 ppm), averaged over a period of at least 1 minute.

2-1.11 MEANS OF HEAT DAMAGE ASSESSMENT FOR THE RECORDING MEDIUM

Where the recording medium cannot be readily and reliably inspected, means shall be provided to enable the accident investigator to determine, prior to an attempted replay, if the recording medium has been subjected to an excessive level of heat where the survival of the medium may be in doubt.

2-1.12 RETENTION OF RECORDED INFORMATION

Following the removal of electrical power to the recorder, the recording medium shall be capable of retaining the information recorded during the preceding operating time for a period of at least 2 years.

2-1.13 DIGITAL RECORDING AND RETRIEVAL CHARACTERISTICS

The organisation of the recording medium and the recording shall be such that:

- a For an undamaged, fully serviceable memory with a normal recording, the recorded information is readily retrievable.
- b For an undamaged, fully serviceable recording medium with a corrupted record, the information can be retrieved, using special techniques if needed, for the periods ending one second, maximum, prior to the period of corruption, and commencing one second, maximum, after the period of corruption.
- c For a damaged or partially failed memory, the available information can be retrieved using special techniques, as required.
- d The organisation of the memory shall contain provisions to detect corruptions in the recording or retrieval, or data losses due to medium management. These provisions could include time stamps, sequence numbers, and block checksums.

The manufacturers shall make available to the accident investigation community the detailed information and/or tools required to enable data recovery down to memory chip level (or equivalent).

2-1.14 CRASH SURVIVAL**2-1.14.1 Information Retrieval**

The recording system shall be constructed such that the information in the recording medium can be retrieved using specified techniques as defined by the manufacturer.

2-1.14.2 Survival Criteria (Fixed Recording Systems)

- a The robust memory module or the robust recorder shall be capable of preserving the recorded information when subjected to the following sequence of tests:

Impact shock followed by static crush then high temperature fire.

- b The same test article shall be used for all of the tests required by the sequence.
- c The need for repairs to the recording medium as a consequence of the crash survival tests shall be minimised. At the conclusion of the test sequence, it shall be possible to recover the data from the recording medium with only simple repairs such as replacing the interconnection harness to the robust memory module. Re-soldering memory devices or ancillary components is not considered a simple repair.
- d Test procedures are defined in Chapter 2-4.

2-1.14.3 Survival Criteria (Deployable Recorders)

- a The robust memory module or the robust recorder shall be capable of preserving the recorded information when subjected to the following sequences of tests.

Sequence 1: Impact shock followed by beacon transmission, then seaworthiness.

Sequence 2: Impact shock followed by high temperature fire.
- b The same test article shall be used for all of the tests required by a sequence. It is not required for one test article to be subjected to both sequences.
- c The need for repairs to the recording medium as a consequence of the crash survival tests shall be minimised. At the conclusion of a test sequence, it shall be possible to recover the data from the recording medium with only simple repairs such as replacing the interconnection harness to the robust memory module. Re-soldering memory devices or ancillary components is not considered a simple repair.
- d Test procedures are defined in Chapter 2-4.

2-1.14.4 Identification

A high proportion of the area of the outer surfaces of the robust memory module shall be coloured bright orange. The outer surfaces of the robust memory module shall be inscribed with the following black letters as large as practicable: "FLIGHT RECORDER".

The identification requirements shall be met after the robust memory module has been subjected to the tests, with the exception of the fire tests, specified in Chapter 2-4 or Chapter 2-4, as applicable.

CHAPTER 2-2**MINIMUM PERFORMANCE SPECIFICATION UNDER STANDARD TEST CONDITIONS
(FIXED RECORDING SYSTEMS)****2-2.1 INTRODUCTION**

The requirements for minimum performance under standard test conditions are flight recording system specific and are detailed in Chapter 3 of each of the relevant function specific Parts of this MOPS.

CHAPTER 2-3

MINIMUM PERFORMANCE SPECIFICATION UNDER ENVIRONMENTAL TEST CONDITIONS (FIXED RECORDING SYSTEMS)

2-3.1 INTRODUCTION

This chapter specifies environmental test conditions. The equipment shall be tested as defined in EUROCAE ED-14F/RTCA DO-160F "Environmental Conditions and Test Procedures for Airborne Equipment", or subsequent issue, using the categories most applicable to the aircraft type, and the location of the equipment to be installed. The final choice of test classes within each environmental category will be defined by the equipment manufacturer. The objective of this level of testing is to prove that the equipment does not present a hazard to the aircraft, and can survive and continue to operate under the environmental conditions to which it will be subjected throughout its life.

Specific testing may be required to demonstrate that the equipment performs its intended functions when operated over the full environmental conditions to which it has been declared to comply, and throughout the extremes which it may be subjected to during an incident or accident. These tests can be undertaken during the specified ED-14F/RTCA DO-160F tests, or separately.

