

# **European Aviation Safety Agency**

## **The Executive Director**

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### **DECISION NO. 2003/10/RM**

#### **OF THE EXECUTIVE DIRECTOR OF THE AGENCY**

**of 24 October 2003**

**on certification specifications, including airworthiness codes and acceptable means of compliance, for European Technical Standard Orders (« CS-ETSO »)**

THE EXECUTIVE DIRECTOR OF THE EUROPEAN AVIATION SAFETY AGENCY,

Having regard to Regulation (EC) No 1592/2002 of the European Parliament and of the Council of 15 July 2002 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency<sup>1</sup> (hereinafter referred to as the “Basic Regulation”), and in particular Articles 13 and 14 thereof,

Having regard to the Commission Regulation (EC) No 1702/2003 of 24 September 2003<sup>2</sup> laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations, in particular 21A.16A of Part 21 thereof;

Whereas :

- (1) The Agency shall issue certification specifications, including airworthiness codes and acceptable means of compliance, as well as guidance material to be used in the certification process.
- (2) The Agency has, pursuant to Article 43 of the Basic Regulation, consulted widely interested parties on the matters which are subject to this Decision and following that consultation provided a written response to the comments received,

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<sup>1</sup> OJ L 240, 7.09.2002, p. 1.

<sup>2</sup> OJ L 243, 27.09.2003, p. 6.

HAS DECIDED AS FOLLOWS:

Article 1

The certification specifications, including airworthiness codes and acceptable means of compliance, for European Technical Standard Orders are those laid down in the Annex to this Decision.

Article 2

This Decision shall enter into force on 24 October 2003. It shall be published in the *Official Publication of the Agency*.

Done at Brussels, 24 October 2003.

For the European Aviation Safety Agency,

Patrick GOUDOU

Executive Director

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**Certification Specifications  
for  
European Technical  
Standard Orders**

**CS-ETSO**



**SUBPART A - GENERAL****1. APPLICABILITY**

- 1.1 Requirements for the issue of European Technical Standard Order (ETSO) Authorisations are found in Part 21 Section A Subpart O.
- 1.2 Marking requirements for the issue of European Technical Standard Order Authorisations are found in Part 21 Section A Subpart Q.

**2. ENVIRONMENTAL AND SOFTWARE STANDARDS TO MEET TECHNICAL CONDITIONS****2.1 Environmental standards:**

Unless otherwise stated in the paragraph 3.1.2 of the specific ETSO, the applicable environmental standards are contained in EUROCAE/RTCA document ED-14D/DO-160D, „Environmental Conditions and Test Procedures for Airborne Equipment“, change 3 dated December 2002.

**2.2 Software standards**

If the equipment design implementation includes a digital computer, the computer software must be verified and validated in an acceptable manner.

Unless stated otherwise in paragraph 3.1.3 of the specific ETSO, one acceptable means of compliance for the verification and validation of the computer software is outlined in EUROCAE/RTCA document ED-12B/DO-178B, „Software considerations in Airborne Systems and Equipment Certification“, dated December 1992.

For those applicants who elect to use EUROCAE/RTCA document ED-12B/DO-178B to demonstrate compliance for the verification and validation of the computer software, the following requirements must be met:

- (i) This document defines five levels of software:  
Level A, Level B, Level C, Level D, and Level E. The applicant must declare the level (or levels) to which the computer software has been verified and validated.
- (ii) If the equipment incorporates more than one software level, appropriate partitioning of different software level is required.

**3. ADDITIONAL INFORMATION**

- 3.1 In some ETSO's, reference is made to an associated FAA standard and in these cases the FAA standard is attached to the ETSO. Where in the associated “FAA” standard, reference is made to “FAA” or “FAR”, it should be substituted by the equivalent reference, “Agency” or “Part/CS”.
- 3.2 The following addresses are provided below:

- EUROCAE documents may be purchased from:  
European Organisation for Civil Aviation Equipment  
17, rue Hamelin 75116 PARIS Cedex 16 - FRANCE  
(web site : [www.eurocae.org](http://www.eurocae.org))

- RTCA documents may be purchased from:  
Radio Technical Commission for Aeronautics, Inc.  
1828 L Street NW, Suite 805-Washington DC 20036-USA  
(web site : [www.rtca.org](http://www.rtca.org))

- SAE documents may be purchased from:  
Society of Automotive Engineers, Inc.  
400 Commonwealth Drive - WARRENDALE, PA 15096-001 – USA  
(web site : [www.sae.org](http://www.sae.org))
  
- NAS specifications may be obtained from:  
Aerospace Industries Association (AIA)  
1327 Jones Drive-Ann Arbor-MI 48105-USA  
(web site : [www.techstreet.com](http://www.techstreet.com))
  
- FAA Standards may be purchased from:  
Superintendent of Documents, Government Printing Office  
732N Capitol Street NW-Washington DC 20401-USA  
(web site : [www.gpoaccess.gov](http://www.gpoaccess.gov))
  
- MIL Specifications may be obtained from:  
DODSSP, Standardization Documents Order Desk  
Building 4D, 700 Robbins Avenue - PHILADELPHIA, PA 19111-5094 – USA  
(web site : <http://dodssp.daps.mil/>)
  
- ASTM documents may be purchased from:  
American Society for Testing and Materials, ASTM International,  
100 Barr Harbor Drive, PO Box C700, West Conshohocken, Pennsylvania 19428-2959, USA.  
(web site: [www.astm.org](http://www.astm.org))

**SUBPART B – LIST OF ETSOs (INDEX 1 AND INDEX 2)**

This Subpart contains two Indexes:

**1 INDEX 1**

- 1.1 Index 1 lists all those ETSOs which are technically similar to FAA-TSOs.
- 1.2 When an article has been approved by the Agency to a ETSO listed in Index 1 the article is to be permanently marked with the appropriate ETSO number. Also, all documentation associated with Certification and Release for installation on an aeroplane must record this ETSO number. The 'E' Symbol signifies that the article has been certified to the relevant ETSO by the Agency.
- 1.3 It should be noted that some FAA-TSO numbers have not been listed in Index 1 because they have not been published by the Agency and cannot therefore be certified or identified by a ETSO number.
- 1.4 Index 1 will be updated from time to time, to reflect the latest edition of a ETSO, for example ETSO-C1b to ETSO-C1c. However, this does not mean that previous editions cannot still be used; it merely means that for new applications it would be the general rule to certificate to the latest edition. Exceptions to this rule would be subject to negotiation with the Agency.
- 1.5 The ETSO numbering system is explained as follows:

ETSO-C5e means:European TSO-Number and revision letter, and so –

ETSO-C95 with no revision letter means initial issue.

NOTE: Copies of ETSOs are listed in Index 1.

**2 INDEX 2**

- 2.1 Index 2 lists all those ETSOs which are not technically similar to FAA-TSOs; examples are:
  - (a) Deviations from an FAA-TSO; or
  - (b) When an FAA-TSO does not exist for a particular application.

- 2.2 Index 2 ETSOs will be numbered as follows:

ETSO-2C41d, in which the 2 denotes that it is from Index 2.

NOTE: Copies of ETSOs are listed in Index 2.

## INDEX 1

<i>ETSO</i>	<i>Subject Title</i>
ETSO-C1c	Cargo Compartment Fire Detection Instruments
ETSO-C2d	Airspeed Instruments
ETSO-C3d	Turn and Slip Instruments
ETSO-C4c	Bank and Pitch Instruments
ETSO-C5e	Direction Instrument, Non-magnetic (Gyroscopically Stabilized)
ETSO-C6d	Direction Instrument, Magnetic (Gyroscopically Stabilized)
ETSO-C7d	Direction Instrument, Magnetic Non-stabilized Type (Magnetic Compass)
ETSO-C8d	Vertical Velocity Instrument (Rate-of-Climb)
ETSO-C9c	Automatic Pilots
ETSO-C10b	Aircraft Altimeter, Pressure Actuated, Sensitive Type
ETSO-C14b	Aircraft Fabric, Intermediate Grade; External Covering Material
ETSO-C15d	Aircraft Fabric, Grade A; External Covering Material
ETSO-C16	Airspeed Tubes (Electrically Heated)
ETSO-C20	Combustion Heaters
ETSO-C21b	Aircraft Turnbuckle Assemblies and/or Turnbuckle Safetying Devices
ETSO-C22g	Safety Belts
ETSO-C23d	Personnel Parachute Assemblies
ETSO-C25a	Aircraft Seats and Berths (Type I Transport 6g Forward Load)
ETSO-C26c	Aircraft Wheels and Wheel-Brake Assemblies (CS-23, -27 and -29 aircraft)
ETSO-C27	Twin Seaplane Floats
ETSO-C28	Aircraft Skis
ETSO-C30c	Aircraft Position Lights
ETSO-C31d	HF Transmitting Equipment
ETSO-C32d	HF Receiving Equipment
ETSO-C39b	Aircraft Seats and Berths
ETSO-C42	Propeller Feathering Hose Assemblies
ETSO-C43c	Temperature Instruments
ETSO-C44b	Fuel Flowmeters
ETSO-C45a	Manifold Pressure Instruments
ETSO-C46a	Maximum Allowable Airspeed Indicator Systems
ETSO-C47	Pressure Instruments – Fuel, Oil and Hydraulic (Reciprocating Engine Powered Aircraft)
ETSO-C48	Carbon Monoxide Detector Instruments
ETSO-C49b	Electric Tachometer:Magnetic Drag (Indicator and Generator)