For the purposes of these environmental tests, the term 'equipment' shall be interpreted to include the recording equipment together with its accessories such as shock or anti-vibration mounts, where these are included as part of the installation for that particular aircraft type and equipment location.

Analysis may be substituted for a test where its use can be shown to produce equivalent evidence of compliance.

NOTE: Additional tests applicable to robustness of the recording medium are required for this specific equipment, as it is necessary for data to be recoverable following incidents and accidents well outside the standard environmental conditions defined in ED-14F/RTCA DO-160F. The extent of such tests is stated in Chapter 2-4.

CHAPTER 2-4

TEST PROCEDURES FOR CRASH SURVIVAL (FIXED RECORDING SYSTEMS)

2-4.1 GENERAL

This section specifies crash survival tests to be applied to the fixed robust recorder or the robust memory module to demonstrate compliance with paragraph 2-1.14.2.

- a Prior to commencement of any crash survival testing a known, random digital data test pattern shall be recorded in the robust memory module.
- b After the test sequence has been performed, this test pattern shall be readily recoverable to establish that the bit error rate defined in Chapter 2-4 has not been exceeded.
- c On completion of a crash survival test sequence, the recording medium may be cleaned and dried. Alterations or repairs between tests shall not be made.

NOTE 1: *Microscopic examination of the surface characteristics of memory devices is not acceptable as means of data recovery.*

NOTE 2: *The repair of individual memory devices is not permitted.*

2-4.2 TEST PROCEDURES

2-4.2.1 Standard Test Conditions

For the purposes of this chapter, standard test conditions are defined in documents EUROCAE ED-14F/RTCA DO-160F, "Environmental Conditions and Test Procedures for Airborne Equipment", paragraph 3.5 as:

- a Temperature : +15 to +35°C
- b Relative Humidity : Not greater than 85%
- c Ambient Pressure: 84 to 107 kPa

2-4.2.2 Impact Shock

Subject the test article to an impact shock applied in each direction successively along three mutually orthogonal axes of the test article. The energy content of the impact shock shall be equal to or greater than that provided by a half-sine wave shock of 5 +/- 1 millisecond duration and a peak acceleration of 9806 m/s² (1 000 g). An acceptable means of compliance is to generate a trapezoidal shock that has an energy content equivalent to that of a half-sine wave as specified above, as shown in Figure 2-4.1 . The shock impulse shall be measured using a calibrated accelerometer and associated instrumentation having a 3dB response over a range of at least 5 to 250 Hz. The following test procedures apply:

- a The test article shall be mounted on the shock test machine in such a manner that it can be subject to shock impulses in each direction successively along the three mutually orthogonal axes of the test article.
- b Apply a 1 000 g shock impulse of duration 5 (±1) ms, to the article test in a direction coincident with the first orthogonal axis.
- c Reset the activation mechanism.
- d Repeat step b and c above, applying the impulse shock in the remaining five directions.

2-4.2.3 Static Crush

- a Subject the test article to a static crush force of 4.54 kN (1,000 lb) applied continuously for a period of 5 minutes. At least four points on the test article, irrespective of its shape, shall be tested including, where applicable, each of the main diagonals and each of the main faces.
- b The minimum number of tests to be performed will depend on the shape of the test article. Where a spherical shaped design is used, at least four tests will be required. For a cuboid shaped design, a total of seven tests will be required e.g. 3 faces plus 4 diagonals.
- c The static crush test may be performed using a hydraulic press and pressure gauge.
- d The test article may be supported in the press by means of circular resilient pads with a diameter of 5 cm (2 in) and a thickness of 1.25 cm (0.5 in).
- e The crush force shall be adjusted following any collapse to restore the required pressure for the full 5 minute period.

2-4.2.4 High Temperature Fire

- a Subject the test article to a fire producing a minimum thermal flux of 158 kW/m² (50 000 Btu/ft²/hour). The entire external surface area of the test article shall be exposed to the fire for a continuous period of at least 15 minutes.

The flame temperature should be 1 100°C nominal. The turbulence and local flame cooling due to the test article under test may cause the temperature to vary between 950°C and 1 100°C. However, the minimum thermal flux stated herein shall be maintained for the duration of the test and monitored by suitable instrumentation. Shielding is not permitted.

An acceptable method is to subject the test article to a fire test with flames generated by an arrangement of burners either gas or oil fired. A mix of air and propane gas is the preferred fuel since the mixture burns cleanly and is readily controllable. The mixture is adjusted to obtain a stable flame.

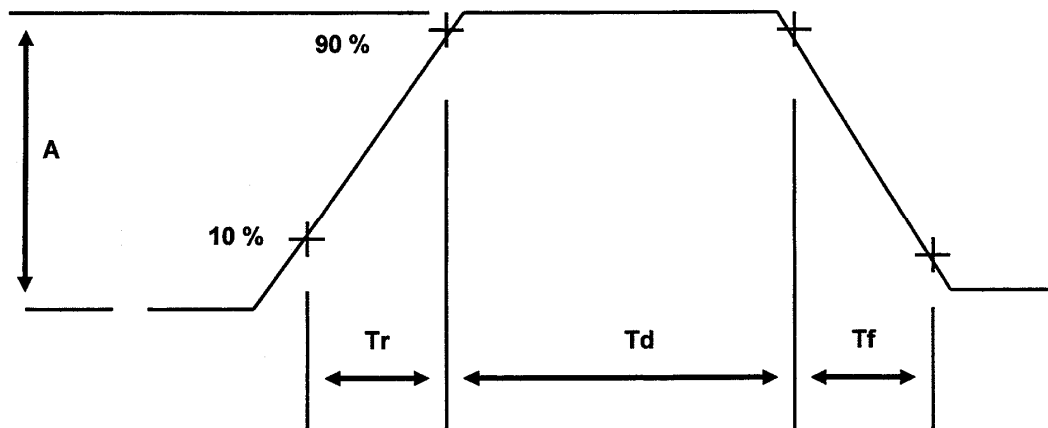
- b At the start of the fire tests precondition the test article to a stable internal temperature equivalent to that reached after operation at ambient pressure and temperature of 25°C ±5°C. Electronic components external to the robust memory module may be removed.

NOTE: *As per ED-14F/DO-160F section 2.1, the equipment is considered stabilised when the temperature of the largest internal mass of the equipment does not vary by more than 2°C per hour. When temperature measurement of the largest internal mass is not practical, the minimum time considered applicable for temperature stabilization shall be two hours.*

- c Where the effectiveness of the fire protection material decreases during normal operation and/or storage of the recording system, precondition the protective material to simulate the effects of ageing e.g. by means of extended pressure and temperature cycles.
- d A water calorimeter shall be used to calibrate the burner array before the fire test is performed. The calorimeter shall be of the dimension shown in Figure 2-4.2.

Where other burner calibration methods are used such as electronic radiometry, the method shall be validated against the calorimeter method.

- e Figure 2-4.3 shows an example of a suitable test arrangement using propane gas burners. The calorimeter is supported on steel angle sections approximately 0.5 m (20 inches) above the ground. The water inlet and outlet pipes are passed through an insulating block wall. The purpose of the wall is to reflect heat onto the rear of the calorimeter (or recorder) and to prevent the water pipes from absorbing heat. The short section of pipes between the wall and the calorimeter should be well insulated.
- f The number and capacity of burners, their positions and the gas pressure should be adjusted to ensure the required criteria of flame coverage, thermal flux and nominal flame temperature are met. It is important that the source of water for the calorimeter, and the source of fuel for the fire, can maintain the required flow rates for the full test period. The flame temperature should be monitored continuously by thermocouples placed approximately 25 mm (1 inch) from the surface of the robust memory module or recording system at the approximate centre of a minimum of three faces. Burner output should be set by adjusting the individual burner gas valves.
- g The thermal flux (Q) is given by:
- $$Q = \frac{dT \times F \times SH}{A \times C} \quad \text{W/m}^2$$
- Where
- dT = temperature rise in cooling water (°C)
 - F = flow rate of cooling water (kg/s)
 - SH = specific heat of cooling water (4187 Joules/kg/°C)
 - A = surface area of calorimeter (sq. metre)
 - C = Absorption Constant. (A value of 0.5 shall be used)
- h Once the required test conditions have been established, the gas pressure should be noted and the supply shut off at the main valve. The individual burner gas valves should not be touched.
- i The test article shall be substituted for the calorimeter, by placing it at the centre of the fire. Where practicable, the internal temperature of the test article should be monitored in order to determine the margin of protection obtained for the particular recording medium. If construction is such that a significant portion of the robust memory module or recording system has been damaged as a result of previous tests and is likely to melt or burn away during the test, the robust memory module or recording system shall be supported in such a way that the robust memory module will be subjected to the full thermal flux for the duration of the test.
- j The fire test is started by turning on the main gas valve. If necessary, this valve should be used to control the gas pressure to the level noted in step h above. Flame temperature, as indicated by the external thermocouples, shall be continuously monitored. A higher temperature than that achieved during the calorimeter test may be observed due to the presence of the robust memory module or recording system. The burner outputs shall not be altered to compensate for this difference.
- k At the end of the test period, the burners should be shut off and the robust memory module or recording system be allowed to cool naturally in ambient conditions. It is permissible to remove the recording system from the vicinity of the support arrangement.