## INDEX 1

<i>ETSO</i>	<i>Subject Title</i>
ETSO-C50c	Audio Selector Panels and Amplifiers
ETSO-C52b	Flight Directors
ETSO-C53a	Fuel and Engine Oil System Hose Assemblies
ETSO-C54	Stall Warning Instruments
ETSO-C55	Fuel and Oil Quantity Instruments (Reciprocating Engine Aircraft)
ETSO-C56a	Engine-driven Direct Current Generators/Starter-generators
ETSO-C57a	Headsets and Speakers
ETSO-C58a	Aircraft Microphones (Except Carbon)
ETSO-C59	Airborne Selective Calling Equipment
ETSO-C60b	Airborne Area Navigation Equipment Using Loran C Inputs
ETSO-C62d	Aircraft Tyres
ETSO-C64a	Oxygen Mask Assembly, Continuous Flow, Passenger
ETSO-C65a	Airborne Doppler Radar Ground Speed and/or Drift Angle Measuring Equipment (for Air Carrier Aircraft)
ETSO-C68a	Airborne Automatic Dead Reckoning Computer Equipment Utilizing Aircraft Heading and Doppler Ground Speed and Drift Angle Data (for Air Carrier Aircraft)
ETSO-C69c	Emergency Evacuation Slides, Ramps and Slide/Raft Combinations
ETSO-C71	Airborne Static ('DC toDC') Electrical Power Converter (for Air Carrier Aircraft)
ETSO-C72c	Individual Flotation Devices
ETSO-C73	Static Electrical Power Inverter
ETSO-C74d	Airborne ATC Transponder Equipment
ETSO-C76	Fuel Drain Valves
ETSO-C78	Crewmember Demand Oxygen Masks
ETSO-C79	Fire Detectors (Radiation Sensing Type)
ETSO-C80	Flexible Fuel and Oil Cell Material
ETSO-C85a	Survivor Locator Lights
ETSO-C88a	Automatic Pressure Altitude Reporting Code Generating Equipment
ETSO-C89	Oxygen Regulators, Demand
ETSO-C90c	Cargo Pallets, Nets and Containers
ETSO-C92c	Ground Proximity Warning, Glide Slope Deviation Alerting Equipment
ETSO-C95	Mach Meters
ETSO-C96a	Anticollision Light Systems
ETSO-C97	Lithium Sulfur Dioxide Batteries
ETSO-C99	Protective Breathing Equipment

## INDEX 1

<i>ETSO</i>	<i>Subject Title</i>
ETSO-C101	Overspeed Warning Instruments
ETSO-C102	Airborne Radar Approach and Beacon Systems for Helicopters
ETSO-C103	Continuous Flow Oxygen Mask Assembly (for Non-transport Category Aircraft)
ETSO-C105	Optional Display Equipment for Weather and Ground Mapping Radar Indicators
ETSO-C106	Air Data Computer
ETSO-C109	Airborne Navigation Data Storage System
ETSO-C110a	Airborne Passive Thunderstorm Detection Systems
ETSO-C113	Airborne Multipurpose Electronic Displays
ETSO-C114	Torso Restraint Systems
ETSO-C115b	Airborne Area Navigation Equipment using Multi-Sensor Inputs
ETSO-C116	Crew Member PBE
ETSO-C117a	Airborne Windshear Warning and Escape Guidance Systems (Reactive Type) for Transport Aeroplanes
ETSO-C118	TCAS I
ETSO-C119b	TCAS II
ETSO-C121	Underwater Locating Devices
ETSO-C123a	Cockpit Voice Recorders Systems
ETSO-C124a	Flight Recorder
ETSO-C127a	Rotorcraft, Transport Aeroplane, and Normal and Utility Aeroplane Seating Systems
ETSO-C129a	Airborne Supplemental Navigation Equipment Using Global Positioning System (GPS)
ETSO-C135	Transport Aeroplane Wheels and Wheel and Brake Assemblies
ETSO-C141	Aircraft Fluorescent Lighting Ballast/Fixture Equipment
ETSO-C144	Airborne Global Positioning System Antenna
ETSO-C145	Airborne Navigation Sensors Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)
ETSO-C146	Stand-Alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)
ETSO-C147	Traffic Advisory System (TAS) Airborne Equipment
ETSO-C151a	Terrain Awareness and Warning System (TAWS)

<b>INDEX 2</b>	
<i>ETSO</i>	<i>Subject Title</i>
ETSO-2C11e	Powerplant Fire Detection Instruments (Thermal and Flame Contact Types)
ETSO-2C19b	Fire Extinguishers, Portable Water Type
ETSO-2C34f	ILS Glide Slope Receiving Equipment Operating within the Radio Frequency Range of 328.6-335.4 Megahertz (MHz)
ETSO-2C35d	Radar Marker Receiving Equipment
ETSO-2C36f	Airborne ILS Localizer Receiving Equipment Operating within the Radio Frequency Range 108-112 Megahertz
ETSO-2C37e	VHF Radio Communication Transmitting Equipment Operating Within the Radio Frequency Range 117.975-137 Megahertz
ETSO-2C38e	VHF Radio Communication Receiving Equipment Operating Within the Radio Frequency Range 117.975-137 Megahertz
ETSO-2C40c	VOR Receiving Equipment Operating Within the Radio Frequency Range 108-117.95 Megahertz
ETSO-2C41d	Airborne Automatic Direction Finding (ADF) Equipment
ETSO-2C63c	Airborne Weather and Ground Mapping Pulsed Radars
ETSO-2C66b	Distance Measuring Equipment (DME) Operating Within the Radio Frequency Range of 960-1215 Megahertz
ETSO-2C75	Hydraulic Hoses Assembly
ETSO-2C87	Low Range Radio Altimeters
ETSO-2C91a	Emergency Locator Transmitter (ELT) Equipment
ETSO-2C93b	Airborne Interim Standard Microwave Landing System Converter Equipment
ETSO-2C104a	Microwave Landing System (MLS) Airborne Receiving Equipment
ETSO-2C112a	Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/MODE S) Airborne Equipment
ETSO-2C122	Devices That Prevent Blocked Channels Used in Two-Way Radio Communications Due to Simultaneous Transmissions
ETSO-2C126	406 MHz Emergency Locator Transmitter (ELT)
ETSO-2C128	Devices That Prevent Blocked Channels used in Two-Way Radio Communications Due to Unintentional Transmissions
ETSO-2C500a	Combined ILS/MLS Airborne Receiving Equipment
ETSO-2C501	Mode S Aircraft Data Link Processor

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# **CS-ETSO**

## **INDEX 1**

# **European Technical Standard Orders**



# European Aviation Safety Agency

## European Technical Standard Order

**Subject :** CARGO COMPARTMENT FIRE DETECTION INSTRUMENTS

### **1 - Applicability**

This ETSO gives the requirements which cargo compartment fire detection instruments that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the SAE Aerospace Standard (AS) 8036 „Cargo Compartment Fire Detection Instruments“, dated April 1, 1985.

##### 3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1.

##### 3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2.

#### 3.2 - Specific

None.

### **4 - Marking**

#### 4.1- General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

Subject: AIRSPEED INSTRUMENTS

### **1 - Applicability**

This ETSO gives the requirements which new models of airspeed instruments that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the SAE Aerospace Standard (AS) 8019 „Airspeed Instruments“, dated March 30, 1981.

##### 3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1

##### 3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2

#### 3.2 - Specific

None.

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** TURN AND SLIP INSTRUMENTS

### **1 - Applicability**

This ETSO gives the requirements which new models of turn and slip instruments that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the SAE Aerospace Standard (AS) 8004 „Turn and Slip Instruments“, dated September 1975.

##### 3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1.

##### 3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2.

#### 3.2 - Specific

None.

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2- Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** BANK AND PITCH INSTRUMENTS

### **1 - Applicability**

This ETSO gives the requirements which bank and pitch instruments that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the SAE Aerospace Standard (AS) document : AS-396B, „Bank and Pitch Instruments“, dated July 15, 1958, as amended and supplemented by this ETSO:

- (i) Conformance with the following paragraphs of AS-396B is not required : 3.1; 3.1.2; 3.2; 4.3.5.
- (ii) Substitute the following for paragraph 7. of AS-396B : „Performance tests : The following tests in addition to any other deemed necessary by the manufacturer, shall be the basis for determining compliance with the performance requirements of this standard.“

##### 3.1.2 - Environmental Standard

As specified in SAE document : AS-396B.

##### 3.1.3 – Computer Software

None

#### 3.2 - Specific

None

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

In addition the following information shall be legibly and permanently marked on the equipment:  
Nominal power input rating (electrical voltage and frequency, vacuum or air pressure).

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** DIRECTION INSTRUMENT, NON-MAGNETIC (GYROSCOPICALLY STABILIZED)

### **1 - Applicability**

This ETSO gives the requirements which new models of direction instruments, non-magnetic (gyroscopically stabilized) that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the SAE Aerospace Standard (AS) document : AS 8021 „Direction Instrument, Non-Magnetic (Gyroscopically Stabilized)“, dated March 16, 1981.

##### 3.1.2 - Environmental Standard

See CE-ETSO Subpart A paragraph 2.1.

##### 3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2.

#### 3.2 - Specific

None

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** DIRECTION INSTRUMENT, MAGNETIC (GYROSCOPICALLY STABILIZED)

### **1 - Applicability**

This ETSO gives the requirements which new models of direction instruments, magnetic (gyroscopically stabilized) that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the SAE Aerospace Standard (AS) document: AS-8013, „Direction Instrument, Magnetic (Gyroscopically Stabilized)“, dated June 1983.

##### 3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1

##### 3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2

#### 3.2 - Specific

None

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** DIRECTION INSTRUMENT, MAGNETIC NON-STABILIZED TYPE (MAGNETIC COMPASS)

### 1 - Applicability

This ETSO gives the requirements which new models of direction instruments, magnetic non-stabilized type (magnetic compass) that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### 2 - Procedures

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### 3 - Technical Conditions

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the SAE Aerospace Standard (AS) document: AS 398A „Direction Instrument, Magnetic Non-Stabilized Type (Magnetic Compass)“, dated July 15, 1958 „reaffirmed October 1984“ (if TSO) except as amended and supplemented by this ETSO:

- (i) Conformance with the following paragraphs of AS 398A is not required: 3.1; 3.1.1; 3.1.2; 3.2.
- (ii) Substitute the following for paragraph 7 of AS 398A:  
„Performance tests: the following tests in addition to any others deemed necessary by the manufacturers, shall be the basis for determining compliance with the performance requirements of this standard.“

##### 3.1.2 - Environmental Standard

The environmental conditions and test procedures in SAE AS 398A are to be used.