$T_r = 3.0 \text{ ms}$ maximum

$T_d = 2.2 \text{ ms}$ minimum

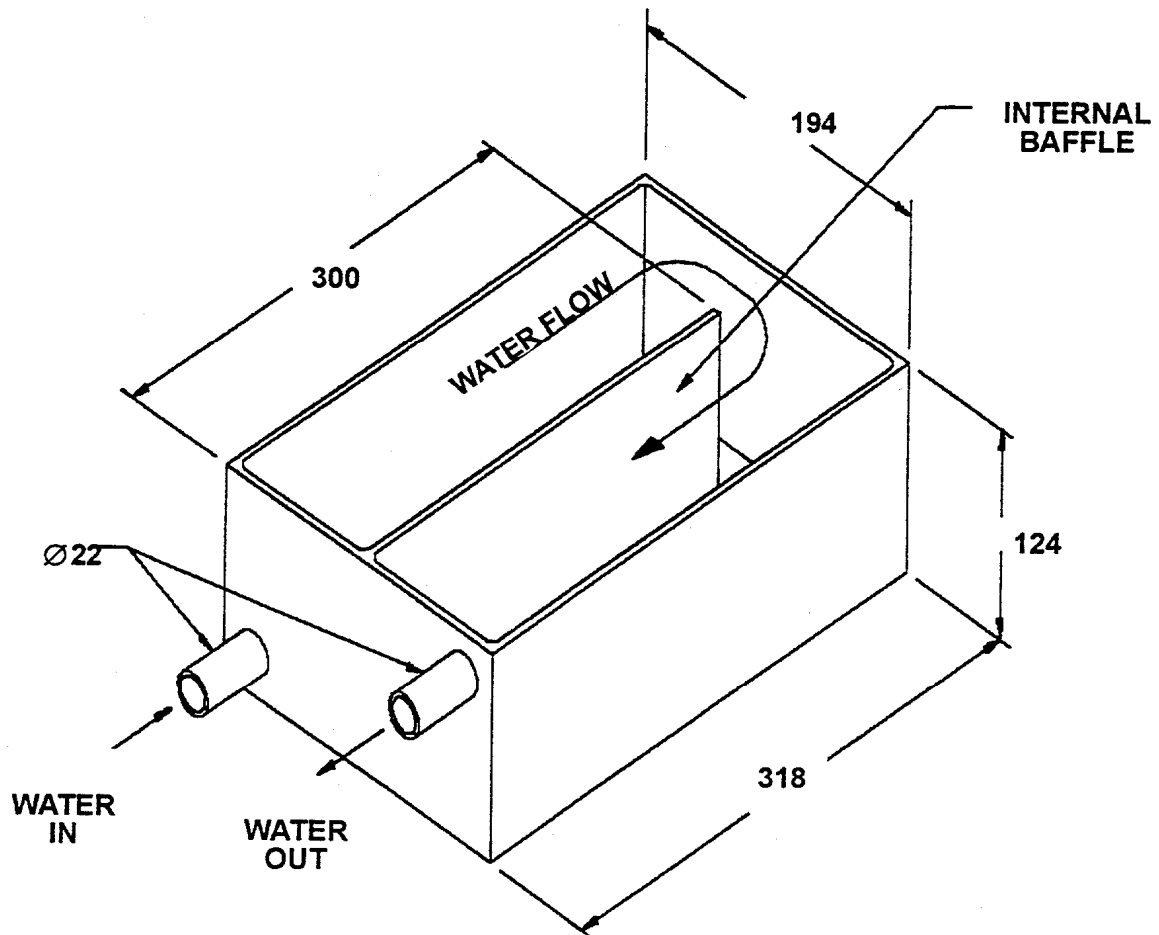
$T_f = 0 \text{ ms}$ minimum

$A = 1\,000 \text{ g}$ (9806 m/s^2) minimum

NOTE 1: The intervals T_r and T_f shall be such that the area under the curve is equal to or greater than that of a half-sine wave shock pulse i.e. $\text{Area} = (5 \times 10^{-3}) \times 1000 / (\pi/2) = 3.183 \text{ g-seconds}$

NOTE 2: In practice, significant ringing of the shock pulse will be observed. Averaging may be applied to establish the effective pulse shape.

FIGURE 2-4.1: TRAPEZOIDAL IMPACT SHOCK WAVEFORM



NOTES:

- a. top removed for clarity
- b. material is 1.6 mm mild steel
- c. dimensions in millimetres

FIGURE 2-4.2: EXAMPLE OF SUITABLE WATER CALORIMETER

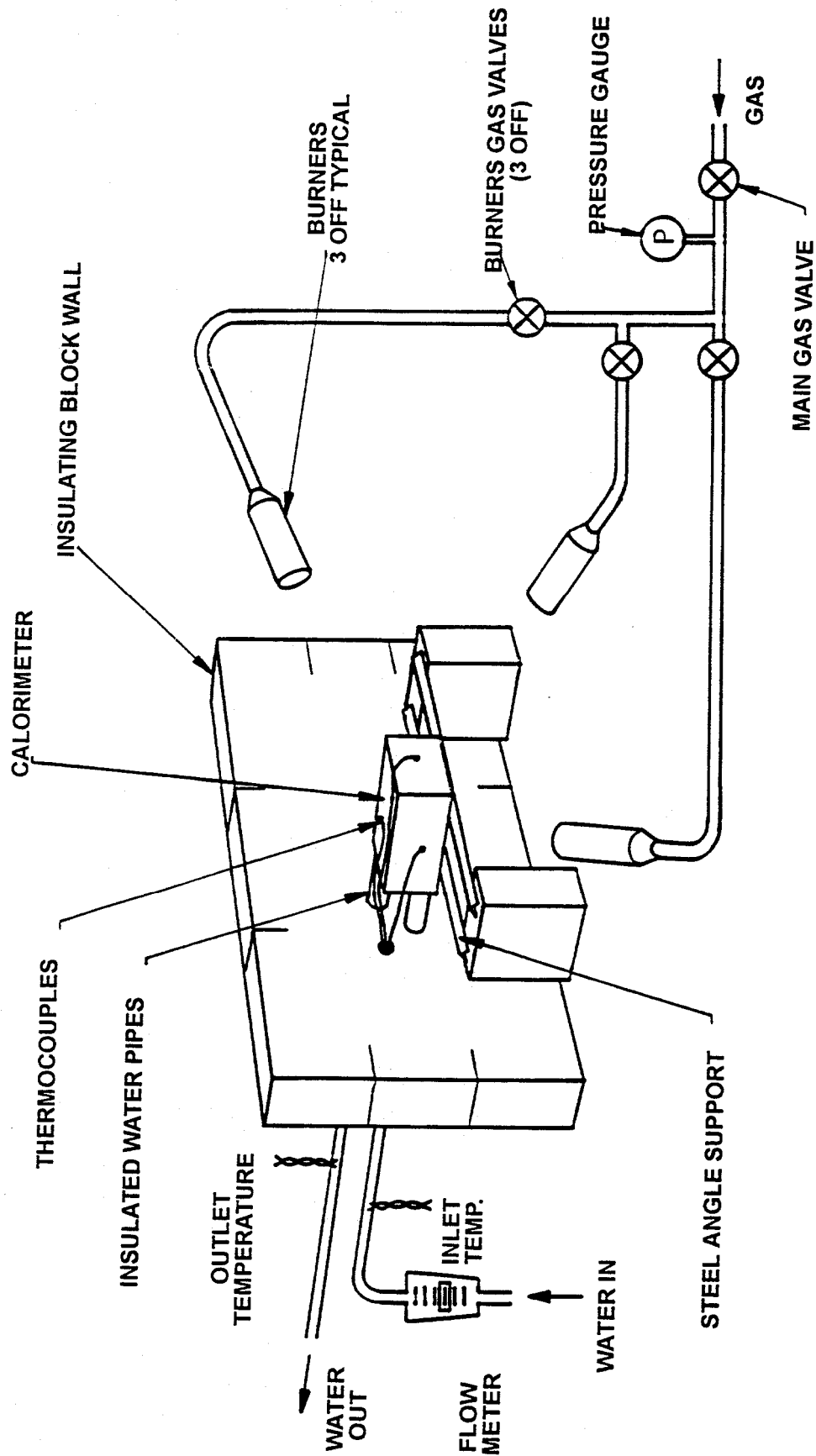


FIGURE 2-4.3: EXAMPLE OF SUITABLE FIRE TEST APPARATUS

CHAPTER 2-5

EQUIPMENT INSTALLATION AND INSTALLED PERFORMANCE

2-5.1 INTRODUCTION

This chapter specifies installation characteristics and performance with procedures for verifying that performance when the equipment is installed in an aircraft.

Installed performance criteria are generally the same as those contained in this section, which were verified through bench and environmental tests. However, certain performance parameters may be affected by the physical installation and can only be confirmed after installation.

2-5.2 GENERAL

Equipment shall be compatible with the environmental conditions present in the specific location in the aircraft where the equipment is installed.

Where the system is connected to mandatory instruments or data sources used for controlling or indicating the flight path of the aircraft, adequate isolation between the instruments or data sources and the flight recording system shall be provided. Particular attention shall be given to ensuring that the segregation required between critical components or systems of the aircraft e.g. power plant installation segregation, is not violated by the installation of the flight recording system.

2-5.3 EQUIPMENT INSTALLATION

2-5.3.1 Aircraft Environment

The flight recording system shall be installed so that it operates within the environmental conditions to which the items of equipment comprising the system have been declared to comply. Operation of the recording system shall not be affected by aircraft manoeuvring or changes in attitude encountered within the certified operational envelope of the aircraft. Operation of the recording system should not be affected by those extreme conditions likely to be encountered during an accident sequence e.g., violent and extreme manoeuvres.

2-5.3.2 Failure Protection

Any probable failure of the flight recording system shall not degrade the airworthiness of the aircraft.

2-5.3.3 Interference Effects

The installed recording system shall not:

- a be the source of harmful conducted or radiated interference, nor
- b be adversely affected by conducted or radiated interference from other equipment or systems installed in the aircraft.