##### 3.1.3 – Computer Software

None

#### 3.2 - Specific

None

### 4 - Marking

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A.

#### 4.2 - Specific

None.

### 5 - Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** VERTICAL VELOCITY INSTRUMENT (RATE-OF-CLIMB)

### **1 - Applicability**

This ETSO gives the requirements which new models of vertical velocity instruments that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the SAE Aerospace Standard (AS) document: AS 8016 „Vertical Velocity Instruments (Rate-of-climb)“, reaffirmed October 1984.

##### 3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1.

##### 3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2.

#### 3.2 - Specific

None

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** AUTOMATIC PILOTS

### 1 - Applicability

This ETSO gives the requirements which new models of vertical velocity instruments that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### 2 - Procedures

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### 3 - Technical Conditions

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the SAE Aerospace Standard (AS) document: AS 402A „Automatic Pilots“, dated February 1, 1959 as amended and supplemented by this ETSO.

##### (1) Exceptions

(i) Conformance with the following paragraph of SAE AS 402A is not required: 3.1, 3.1.1, 3.1.2, 3.2.

(ii) Substitute the following for section 7 of SAE AS 402A:

“Performance tests: The following tests, in addition to any others deemed necessary by the manufacturer, shall be the basis for determining compliance with the performance requirements of this standard.”

##### (2) Additions

In addition to the means of indication specified in paragraph 4.3 of SAE AS 402A, the following shall be included:

(i) Power malfunction indication. Means shall be provided to indicate readily to the pilot in a positive manner when each phase of the primary power (voltage and/or current) to the automatic pilot is not adequate for safe operation.

(ii) Airborne navigation reference indication. A visual means shall be provided to indicate readily to the pilot in a positive manner when the automatic pilot is not engaged to the airborne navigation reference.

##### 3.1.2 - Environmental Standard

As indicated in SAE AS 402A.

##### 3.1.3 – Computer Software

None

#### 3.2 - Specific

None

**4 - Marking**

4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

4.2 - Specific

None.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** AIRCRAFT ALTIMETER, PRESSURE ACTUATED, SENSITIVE TYPE.

### 1 - Applicability

This ETSO gives the requirements which altimeters pressure actuated that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### 2 - Procedures

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### 3 - Technical Conditions

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the SAE Aerospace Standard (AS) document: AS 392C, „Altimeter, Pressure Actuated Sensitive Type“, revision date February, 1959 with the following exceptions, and as amended and supplemented by this ETSO:

Exceptions

- (i) The following specifically numbered paragraphs in AS 392C do not concern minimum performance and therefore are not essential to compliance with this paragraph: 3.1, 3.1.1, 3.1.2, 3.2, 3.2(a)(b)(c)(d)(e)(f).
- (ii) In lieu of Section 7. in AS 392C, it is a requirement that the altimeters covered by this section be capable of successfully passing the test in paragraphs 7.1 through 7.5 and an External Case Pressure Test which is as follows:

External Case Pressure Test The static pressure source of the instrument shall be sealed when an ambient temperature of 25°C and an ambient pressure of 29.92 inches (absolute) of mercury have been achieved. The ambient pressure shall then be increased at a rate of 20 inches of mercury in two seconds to 50 inches (absolute) of mercury and held at that pressure for three minutes. There shall be no adverse effect on the instrument or its accuracy.

- (iii) The „Reference Section“ under Table II of AS 392C is not applicable.

##### 3.1.2 – Computer Software

None

#### 3.2 - Specific

None

### 4 - Marking

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A Paragraph 1.2. In addition, the maximum altitude for which altimeter is qualified to operate shall be legibly and permanently marked.

#### 4.2 - Specific

None.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** AIRCRAFT FABRIC, INTERMEDIATE GRADE.

### 1 - Applicability

This ETSO gives the requirements which new models of aircraft fabric, intermediate grade that is manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### 2 - Procedures

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### 3 - Technical Conditions

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the SAE Aerospace Material Specification (AMS) 3804c „Cloth Airplane Cotton Mercerized 651b (290N) Breaking Strength“, dated January 1, 1984 as amended and supplemented by this ETSO:

Exceptions:

- (i) Delete from paragraph 2 of SAE AMS 3804c the following: „the latest issue of Aerospace Material Specification (AMS) shall apply.“
- (ii) Compliance with paragraphs 4.2.2.1, 5.2.4, and 8.3 of SAEAMS 3804c is not required.

Additions:

- (i) Paragraph 1.1 of SAEAMS 3804c shall read as follows: Form:This specification covers one strength and one weave of mercerized cotton cloth known as „airplane cloth“. However, synthetic fabric material, in particular polyester in the greige condition, also may be identified and used as „airplane cloth“ if the fabric is shown to have certain equivalent properties as cotton cloth.
- (ii) Paragraph 1.2 of SAEAMS 3804c shall read as follows:Application. Aircraft with wing loading less than 9 pounds per square foot (psf) and never-exceed speeds 160 miles per hour (mph). Primarily for the external covering of aircraft surfaces, such as wings, fuselage, ailerons, elevators and other airfoil surfaces.
- (iii) Replace the word cotton with cotton cloth in paragraph 3.1.1 of SAE AMS 3804c.
- (iv) Paragraph 3.1.2 of SAEAMS 3804c shall read as follows:Yarn:The cloth shall be woven from 2-ply combed cotton yarn or synthetic continuous filament yarn.
- (v) Paragraph 3.1.4 of SAEAMS 3804c shall read as follows:Finishing:The cloth shall be uniformly finished in accordance with the best practice for high grade airplane cloth. Finishing of cotton cloth shall consist of washing, framing and calendaring. The calendaring shall be sufficient to lay any nap present and shall provide a smooth even surface. Nap may be removed by singeing. Synthetic cloth shall remain unfinished (greige).
- (vi) In addition to the requirements of paragraphs 3.2.1, 3.2.2 and 3.2.5 of SAEAMS 3804c, include the following after each title: (cotton cloth only).

- (vii) The first sentence of paragraphs 3.3 of SAEAMS 3804c, shall read as follows:  
Quality: The cotton fibers and synthetic filament shall be evenly spun into yarns of proper and uniform yarn count, twist and diameter to produce the texture and weight required.
- (viii) In addition to the requirements of paragraphs 4.6.1, 4.6.2 and 5.2.2 of SAEAMS 3804c, replace reference to AMS 3804c with ETSO-C14b.

3.2 - Specific  
None.

**4 - Marking**

4.1 - General

Requirements for marking are specified in paragraph 5.1 of SAE AMS 3804c.

4.2 - Specific

None.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** AIRCRAFT FABRIC, GRADE A.

### 1 - Applicability

This ETSO gives the requirements which new models of aircraft fabric, grade A that is manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### 2 - Procedures

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### 3 - Technical Conditions

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the SAE Aerospace Material Specification (AMS) 3806d „Cloth Airplane Cotton Mercerized 80lb (355N) Breaking Strength“, [dated April 15, 1980] as amended and supplemented by this ETSO:

Exceptions:

- (i) Delete from paragraph 2 of SAE AMS 3806d the following: „the latest issue of Aerospace Material Specification (AMS) shall apply.“
- (ii) Compliance with paragraphs 4.2.2.1, 5.2.4, and 8.3 of SAEAMS 3806d is not required.

Additions:

- (i) Paragraph 1.1 of SAEAMS 3806d shall read as follows: Form:This specification covers one strength and one weave of mercerized cotton cloth known as „airplane cloth“. However, synthetic fabric material, in particular polyester in the greige condition, also may be identified and used as „airplane cloth“ if the fabric is shown to have certain equivalent properties as cotton cloth.
- (ii) Paragraph 1.2 of SAEAMS 3806d shall read as follows:Application. Aircraft with wing loading less than 9 pounds per square foot (psf) and never-exceed speeds 160 miles per hour (mph) or greater. Primarily for the external covering of aircraft surfaces, such as wings, fuselage, ailerons, elevators and other airfoil surfaces.
- (iii) Replace the word cotton with cotton cloth in paragraph 3.1.1 of SAE AMS 3806d.
- (iv) Paragraph 3.1.2 of SAEAMS 3806d shall read as follows:Yarn:The cloth shall be woven from 2-ply combed cotton yarn or synthetic continuous filament yarn.
- (v) Paragraph 3.1.4 of SAEAMS 3806d shall read as follows:Finishing:The cloth shall be uniformly finished in accordance with the best practice for high grade airplane cloth. Finishing of cotton cloth shall consist of washing, framing and calendaring. The calendaring shall be sufficient to lay any nap present and shall provide a smooth even surface. Nap may be removed by singeing. Synthetic cloth shall remain unfinished (greige).

- (vi) In addition to the requirements of paragraphs 3.2.1, 3.2.2 and 3.2.6 of SAEAMS 3806d, include the following after each title: (cotton cloth only).
- (vii) The first sentence of paragraphs 3.3 of SAEAMS 3806d, shall read as follows:  
Quality: The cotton fibers and synthetic filament shall be evenly spun into yarns of proper and uniform yarn count, twist and diameter to produce the texture and weight required.
- (viii) In addition to the requirements of paragraph 4.6.1, 4.6.2, 5.1 and 5.2.2 of SAEAMS 3806d, replace reference to AMS 3806d with ETSO-C15d.

3.2 - Specific  
None.

**4 - Marking**

4.1 - General

Requirements for marking are specified in paragraph 5.1 of SAE AMS 3806[d].

4.2 - Specific

None.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** AIRSPEED TUBES (ELECTRICALLY HEATED)

### **1 - Applicability**

This ETSO gives the requirements which airspeed tubes (electrically heated) that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the SAE Aerospace Standard (AS) document: AS 393 „Airspeed Tubes (electrically heated)“, dated January 12, 1947.

##### 3.1.2 - Environmental Standard

As indicated in SAE 393 document.