NOTE: *Electromagnetic compatibility problems noted after installation of the equipment may result from such factors as the design characteristics of previously installed systems or equipment and the physical installation itself. It is not intended that the equipment manufacturer design for all installation environments. The installer will be responsible for resolving any incompatibility between the equipment and previously installed equipment.*

2-5.3.4 Stray Magnetic Field

When the recording system is placed, either in an operating or non-operating state in an area free from local magnetic disturbances, the stray magnetic field of this equipment shall cause not more than a 1 degree deflection of a magnetic compass when the closest edge of the equipment is at a distance of 300 mm from the compass.

2-5.3.5 Insulation Resistance

The insulation resistance between any exposed conducting material of the recording system (non-electrical circuit) and the electrical circuit of this equipment shall be at least 10 MOhms when measured with an applied voltage of at least 50 volts DC.

2-5.3.6 Inadvertent Turnoff

Protection shall be provided, or the installation shall be designed, to prevent the inadvertent turnoff of the recording system.

2-5.3.7 Aircraft Electrical Power Source

The recording system shall be connected to a power source having the characteristics which ensure proper and reliable recording in the operational environment.

2-5.4 EQUIPMENT LOCATION**2-5.4.1 Location of Robust Recorder**

Insofar as it is practicable, each robust recorder should be located and mounted so as to minimise the probability of container rupture resulting from crash impact. Also the risk of exposure of the recording medium to subsequent damage from fire should be minimised.

2-5.5 INSTALLATION OF EQUIPMENT**2-5.5.1 Strength of Installation**

The structural provisions within the aircraft for the mounting of the robust recorder (including its anti-vibration mount where used) should be able to withstand the loads (to be treated as limit loads) resulting from severe vibration or buffet. In addition, the strength of the local attachments shall be able to withstand the crash safety loads prescribed for the aircraft.

SECTION 3

DEPLOYABLE RECORDERS

CHAPTER 3-1

GENERAL

3-1.1 INTRODUCTION

This section details the additional requirements and exceptions that are specific to lightweight deployable recorders. The requirements specified in this section shall be met in addition to the requirements of Section 1 and Section 2, Chapter 2-1 and the appropriate recording system specific parts. It is applicable to any robust recorder that is designed to be deployed, its ancillary equipment and its installation in civil aircraft.

3-1.2 DEPLOYABLE RECORDING SYSTEM TECHNOLOGY

A deployable recorder is a recording medium housed in an enclosure that is automatically deployed (released) from the aircraft at the start of an accident sequence. Its characteristics have the objective of enabling it to land at lower speeds clear of the main aircraft wreckage, or, in the event of an accident over water, its flotation characteristics enable it to float. Since the recorder is no longer with the aircraft it should be equipped with a means to locate it.

This type of recorder is attached to the exterior of the airframe, and under normal conditions, functions in the same manner as a fixed recorder. The recorder memory module, beacon transmitters, antennas, battery pack and the survival packaging for these units are all an integral part of the automatic deployable package.

The deployable package incorporates flight characteristics that enable it to deploy and rapidly establish a flight trajectory that clears the airframe.

Compliance with this section will ensure that deployable systems will perform their function under the conditions encountered in aircraft operations.

3-1.3 AIRWORTHINESS AND CERTIFICATION

3-1.3.1 Safety

In addition to the safety requirements specified in paragraph 2-1.3.1, the exterior of the equipment shall have no sharp edges or projections that could damage inflatable survival equipment or injure persons.

3-1.3.2 Documents for Certification

In addition to the certification documents specified in paragraph 2-1.3.4, the following shall be provided.

- a Instructions shall be provided for safely removing deployable recorders from the aircraft for maintenance purposes.
- b The transmission frequency and modulation characteristics of the radio location beacon.

3-1.4 RECORDER OPERATION

In addition to the requirements defined in paragraph 2-1.5, the deployable recorder shall not continue to record once it has been deployed.

3-1.5 DEPLOYMENT CRITERIA

- a The design characteristics of a deployable recorder shall result in the recorder landing clear of the aircraft wreckage.
- b The unit shall incorporate flight characteristics that enable it to rapidly establish a flight trajectory that clears the airframe.
- c The unit shall not be given sufficient initial momentum on deployment such that its release could endanger ground support personnel or the aircraft itself.

- d Sufficient sensors shall be installed and located to detect impact, and water immersion resulting from an accident.
- e Controls and safeguards shall be in place to prevent inadvertent manual deployment.

3-1.5.1 Impact Initiation

- a There shall be an automatic means of impact detection and deployment initiation. Frangible or deformation sensors shall be installed in both the nose and the tail of the aircraft.
- b An alternative solution is installation of single or multiple MEMS based G-switches or accelerometers with deploy algorithms based on industry best practices in crash detection.
- c Impact sensors shall be designed such that they will only trigger when the structure has been significantly deformed (representing a catastrophic accident).

3-1.5.2 Hydrostatic Initiation

For both fixed and rotary wing aircraft, a hydrostatic sensor shall deploy the recorder at a depth of 3m or more.

3-1.6 CRASH SURVIVAL

3-1.6.1 Deployable recorder

Paragraph 2-1.3.4 defines the crash survival tests to be performed on the deployable recorder system.

3-1.6.2 Radio Location Beacon

All deployable recorders shall be equipped with a radio location beacon compliant with the requirements of ED-62 or RTCA DO-204A. This beacon shall be part of the deployable package.

The radio locating device shall be attached to the deployable recorder such that the aerodynamic properties of the recorder are not adversely affected and the risk of damage to, or separation of, the locating device is minimised.

In addition to meeting the endurance requirements of ED-62 (50 hours), the 121.5 MHz homing frequency of the ELT shall operate for a minimum of 100 additional hours, bringing the total minimum operational duration to 150 hours. For the additional 100 hours duration the ELT is not required to operate at the same power as the initial 50 hours but it shall have a minimum EIRP of 5mW.

NOTE: *Other required characteristics of the radio location beacon are outside the scope of this MOPS. Reference should be made to the applicable equipment standard.*

CHAPTER 3-2**MINIMUM PERFORMANCE SPECIFICATION UNDER STANDARD TEST CONDITIONS****3-2.1 INTRODUCTION**

The requirements for minimum performance under standard test conditions are flight recording system specific and are detailed in Chapter 3 of each of the relevant function specific Parts of this MOPS.

CHAPTER 3-3**MINIMUM PERFORMANCE UNDER ENVIRONMENTAL TEST CONDITIONS****3-3.1****INTRODUCTION**

Chapter 2-3 defines the environmental tests to be performed on the recorder system.

Deployable recorders shall satisfy the functional requirements as detailed in Chapter 4 of each of the applicable function specific Part(s).

CHAPTER 3-4

TEST PROCEDURES FOR CRASH SURVIVAL

3-4.1 GENERAL

This chapter replaces the procedures for crash survival defined in Chapter 2-4.

This section specifies crash survival tests to be applied to the deployable robust recorder to demonstrate compliance with paragraph 2-1.14.3.

- a Prior to commencement of any crash survival testing a known, random digital data test pattern shall be recorded in the robust memory medium.
- b After the test sequences have been performed, this test pattern shall be readily recoverable and replayed to establish that the data error rate defined in 2-1.6 has not been exceeded.
- c On completion of a crash survival test sequence, the recording medium may be cleaned and dried. Alterations or repairs between tests shall not be made.

NOTE 1: *Microscopic examination of the surface characteristics of memory devices is not acceptable as means of data recovery.*

NOTE 2: *The repair of individual memory devices is not permitted.*

3-4.2 TEST PROCEDURES

3-4.2.1 Standard Test Conditions

For the purposes of this chapter, standard test conditions are defined in documents EUROCAE ED-14F/RTCA DO-160F, "Environmental Conditions and Test Procedures for Airborne Equipment", paragraph 3.5 as:

- a Temperature : +15 to +35°C
- b Relative Humidity : Not greater than 85%
- c Ambient Pressure: 84 to 107 kPa

3-4.2.2 Impact Shock

The integrity of the robust recording medium contents and the proper operation of the radio location beacon are to be validated when subjected to the following impact shock test.

- a Subject the deployable recorder package, to an impact shock applied to the most probable landing attitude in the most damage vulnerable direction. The shock shall be such a level as to simulate a landing velocity of 25 m/s (80 ft/s) onto a hard surface such as rock, concrete or steel.

NOTE: *The definitions of "landing attitude" and "most damage-vulnerable direction" should not be limited to the three primary axes of the recorder.*

- b The deployable recorder containing the robust memory module shall impact or be impacted by a hard surface (50 mm thick steel plate of dimensions greater than the overall dimensions of the recorder) at a minimum impact velocity of 25 m/s (80 ft/s). Figure 3-4.1 illustrates an acceptable impact shock test setup for deployable recorders. Figure 3-4.2 illustrates an acceptable method and setup for retrieval of the deployable after impact. The mass of the impact plate shall be greater than 10 times the mass of the deployable recorder and experience no yield when subjected to the impact.

3-4.2.3 Radio Location Beacon Transmission

Place the deployable recorder in a shielded bag and confirm that the beacon transmits on 121.5 MHz with required power output for at least 150 hours.

3-4.2.4 Seaworthiness

The deployable package shall be buoyant and sufficiently self-righting in fresh and salt water to maintain the antenna substantially in its normal operating position. This shall be demonstrated by testing with fresh and then salt water and confirming the reception of 121.5 MHz transmissions from the transmitter. This test shall be performed in water conditions representative of an open sea state 7 (equivalent to Beaufort scale force 10).

3-4.2.5 High Temperature Fire

Subject the test article to a fire producing a minimum thermal flux of 158 kW/m^2 ($50\,000 \text{ Btu/ft}^2/\text{hour}$). The entire external surface area of the test article shall be exposed to the fire for a continuous period of at least 5 minutes.