##### 3.1.3 – Computer Software

None

#### 3.2 - Specific

None

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** COMBUSTION HEATERS

### **1 - Applicability**

This ETSO gives the requirements which combustion heaters that are manufactured on or after the date of this ETSO, must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the Society of Automotive Engineers, Inc ., (SAE) Aerospace Standard AS 143B „HEATERS, AIRPLANE, INTERNAL COMBUSTION HEAT EXCHANGER TYPE“, issued January 11, 1943, revised January 1949.

##### 3.1.2 - Environmental Standard

As indicated in AS 143B.

##### 3.1.3 – Computer Software

None

#### 3.2 - Specific

None

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** AIRCRAFT TURNBUCKLE ASSEMBLIES AND/OR TURNBUCKLE SAFETYING DEVICES.

### 1 - Applicability

This ETSO gives the requirements which new models of aircraft turnbuckle assemblies and/or turnbuckle safetying devices that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### 2 - Procedures

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### 3 - Technical Conditions

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in Sections 3 and 4 of Military Specifications MIL-T-5685A, dated April 6, 1950 with the additional tests, when applicable, listed below and as amended and supplemented by this ETSO:

Tests The following tests, when applicable, are required in addition to those set forth in MIL-T-5685A, and shall be conducted to substantiate the strength and reliability of special turnbuckle assemblies and/or safetying devices. A minimum of six samples each shall be used in conducting the tests for torsion, tension, fatigue (tensile), and fatigue (torsion).

- (i) Torsion. At least one sample of each size turnbuckle assembly and safetying device shall be tested in torsion to determine that the torque necessary to overcome the turnbuckle thread friction and break the safetying device is equal to or greater than that required when the conventional safety wire is used in accordance with the safetying procedure recommended in Civil Aeronautics Manual 4b.329-2.
- (ii) Tension. At least one sample of each size turnbuckle and safetying device assembly shall be tested to determine that the turnbuckle assembly (including safetying device) will not fail at any tensile load under the maximum (ultimate) tensile strength for which the comparable standard MIL or NAS turnbuckle is rated. For this test, the sample shall consist of the turnbuckle assembly (including safetying device) with a two (2) foot length of cable appropriately attached to each terminal (end) of the turnbuckle. In making the determination, the sample shall be tested for tensile strength in accordance with Federal Test Method Std. N° 151.3. If the sample does not fail under the specified maximum load, it need not be tested further to destruction.
- (iii) Vibration. At least one sample of each of 3 representative sizes of turnbuckle assemblies, i.e., the smallest, the largest, and an intermediate size, shall be vibrated to determine that the lock wire, or other safetying device which relies upon spring action or clamping to safety the turnbuckle, can be depended upon not to jump out of place or otherwise lose its safetying properties, under vibratory conditions apt to be encountered in aircraft service. It

is suggested that a cable tension load equal to 25 percent of rated ultimate cable strength and a frequency of 3600 cpm with an overall amplitude of 1/8 inch (parallel to the axis of the hole through the barrel) for 25 hours, be used for this determination.

- (iv) Fatigue (Tensile). At least one sample of each size turnbuckle assembly shall be given a repeated load test, in which a load equal to 2/3 the ultimate tensile strength requirement is applied repeatedly in tension for 300 applications of the load without failure of any component part. For this test, the sample shall consist of the turnbuckle assembly (including safetying device) with a two (2) foot length of cable appropriately attached to each terminal (end) of the turnbuckle.
- (v) Fatigue (Bending). The safety wire used in the conventional lock wire safetying procedure recommended in CAM 4b.329-2 is not considered to be re-usable. If the safety device used with the special aircraft turnbuckle assembly is to be considered re-usable, at least three (3) samples of the shortest formed non-standard safety wire (or other finished safetying device) shall be tested by alternate fastening and unfastening of the wire (or other safetying device), to determine that the device will not break after repeated applications of the bending loads involved. 200 on and off cycles, simulating rough treatment apt to be experienced during maintenance should substantiate a reasonable service life. It is felt that the shortest safety wire (or other safetying device) will be subjected to the greatest bending stresses. However, if the stresses may be greater in a longer wire (or other safetying device) intended for a larger size turnbuckle, the larger size turnbuckle and the longer wire (or other safetying device) shall be used for this test.
- (vi) Fatigue (Torsion). At least one sample of each size turnbuckle assembly and/or safetying device shall be given a repeated load test in which a load equal to 2/3 the torque (determined in test No 1 above) required to overcome the turnbuckle thread friction and break the conventional safety wire (CAM 4b.329-2) is applied in torsion first in one direction and then reversed for 3000 complete cycles of reversal without failure of any component part.

3.2 - Specific

None

#### **4 - Marking**

4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

4.2 - Specific

None.

#### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

# European Aviation Safety Agency

## European Technical Standard Order

Subject: SAFETY BELTS

### 1 - Applicability

This ETSO gives the requirements that safety belts which are manufactured on or after the date of this ETSO, must meet in order to be identified with the applicable ETSO marking.

### 2 - Procedures

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### 3 - Technical Conditions

#### 3.1 - General

##### 3.1.1 - Minimum Performance Standard

Standards set forth in Society of Automotive Engineers, Inc. (SAE) Aerospace Standard (AS) Document No. AS 8043, „Torso Restraint Systems,“ dated March 1986, with the exceptions and revisions covered in subparagraphs 3.1.1.(3) and 3.1.1.(4) of this ETSO. Through these exceptions and additions, this ETSO only uses those paragraphs of SAE AS 8043 applicable to the pelvic restraint (seat belt) portion of the torso restraint system.

##### (1) Exceptions.

- (i) Wherever SAE AS 8043 refers to torso restraint system(s) or pelvic restraint it shall be considered to be applicable to safety-belt restraint system(s).
- (ii) The information contained in Sections 1., 2.1, 2.3, and 2.9 of SAE AS 8043 is not relevant to safety belt restraint systems and shall be disregarded.
- (iii) Compliance with Sections 3.2, 3.2.2, 3.8, 5.9, 6.1, 6.1.2, 8.9, 9.3 and 9.4 of SAE AS 8043 is not required.
- (iv) Disregard references to breaking strength of upper torso restraint webbing and attachment hardware specified in Sections 4.2, 4.4, and 5.3 of SAE AS 8043 respectively.

##### (2) Additions.

- (i) The definition in Section 2.2 of SAE AS 8043 shall read as follows: Safety Belt Restraint System: Consists of any webbing or similar device including all buckles or other fasteners, and all integral hardware designed to restrain movement of the pelvis, commonly referred to as a lap belt or safety belt.
- (ii) The requirements of Section 3.2.1 of SAE AS 8043 shall read as follows: Safety Belt Restraint System: A safety belt restraint system shall provide pelvic restraint and shall not incorporate emergency locking retractors (inertia reels).
- (iii) Section 9.1 of SAE AS 8043 is revised and shall read as follows: Installation: All components of three seat belt restraint systems shall be tested using a rigid test block, as shown in Figures 2 and 3, or a modified test block incorporating only the first 6 inches of the test block shown in Figure 3, or the equivalent, using the procedures in paragraph 9.2, as appropriate. Install the seat belt restraint system on the test block, as shown in Figure 2 and adjust to a length of 1220-1270 mm (48-50 inches), or as near as possible. An automatic

locking retractor should be locked at the start of the test with a force on the webbing just sufficient to keep the retractor locked.

- (3) Environmental Standards. SAE AS 8043 incorporates as reference the following environmental standards, for which a more recent version of these standards may be substituted, if approved by the Agency .
  - (i) American Society for Testing Materials (ASTM) G23-81, Standard Practice for Operating Light-Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials.
  - (ii) ASTM B117-73, Standard Method of Salt Spray (Fog) Testing.
  - (iii) ASTM D756-78, Standard Practice for Determination of Weight and Shape Changes of Plastics Under Accelerated Service Conditions.
- (4) Test Methods. SAE AS 8043 incorporates as a reference the following test standards, for which a more recent version of these standards may be substituted, if approved by the Agency .
  - (i) American Association of Textile Chemist and Colorists (AATCC) Standard Test Method 8-1981, Colorfastness to Crocking.
  - (ii) AATCC Standard Test Method 107-1981, Colorfastness to Water.
  - (iii) Federal Test Method Standard 191, Method 5906.
  - (iv) AATCC Chart for Measuring Transference of Color.

#### **4 - Marking**

##### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

##### 4.2- Specific

None.

#### **5 - Availability of Referenced Document**

- See CS-ETSO Subpart A paragraph 3.
- Copies of AATCC 8-1981 and 107-1981 may be purchased from the American Association of Textile Chemists and Colorists, PO Box 12215, Research Triangle Park, NC 27709, USA.
- Copies of Federal Test Method Standard 191 Method 5906 may be purchased from the Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120, USA.

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** PERSONNEL PARACHUTE ASSEMBLIES

### **1 - Applicability**

This ETSO gives the requirements which personnel parachutes assemblies that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the Society of Automotive Engineers, Inc., (SAE) Aerospace Standard (AS) Document : AS 8015B „Parachute Assemblies and Components, Personnel“, dated July 7, 1992.

##### 3.1.2 - Environmental Standard

None.

##### 3.1.3 – Computer Software

None

#### 3.2 - Specific

None.