The method of testing the test article is identical to the paragraph 2-4.2.4.

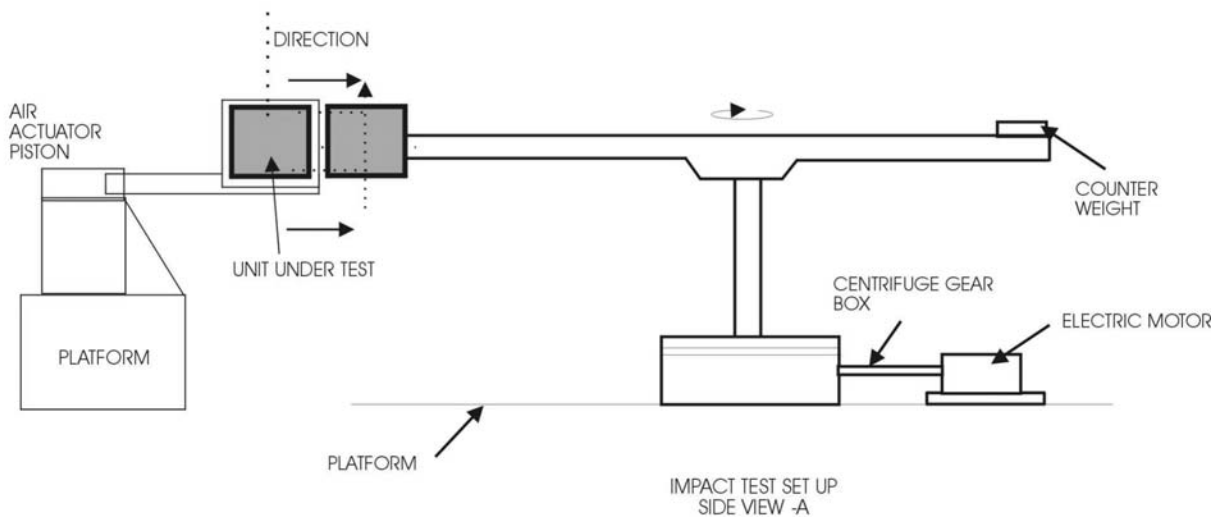
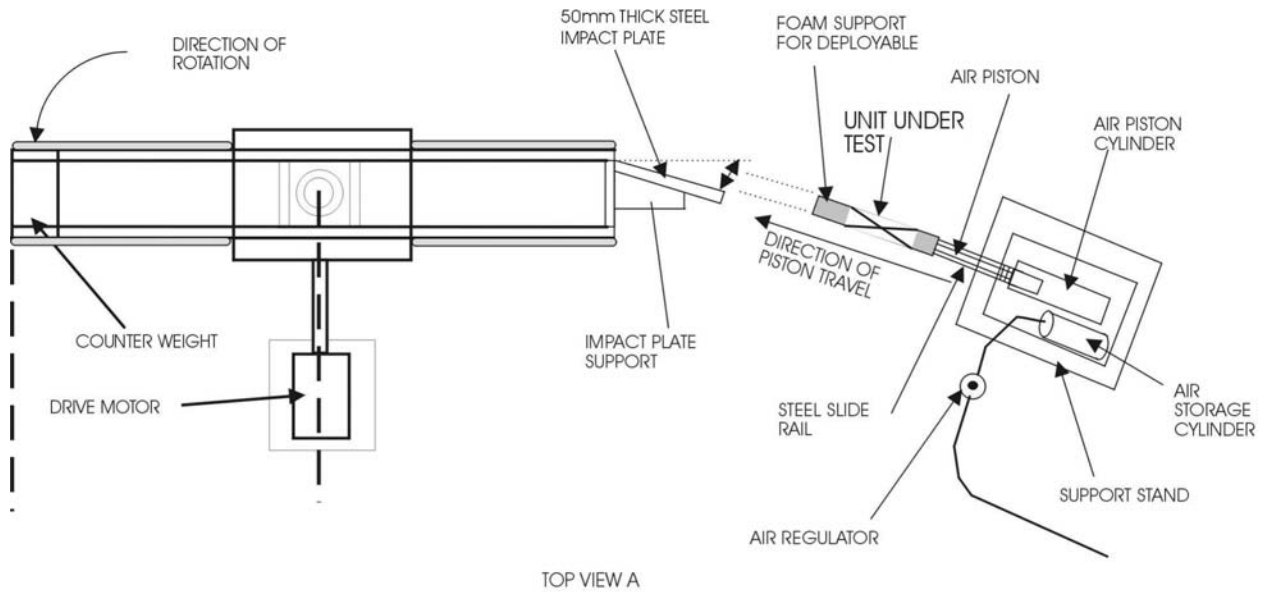


FIGURE 3-4.1: IMPACT SHOCK TEST SETUP