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** AIRCRAFT SEATS AND BERTHS (TYPE I TRANSPORT 6g FORWARD LOAD)

### 1 - Applicability

This ETSO gives the requirements which seats, used in transport category aircraft for which an application for type certificate was made prior to March 5, 1952, that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### 2 - Procedures

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### 3 - Technical Conditions

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in National Aircraft Standard Specification 806, revised January 1, 1956, as amended and supplemented by this ETSO:

Exceptions

- (i) The ultimate loads corresponding to the aircraft reduced weight gust load factor or the airplane designer's special requirements may exceed the ultimate down loads for Type I seats specified in subparagraph 4.1.2 of NAS 806. For the purpose of this order, in order to provide for such loading conditions, the ultimate down loads specified in table 1 of 4.1.2 for Type I seats shall be 1,000 pounds (6g) instead of 765 pounds.
- (ii) To insure that pilot and copilot seats will provide for the rearwards loads resulting from the application of pilot forces to the flight controls, such seats shall withstand a rearward load of 450 pounds. The load shall be applied 8 inches above the intersection of the seat back with the seat bottom.
- (iii) The weight of the seat or berth times the appropriate „g“ value shall be added to the design ultimate load specified in subdivision (i) and in subparagraph 4.1.2 of NAS 806.
- (iv) For the purpose of this order, 4.3(c) of NAS 806 should read: „that the structure is capable of supporting without failure for at least 3 seconds the ultimate loads specified in this order when applied separately.“

##### 3.1.2 - Environmental Standard

None.

##### 3.1.3 – Computer Software

None

#### 3.2 - Specific

None.

**4 - Marking**

4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

4.2 - Specific

None.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

# European Aviation Safety Agency

## European Technical Standard Order

Subject: AIRCRAFT WHEELS AND WHEEL-BRAKE ASSEMBLIES (CS-23, -27 and -29 aircraft)

### 1- Applicability

This ETSO gives the requirements which aircraft wheels and wheel-brake assemblies for CS-23, CS-27 and CS-29 aircraft that are manufactured on or after the date of this ETSO must meet in order to be identified with applicable ETSO marking. The requirements which transport aeroplane wheels and wheel-brake assemblies (CS-25 aircraft) must meet are contained in ETSO-C135.

### 2 - Procedures

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### 3 - Technical Conditions

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the appendix 1 to this ETSO.

Where applicable, instead of the referenced FAA documents/paragraph the corresponding Part, CS or ETSO document/paragraph shall be used, when available.

#### 3.2 - Specific

None.

### 4 - Marking

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2. In addition, the wheels must be legibly and permanently marked with the size of the wheel.

#### 4.2- Specific

None.

### 5 - Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.

**APPENDIX 1 - FEDERAL AVIATION ADMINISTRATION STANDARD FOR AIRCRAFT WHEELS  
AND WHEEL-BRAKE ASSEMBLIES DATED MAY 18, 1984**

1. Purpose.

This document contains minimum performance standards for aircraft landing wheels and wheel-brake assemblies.

2. Design and Construction.

(a) Design.

(1) Lubricant retainers. Lubricant retainers must retain the lubricant under all operating conditions, prevent the lubricant from reaching braking surfaces, and prevent foreign matter from entering the bearings.

(2) Removable flanges. All removable flanges must be assembled onto the wheel in a manner that will prevent the removable flange and retaining device from leaving the wheel if a tire should deflate while the wheel is rolling.

(3) Adjustment. When necessary to assure safe performance, the brake mechanism must be equipped with suitable adjustment devices.

(4) Water seal. Wheels intended for use on amphibious aircraft must be sealed to prevent entrance of water into the wheel bearings or other portions of the wheel or brake, unless the design is such that brake action and service life will not be impaired by the presence of sea water or fresh water.

(5) Explosion prevention. Unless determined to be unnecessary, means must be provided to minimize the probability of wheel and tire explosions which result from elevated brake temperatures.

(b) Construction.

(1) Castings. Castings must be of high quality, clean, sound and free from blowholes, porosity, or surface defects caused by inclusions, except that loose sand or entrapped gases may be allowed when the serviceability of the casting has not been impaired.

(2) Forgings. Forgings must be of uniform condition and free from blisters, fins, folds, seams, laps, cracks, segregation, and other defects. If strength and serviceability are not impaired, imperfections may be removed.

(3) Rim surfaces. For wheels designed for use with a tire and inner tube combination, the surface of the rim between bead seats must be free from defects which would be injurious to the inner tube while mounting the tire or while in service.

(4) Rim joints. For wheels designed for use with a tire and inner tube combination, joints in the rim surface and joints between rim surfaces and demountable flanges must be smooth, close fitting, and noninjurious to the inner tube while mounting the tire or while in service.

(5) Rivets and bolts. When rivets are used, they must be well beaded over, and rivets and bolts coming in contact with the casing or tube must be smooth enough not to damage the tube or casing during normal operation.

(6) Bolts and studs. When bolts and studs are used for fastening together sections of a wheel, the length of the threads for the nut extending into and bearing against the sections must be held to a minimum and there must be sufficient unthreaded bearing area to carry the required load.

(7) Steel parts. All steel parts, except braking surfaces and those parts fabricated from corrosion-resistant steel must be cadmium plated or zinc plated or have equivalent protection from corrosion.

(8) Aluminium parts. All aluminium alloy parts must be anodized or have equivalent protection from corrosion. This protection must include protection for fuse plug holes, valve stem holes, and other passages.

(9) Magnesium parts. All magnesium alloy parts must receive a suitable dichromate treatment or have equivalent protection from corrosion. This protection must include protection for fuse plug holes, valve stem holes, and other passages.

(10) Bearing and braking surfaces. The bearing and braking surfaces must be protected during the application of finish to the wheels and brakes.

(11) Fatigue. The construction of the wheel must take into account techniques used to improve fatigue resistance of critical areas of the wheels.

3. Rating.

(a) Each wheel design must be rated for the following:

- (1) S=Maximum static load in pounds (ref. FAR §§ 23.731(b), 27.731(b), and 29.731(b) of Title 14 Chapter 1).
  - (2) L=Maximum limit load in pounds (ref. FAR §§ 23.731(c), 27.731(c), and 29.731(c) of Title 14 Chapter 1).
- (b) Each wheel-brake assembly design must be rated for the following:
- (1)  $KE_{DL}$ =Kinetic energy capacity in foot-pounds per wheel-brake assembly at the design landing rate of absorption.

#### 4. Qualification Tests

The aircraft wheels and wheel-brake assemblies required by the TSO must be tested as follows and the test data included in the applicant's test report required by the TSO.

4.1 Wheel tests. To establish the S and L ratings for a wheel, test a standard sample in accordance with the following radial, combined, and static load tests:

- (a) Maximum radial load test. Test the wheel for yield and ultimate loads as follows:
  - (1) Test method. Mount the wheel with a suitable tire of proper fit installed, on its axle, and position it against a flat nondeflecting surface. The wheel axle must have the same angular orientation to the nondeflecting surface that it will have to the runway when it is mounted on the aircraft and is under the maximum limit load. Inflate the tire to the pressure recommended for the S load with air or water. If water inflation is used, water must be bled off to obtain the same tire deflection that would result if air inflation were used. Water pressure may not exceed the pressure which would develop if air inflation were used and the tire deflected to its maximum extent. Load the wheel through its axle perpendicular to the flat nondeflecting surface. Deflection readings must be taken at suitable points to indicate deflection and permanent set of the wheel rim at the bead seat.
  - (2) Yield load. Apply to the wheel a load not less than 1.15 times the maximum radial limit load, determined under FAR §§ 23.471 through 23.511, or FAR §§ 27.471 through 27.505, or FAR §§ 29.471 through 29.511 of Title 14 Chapter 1, as appropriate. Apply the load with the wheel positioned against the nondeflecting surface, and the valve hole positioned at 90 degrees with respect to the line between the center of the wheel and the point of contact, then with the valve hole positioned at 180 degrees, 270 degrees, and 0 degrees from the nondeflecting surface. The 90 degree increments must be altered to other positions if the other positions are more critical. Three successive loadings at the 0 degree position may not cause permanent set increments of increasing magnitude. The permanent set increment caused by the last loading at the 0 degree position may not exceed 5 percent of the deflection caused by that loading or 0.005 inches, whichever is greater. The bearing cups, cones, and rollers used in operation must be used for these loadings. There must be no yielding of the wheel such as would result in loose bearing cups, air, or water leakage through the wheel or past the wheel seal, or interference in any critical areas.
  - (3) Ultimate load. Apply to the wheel a load not less than 2 times the maximum radial limit load for castings and 1.5 times the maximum radial limit load for forgings, determined under FAR §§ 23.471 through 23.511, or FAR §§ 27.471 through 27.505 or FAR §§ 29.471 through 29.511 of Title 14 Chapter 1, as appropriate. Apply the load with the same wheel positioned against the nondeflecting surface and the valve hole positioned at 0 degrees with respect to the line between the center of the wheel and the point of contact. The wheel must be able to support the load without failure for at least 3 seconds. The bearing cones may be replaced with conical bushings, but the cups used in operation must be used for this loading. If, at a point of loading during the test, it is shown that the tire will not successfully maintain pressure or if bottoming of the tire on the nondeflecting surface occurs, the tire pressure may be increased to no more than 2 times the rated inflation pressure. If bottoming of the tire continues to occur with this increased pressure, a loading block which fits between the rim flanges and simulates the load transfer of the inflated tire may be used. The arc of wheel supported by the loading block must be no greater than 60 degrees.
  - (4) If the radial limit load in paragraph 4.1(b) is equal to or greater than the maximum radial limit in paragraphs 4.1(a)(2) and (3), the test specified in paragraph 4.1(a)(2) and (3) may be omitted.
- (b) Combined radial and side load test. Test the wheel for the yield and ultimate loads as follows:
  - (1) Test method. Mount the wheel, with a suitable tire of proper fit installed, on its axle, and position it against a flat nondeflecting surface. The wheel axle must have the same angular

orientation to the nondeflecting surface that it will have to the runway when it is mounted on the aircraft and is under the combined radial and side load. Inflate the tire to the pressure recommended for the maximum static load with air or water. If water inflation is used, the water must be bled off to obtain the same tire deflection that would result if air inflation were used. Water pressure may not exceed the pressure which would develop if air inflation were used and the tire deflected to its maximum extent. For the radial load component, load the wheel through its axle perpendicular to the flat nondeflecting surface. For the side load component, load the wheel through its axle parallel to the flat nondeflecting surface. The side load reaction must arise from the friction of the tire or the loading block on the nondeflecting surface. Apply the two loads simultaneously, increasing them either continuously or in increments no larger than 10 percent of the loads to be applied. Alternatively, a resultant load equivalent to the radial and side loads may be applied to the axle. Deflection readings must be taken at suitable points to indicate deflection and permanent set of the wheel rim at the bead seat.

- (2) Yield load. Apply to the wheel radial and side loads not less than 1.15 times the respective ground loads determined under FAR §§ 23.485, 23.497, and 23.499, or FAR §§ 27.485 and 27.497, or FAR §§ 29.485 and 29.497 of Title 14 Chapter 1, as appropriate. Apply these loads with the wheels positioned against the nondeflecting surface and the valve hole positioned at 90 degrees with respect to the line between the center of the wheel and the point of contact, then with valve hole positioned at 180 degrees, 270 degrees, and 0 degrees from the nondeflecting surface. The 90 degree increments must be altered to other positions if the other positions are more critical. Three successive loadings at the 0 degree positions may not cause permanent set increments of increasing magnitude. The permanent set increment caused by the last loading at the 0 degree position may not exceed 5 percent of the deflection caused by that loading, or 0.005 inches, whichever is greater. The bearing cups, cones, and rollers used in operation must be used in this test. There must be no yielding of the wheel such as would result in loose bearing cups, air or water leakage through the wheel or past the wheel seal, or interference in any critical areas. A tire and tube may be used when testing a tubeless wheel only when it has been demonstrated that pressure will be lost due to the inability of a tire bead to remain properly positioned under the load. The wheel must be tested for the most critical inboard and outboard side loads.
  - (3) Ultimate loads. Apply to the wheel radial and side load not less than 2 times for castings and 1.5 times for forgings the respective ground loads determined under FAR §§ 23.485, 23.497, and 23.499, or FAR §§ 27.485 and 27.497, or FAR §§ 29.485 and 29.497 of Title 14 Chapter 1 as appropriate. Apply these loads with the same wheel positioned against the nondeflecting surface and the valve hole positioned at 0 degrees with respect to the center of the wheel and the point of contact. The wheel must be able to support the load without failure for at least 3 seconds. The bearing cones may be replaced with conical bushings, but the cups used in operation must be used for this loading. If, at a point of loading during the test, it is shown that the tire will not successfully maintain pressure or if bottoming of the tire on the nondeflecting surface occurs, the tire pressure may be increased to no more than 2 times the rated inflated pressure. If bottoming of the tire continues to occur with this increased pressure, a loading block which fits between the rim flanges and simulates the load transfer of the inflated tire may be used. The arc of wheel supported by the loading block must be no greater than 60 degrees.
- (c) Maximum static load test. Test the wheel for the maximum static load test as follows:
- (1) Test method. Mount the wheel, with a suitable tire of proper fit installed, on its axle, and position it against a flat nondeflecting surface or a flywheel. The wheel axle must have the same angular orientation to the load surface that it will have to the runway when it is mounted on the aircraft and is under the maximum static load. Inflate the tire to the pressure recommended for the maximum static load „S“. The radial load must be applied to the wheel through the axle and perpendicular to the load surface. The side load, when required, must be applied through the wheel axle and parallel to the load surface. For the side load, the wheel axle must be rotated or yawed to the angle which will produce a side load component equal to 0.15 „S“ while the wheel is being roll tested.
  - (2) Roll test. The wheel must be tested under the loads and for the distance shown in Table I. At the end of the test there must be no cracks on the wheel and no leakage through the wheel or past the wheel seal, and the bearing cups may not be loosened in the hub.

TABLE I

Category of Aircraft	Load Conditions	Roll Distance (miles)
Part 23	Maximum static load, „S“	1000
Parts 27 and 29	Maximum static load, „S“	250

(3) Reserved

TABLE II - Reserved

- (d) Pressure test. Pressure test the wheel in accordance with the following:
- (1) Overpressure test. The wheel must be hydrostatically tested to withstand without failure for at least 3 seconds application of an overpressure factor not less than 3.5 for Part 23 airplanes, and 3.0 for rotorcraft, times the rated inflation pressure determined by the applicant.
  - (2) Diffusion test. The tubeless tire and wheel assembly must hold the rated inflation pressure for 24 hours with no greater pressure drop than 5 percent. This test must be performed after the tire growth has stabilized.
- 4.2 Wheel-brake assembly test. A sample of a wheel-brake assembly design, with a suitable tire of proper fit installed, must meet the following tests to qualify the design for its kinetic energy ratings. The wheel of a wheel-brake assembly must be separately tested under paragraph 4.1. The wheel-brake assembly must be tested with the operating medium specified by the manufacturer.
- (a) Dynamic torque tests. Test the wheel-brake assembly on the suitable inertial brake testing machine in accordance with the following:
- (1) Speed and weight values. For airplanes, select either Method I or Method II below to calculate the kinetic energy level which a single wheel and wheel-brake assembly will be required to absorb. For rotorcraft, use Method I.
    - (i) Method I. Calculate the kinetic energy level to be used in the brake testing machine by using the equation:

$$KE = \frac{0.0443WV^2}{N}$$

where:

KE = Kinetic energy per wheel-brake assembly (ft.-lbs.);

W = Design landing weight (lbs.);

V = Aircraft speed in knots. V must be not less than  $V_{SO}$  the poweroff stalling speed of the aircraft at sea level, at the design landing weight, and the landing configuration.;

N = Number of wheels with brakes. For rotorcraft, the manufacturer must calculate the most critical combination of takeoff weight and brake application speed to be used in the above equation.

- (ii) Method II. The speed and weight values may be determined by other equations based on rational analysis of the sequence of events expected to occur during an accelerate-stop condition or an operational landing at maximum landing weight. The analysis must include rational or conservative values for braking coefficients of friction between the tire and runway, aerodynamic drag, propeller drag, powerplant forward thrust, and, if critical, loss of drag credit for the most adverse single engine or propeller due to malfunction. Do not consider the decelerating effects of propeller reverse pitch, drag parachutes, and powerplant thrust reversers.
- (2) Test requirements. The wheel-brake assembly must bring the inertial testing machine to a stop at the average deceleration, and for the number of repetitions specified in Table III without failure, impairment of operation, or replacement of parts except as permitted in paragraph 4.2(a)(3).

TABLE III

Category of Aircraft	Test
Parts 23	KE <sub>DL</sub> : 100 design landing stops at a deceleration selected by manufacturer but not less than 10 ft./sec. <sup>2</sup>
Parts 27 and 29	RE <sub>DL</sub> : 20 design landing stops at a deceleration selected by manufacturer but not less than 6 ft./sec. <sup>2</sup>

- (3) General Conditions.
- (i) During landing stop tests (KE<sub>DL</sub>), one change of brake lining is permissible. The remainder of the brake assembly parts must withstand the 100 KE<sub>DL</sub> stops without failure or impairment of operations.
- (b) Brake structural torque test. Apply load S and a torque load specified in paragraphs 4.2(b)(1) or (2), as applicable, for at least 3 seconds. Rotation of the wheel must be resisted by a reaction force transmitted through the brake or brakes by an application of at least maximum brake line pressure or brake cable tension in the case of a nonhydraulic brake. If such pressure or tension is insufficient to prevent rotation, the friction surface may be clamped, bolted, or otherwise restrained while applying the pressure or tension.
- (1) For landing gears with only one wheel per landing gear strut, the torque load is 1.2 SR where R is the normal loaded radius of the tire at rated inflation pressure under load S.
  - (2) For landing gears with multiple wheels per landing gear strut, the torque load is 1.44 SR where R is the normal loaded radius of the tire at rated inflation pressure under load S.
- (c) Overpressure-hydraulic brakes. The brake with actuator piston extended to simulate a maximum worn condition must withstand hydraulic pressure for at least 3 seconds, equal to the following:
- (1) For airplanes, 2 times the maximum brake line pressure available to the brakes.
  - (2) For rotorcraft, 2 times the pressure required to hold the rotorcraft on a 20 degree slope at design takeoff weight.
- (d) Endurance tests-hydraulic brakes. The hydraulic brake assembly must be subjected to an endurance test during which the total leakage may not exceed 5cc and no malfunction may occur during or upon completion of the test. Minimum piston travel during the test may not be less than the maximum allowable piston travel in operation. The tests must be conducted by subjecting the hydraulic brake assembly to:
- (1) 100,000 cycles for airplanes, and 50,000 cycles for rotorcraft, of application and release of the average hydraulic pressure needed in the KE<sub>DL</sub> tests specified in paragraph 4.2(a)(2) except that manufacturers using Method II in conducting the tests specified in paragraph 4.2(a)(2) must subject the wheel-brake assembly to the average of the maximum pressure needed in those tests. The piston must be adjusted so that 25,000 cycles for airplanes, and 12,500 cycles for rotorcraft are performed at each of the four positions where the piston would be at rest when adjusted for 25, 50, 75, and 100 percent of the wear limit; and
  - (2) 5,000 cycles for airplanes, and 2,500 cycles for rotorcraft at the maximum system pressure available to the brakes.

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** TWIN SEAPLANES FLOATS

### 1 - Applicability

This ETSO gives the requirements which twin seaplanes floats that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### 2 - Procedures

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### 3 - Technical Conditions

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the National Aircraft Standards Specification NAS 807, dated June 1, 1951 as amended and supplemented by this ETSO:

- (i) Section 4.3.3.4 Unsymmetrical Landing. Two-Float Landing with Drift.

Third sentence :

„The side load shall be  $\tan b/4$  times the step landing load of 4.3.3.1.“

- (ii) Section 4.3.3. Limit Load Factors for General Structure Design. Definition of symbols following subpart (b) :

„ $V_{SO}$  = airplane design stalling speed at design landing weight with zero thrust and landing flaps or other high lift devices in position for landing.

$W$  = one half the airplane design landing weight.“

##### 3.1.2 - Environmental Standard

None.

##### 3.1.3 – Computer Software

None

#### 3.2 - Specific

None.

### 4 - Marking

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 Specific

None.

### 5 - Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** AIRCRAFT SKIS

### **1 - Applicability**

This ETSO gives the requirements which aircraft skis that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the National Aircraft Standards Specification NAS 808, dated December 15, 1951.

##### 3.1.2 - Environmental Standard

None.

##### 3.1.3 - Computer Software

None

#### 3.2 - Specific

None.

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** AIRCRAFT POSITION LIGHTS

### **1 - Applicability**

This ETSO gives the requirements which new models of aircraft position lights that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 Minimum Performance Standard

Standards set forth in the Society of Automotive Engineers, Inc., (SAE) Aerospace Standard (AS) Document AS 8037 „Minimum Performance Standard for Aircraft Position Lights“ dated January 1986.

##### 3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1

##### 3.1.3 - Computer Software

None

#### 3.2 - Specific

None.

### **4 - Marking**

#### 4.1 - General

In lieu of the marking detailed in CS-ETSO Subpart A paragraph 1.2, the minimum lamp candle power or lamp part number shall be shown.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** HIGH FREQUENCY (HF) RADIO COMMUNICATIONS TRANSMITTING EQUIPMENT  
OPERATING WITHIN THE RADIO FREQUENCY RANGE 1.5-30 MEGAHERTZ.

### 1 - Applicability

This ETSO gives the requirements which new models of high frequency radio communications transmitting equipment operating within the radio frequency range 1.5-30 megahertz must meet in order to be identified with the applicable ETSO marking.

### 2 - Procedures

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### 3 - Technical Conditions

#### 3.1 - General

##### 3.1.1 - Minimum Performance Standard

Standards set forth in Radio Technical Commission for Aeronautics (RTCA) Document DO-163 dated March 19, 1976 as amended and supplemented by this ETSO.

Additions

In addition to paragraph 1.0, General Standards, of RTCA DO-163, all materials used except small parts (such as knobs, fasteners, seals, grommets and small electrical parts) that would not contribute significantly to the propagation of a fire, must be self-extinguishing when tested in accordance with applicable requirements of CS 25.869(a)(4) and Appx F.

##### 3.1.2 - Environmental Standard:

See CS-ETSO Subpart A paragraph 2.1.

##### 3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2.

#### 3.2 - Specific

None.

### 4 - Marking

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### 5 - Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** HIGH FREQUENCY (HF) RADIO COMMUNICATIONS RECEIVING EQUIPMENT  
OPERATING WITHIN THE RADIO FREQUENCY RANGE 1.5-30 MEGAHERTZ.

### **1 - Applicability**

This ETSO gives the requirements which new models of high frequency radio communications receiving equipment operating within the radio frequency range 1.5-30 megahertz must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - General

##### 3.1.1 - Minimum Performance Standard

Standards set forth in Radio Technical Commission for Aeronautics (RTCA) Document DO-163 dated March 19, 1976 as amended and supplemented by this ETSO.

##### Additions

In addition to paragraph 1.0, General Standards, of RTCA DO-163, all materials used except small parts (such as knobs, fasteners, seals, grommets and small electrical parts) that would not contribute significantly to the propagation of a fire, must be self-extinguishing when tested in accordance with applicable requirements of CS 25.869(a)(4) and Appx F.

##### 3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1.

##### 3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2.

#### 3.2 - Specific

None.

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** AIRCRAFT SEATS AND BERTHS

### 1 - Applicability

This ETSO gives the requirements which aircraft seats and berths that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking for the following types:

- Type I – Transport/Large Aeroplane (9g forward load)
- Type II – Normal and Utility
- Type III – Aerobatic
- Type IV – Rotorcraft

### 2 - Procedures

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### 3 - Technical Conditions

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the National Aerospace Standard (NAS) Specification 809, dated January 1, 1956 with the following exceptions, and as amended and supplemented by this ETSO:

Exceptions

- (i) The sideward loads as specified in 4.1.2. Table I of NAS 809 need not exceed the requirements of the applicable Certification Specification (CS).
- (ii) In lieu of compliance with 2.1, 3.1.2, and 4.3.2 of NAS 809, materials in Type I seats must comply with the fire protection requirements of CS 25.853, including the requirements of CS 25.853(c). Materials in Type I berths must comply with the fire protection provisions of CS 25.853(b).

Additions

Tests for Fire Blocking of Seat Cushions Tests must be conducted in accordance with Appendix F, Part II of CS 25.

#### 3.2 - Specific

None.

### 4 - Marking

#### 4.1 - General

Marking as detailed in CS-ETSO Subpart A paragraph 1.2. In addition, the following additional information must be shown when tested to the fire blocking requirements above:

„Compliance with CS 25.853(c),“

4.2 - Specific  
None.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** PROPELLER FEATHERING HOSE ASSEMBLIES

### 1 - Applicability

This ETSO gives the requirements which propeller feathering hoses assemblies of the following types that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking:

- (i) Type 1 (pressure line) hose assemblies which are intended to be used in the line connecting the feathering pump outlet to the propeller governor.
- (ii) Type 2 (supply line „fire resistant“) hose assemblies which are intended to be used in the line connecting the oil supply to the feathering pump where this entire line is located aft of the firewall.
- (iii) Type 3 (supply line „fire proof“) hose assemblies which are intended to be used in the line connecting the oil supply to the feathering pump where this entire line is located wholly or in part forward of the firewall.

### 2 - Procedures

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### 3 - Technical Conditions

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in Sections 3 and 4 of Military Specifications MIL-H-8795D, dated October 14, 1985, or MIL-H-8790D dated December 30, 1981 with the following exception and shall also meet the appropriate fire test requirements listed below:

Test Methods

- a - *Exception:* the hydraulic impulse test requirements in MIL-H-8795D and MIL-H-8790 need not be met for the purposes of this paragraph.
- b - *Pressure line (type 1) hose assembly fire test*
  - (i) *Test set up and flame requirements*
    - (a) For the purpose of this test, a length of hose five times the outside diameter or longer shall be subjected to a flame of the size and temperature specified in (d) and (e) of this subdivision while the hose is in a horizontal position. The entire end fitting shall also be subjected to this flame.
    - (b) The hose assembly shall be installed horizontally in the test setup in such a manner that it includes at least one full 90° bend so that the pressure existing inside the hose will exert an axial force on the end fitting equal to the inside area of the hose multiplied by the internal pressure.
    - (c) During the test the end fitting which is subjected to flame shall be vibrated at the rate of 33 hertz through a total amplitude of not less than 3.2 mm i.e. a displacement of 1.6 mm on each side of the neutral position.

- (d) The flame temperature shall be 1100°C plus or minus 30°C as measured within 6.35 mm of the surface of the hose and end fitting at the point nearest the flame. Suitable shielded thermocouples or equivalent temperature measuring devices shall be used for measuring the flame temperature. A sufficient number of these shall be used to assure that the specified temperature exists at least along the entire end fitting and along the hose for a distance of not less than three times its outside diameter.
- (e) The flame diameter shall not be less than three times the maximum diameter of the hose or three times the maximum diameter of the end fitting (whichever is the greater). The length of the flame shall be such that it extends beyond the end fitting and hose when they are in place during the test, for a distance of not less than three times the maximum diameter of the hose or three times the maximum diameter of the end fitting (whichever is the greater).
- (f) During the test SAE 20 oil or equivalent shall be circulated through the hose assembly and the oil shall enter the hose assembly at a temperature of not less than 93°C.
- (ii) *Fire test procedure*
  - (a) Part I  
Pressure: 1034kPa (150 psi) (minimum).  
Oil flow rate: 1.23dm<sup>3</sup> (1.3 quart)/minute (maximum).  
Duration: 4 minutes, 30 seconds.
  - (b) Part II (which shall immediately follow Part I)  
Pressure: 11378kPa (1650 psi) (minimum).  
Oil flow rate: 13.2dm<sup>3</sup> (14 quarts)/minute (maximum); any lower flow rate is acceptable).  
Duration: 30 seconds.
- (iii) *Criteria for acceptability*  
The hose assembly under test shall be considered acceptable if it complies with these tests conditions without evidence of leakage.
- c - *Supply line „fire-resistant“ (type 2) hose assembly fire test*
  - (i) *Test set up and flame requirements*  
Same as paragraph (b)(i) of this paragraph.
  - (ii) *Fire test procedure*  
Pressure: 207kPa (30 psi) (minimum).  
Oil flow rate: 13.2dm<sup>3</sup> (14 quarts)/minute (maximum).  
Duration: 5 minutes.
  - (iii) *Criteria for acceptability*  
Same as paragraph (b)(iii) of this paragraph.
- d - *Supply line „fire proof“ (type 3) hose assembly fire test*
  - (i) *Test set up and flame requirements*  
Same as paragraph (b)(i) of this paragraph.
  - (ii) *Fire test procedure*  
Pressure: 207 kPa (30 psi) (minimum).  
Oil flow rate: 13.2dm<sup>3</sup>/minute (14 quarts/minute,) (maximum).  
Duration: 15 minutes.
  - (iii) *Criteria for acceptability*  
Same as paragraph (b)(iii) of this paragraph.

3.2 - Specific  
None

#### 4 - Marking

4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

4.2 - Specific

None.

#### 5 - Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** TEMPERATURE INSTRUMENTS

### **1 - Applicability**

This ETSO gives the requirements which new models of temperature instruments that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the SAE Aerospace Standard (AS) 8005 „Minimum Performance Standard for Temperature Instruments“, reaffirmed October, 1984 as amended and supplemented by this ETSO:

Exceptions:

- (i) In the friction error test SAE AS 8005, paragraph 4.8, the vibration (to minimize friction) provisions of paragraph 4.3 do not apply.
- (ii) For clarification, the vibration test of SAE AS 8005, paragraph 5.8, shall be conducted in accordance with the test procedure of RTCA document DO-160D, paragraph 8.5.1.

##### 3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1.

##### 3.1.3 -Computer Software

See CS-ETSO Subpart A paragraph 2.2.

#### 3.2 - Specific

None.

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** FUEL FLOWMETERS

### 1 - Applicability

This ETSO gives the requirements which fuel flowmeters that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### 2 - Procedures

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### 3 - Technical Conditions

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the SAE Aeronautical Standard AS-407B „Fuel Flowmeters“, revised March 1, 1960, and reconfirmed May 1991, as amended and supplemented by this ETSO:

Exceptions:

- (i) Correction to Section 1. of AS 407B: As referenced in this ETSO, AS 407B specifies minimum requirements for fuel flowmeters for use on reciprocating engines or turbine-powered civil aircraft. In addition, the following specifically numbered subparagraphs in AS 407B do not concern minimum performance and, therefore, it is not essential to show compliance with this paragraphs: 3.1, 3.2 and 4.2.1.
- (ii) Thermal shock: This test shall apply to any hermetically sealed components. The components shall be subjected to four cycles of exposure to water at  $85^{\circ}\pm 2^{\circ}$  and  $5^{\circ}\pm 2^{\circ}$ C without evidence of moisture penetration or damage to coating or enclosure. Each cycle of the test shall consist of immersing the component in water at  $85^{\circ}\pm 2^{\circ}$ C for a period of 30 minutes and then within 5 seconds of removal from the bath, the component shall be immersed for a period of 30 minutes in the other bath maintained at  $5^{\circ}\pm 2^{\circ}$ C. This cycle shall be repeated continuously, one cycle following the other until four cycles have been completed. Following this test, the component shall be subjected to the Sealing test specified in (ii). No leakage shall occur as a result of the test.
- (iii) Sealing: This performance test shall apply to any hermetically sealed components, The component shall be immersed in a suitable liquid, such as water. The absolute pressure of the air above the liquid shall then be reduced to approximately 34 hPa (1 inch of mercury (Hg)) and maintained for 1 minute, or until air bubbles cease to be given off by the liquid, whichever is longer. The absolute pressure shall then be increased by 85 hPa (2 1/2 inches Hg). Any bubbles coming from within the indicator case shall be considered as leakage and shall be cause for rejection. Bubbles which are the result of entrapped air in the various exterior parts of the case shall not be considered as leakage. Other test methods which provide evidence equal to the immersion test of the integrity of the instrument's seals may be used. If the component incorporates non hermetically sealed appurtenances such as a case extension, these appurtenances may be removed prior to the Sealing test.

(iv) Correction to subparagraph 3.3.1: Under column A, the temperature values for unheated areas (Temperature Uncontrolled) shall be -55° to 70°C.

3.1.2 - Environmental Standard

The conditions and procedures prescribed in AS 407B are to be used.

3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2

3.2 - Specific

None.

**4 - Marking**

4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2. In addition, the range (transmitters only) and electrical rating shall be shown.

4.2 - Specific

None.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** MANIFOLD PRESSURE INSTRUMENTS

### **1 - Applicability**

This ETSO gives the requirements which manifold pressure instruments that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the SAE Aerospace Standard (AS) document : AS-411 „Manifold Pressure Instruments“, dated November 1, 1948.

##### 3.1.2 - Environmental Standard

As indicated in AS-411.

##### 3.1.3 – Computer Software

None

#### 3.2 - Specific

None

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2; in lieu of the weight, the range shall be shown.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** MAXIMUM ALLOWABLE AIRSPEED INDICATOR SYSTEMS

### **1 - Applicability**

This ETSO gives the requirements which maximum allowable airspeed indicator systems that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the attached „Federal Aviation Administration Standard, Maximum Allowable Airspeed Indicator Systems“ as amended and supplemented by this ETSO:

- a. Tests procedures set forth in Society of Automotive Engineers (SAE) Aeronautical Standard (AS) 418A dated May 15, 1961, „Maximum Allowable Airspeed Instrument, Reciprocating Engine Powered Aircraft“, or SAE AS 437 dated April 15, 1963, „Maximum Allowable Airspeed Instrument, Turbine Powered Aircraft“, may be used for the purpose of showing compliance with related standards in this ETSO. However, environmental limits, or other limits, specified in these procedures must be adjusted if necessary to agree with those specified in this ETSO.
- b. Other test procedure may also be adequate and valid for the purpose.
- c. Where applicable, instead of the referenced FAA documents/paragraph the corresponding IR, CS or ETSO document/paragraph shall be used, when available.

##### 3.1.2 - Environmental Standard

As stated in the „Federal Aviation Administration Standard, Maximum Allowable Airspeed Indicator Systems“.

##### 3.1.3 – Computer Software

None

#### 3.2 - Specific

None.

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2; in addition to the markings required by this paragraph, the instrument must be marked to indicate its range in knots and, if applicable, to identify the calibration employed to control the movement of the maximum allowable airspeed

pointer in the Vmo and Mmo ranges, or to identify the particular aircraft type design on which the instrument is intended to be used.

4.2 - Specific  
None.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

FEDERAL AVIATION ADMINISTRATION STANDARD  
Maximum Allowable Airspeed Indicator Systems

1. Purpose.

This document specifies minimum performance standards for pitot-static type, maximum allowable airspeed indicator systems which indicate continuously both indicated airspeed and maximum allowable airspeed.

2. Performance Requirements.

2.1 General

(a) *Materials.* Materials must be of a quality demonstrated to be suitable and dependable for use in aircraft instruments.

(b) *Environmental conditions.* The instrument must be capable of performing its intended function and not be adversely affected during or following prolonged exposure to the environmental conditions stated under section 3. Where optional environments conditions are set forth, the conditions selected must be declared as equipment limitations.

2.2 Detail requirements.

(a) *Indicating means.* Indicated airspeed and maximum allowable airspeed must be displayed in such a manner that the numerical values on the scale increase in a clockwise, left to right, or bottom to top direction.

(b) *Case markings.* The outlets in the case must be marked with „P“ for the pitot pressure connection, and with „S“ for the static pressure connection.

2.3 Design requirements.

(a) *Adjustable settings.*

(1) *Maximum allowable airspeed pointer.* An adjustable stop may be provided in the instrument for limiting the movement of the maximum allowable airspeed pointer. If included, the design of this adjustment must be such that it will not affect the indication of the pointer when the altitude pressure conditions and Mach Number setting are such that the limiting speed will be lower than that set by the adjustable stop.

(2) *Mach Number.* If a readily accessible means is provided for setting the instrument to any desired Mach Number, the value of the setting must be visible from the front of the instrument. When the instrument does not contain an external Mach Number setting adjustment, the value of the permanent Mach Number setting need not be visible from the front of the instrument.

(b) *Visibility.* The indicating means and all markings must be visible from any point within the frustum of a cone, the side of which makes an angle of at least 30° with the perpendicular to the dial and the small diameter of which is the aperture of the instrument case. The distance between the dial and the cover glass must be a practical minimum.

(c) *Calibration.*

(1) *Indicated air-speed pointer.* The indicated airspeed pointer must indicate airspeed in accordance with the values contained in Table I.

(2) *Maximum allowable airspeed pointer.* The maximum allowable airspeed pointer must indicate maximum allowable airspeed values in the V<sub>mo</sub> and M<sub>mo</sub> limit ranges which -

(i) Follow the standard fundamental relationships of subsonic compressible flow gas dynamics which are stated in appendix A; or

(ii) Are adjusted to account for design factors that are characteristic of a particular aircraft type design such as, but not limited to, static source

pressure error variations and variable speed limitations with altitude.

(d) *Scale error.*

(1) *Instruments with permanent Mach Number setting.* The indicated airspeed scale error and the maximum allowable airspeed scale error must not exceed the tolerances specified in Tables I and II, respectively, with the instrument set at its permanent Mach Number.

(2) *Instruments with means for external Each Number setting adjustment.*

(i) The indicated airspeed scale error must not exceed the tolerances specified in Table I with the instrument set at the lowest Mach number.

(ii) The maximum allowable airspeed scale error must not exceed the tolerances specified in Table II with the instrument set at the lowest Mach Number and at increasing Mach Number setting of not more than 0.10 to and including the maximum Mach Number.

(e) *Hysteresis.* The reading of the maximum allowable airspeed pointer first at 30,000 feet altitude and then at 10,000 feet altitude must not differ by more than 2 knots from the corresponding readings obtained for increasing altitudes during tests to assure the instrument complies with the scale error requirements of section 2.3(d) (2) (ii) of this TSO.

(f) *After effect.* To assure the instrument complies with the scale error requirements of section 2.3 (d) (2) (ii) of this TSO, the maximum allowable airspeed pointer must return to its original readings, corrected for any change in atmospheric pressure, within 3 knots, after not less than 1 or more than 5 minutes have elapsed following completion of performance tests.

(g) *Friction.*

(1) *Maximum allowable airspeed pointer.* The friction of the pointer must not produce an error exceeding 4 knots at each point indicated by an asterisk in Table II.

(2) *Indicated airspeed pointer.* The friction on the pointer must not produce an error exceeding 3 knots at each point indicated by an asterisk in Table I.

(h) *Leak.*

(1) *Case leak.* When subjected to a static pressure differential of 15 inches of mercury between the inside and outside of the case, the internal pressure must not increase because of case leaks more than 0.05 inches of mercury at the end of 1 minute time following first application of the differential pressure.

(2) *Airspeed diaphragm leak.* There must not be any apparent movement of the indicated airspeed pointer for 1 minute after a sequence of events in which pressure sufficient to produce full scale deflection of the indicated airspeed pointer is applied to the pitot connection (static pressure connection open to atmosphere), the pressure source is stopped, and the connection tubing pinched.

3. Environmental Conditions.

3.1 *Temperature.* The instrument must perform its intended function over the range of ambient temperature from -30° to 50° C. With the instrument temperature stabilized at the limits of the range, the scale error must not exceed by more than 4.5 knots the tolerances specified in Tables I and II at the points marked with an asterisk. The instrument must not be adversely affected by exposure to the range of ambient temperature from -65° to 70° C.

3.2 *Altitude.* The instrument must perform its intended function and must not be adversely affected when operating in the pressure range from -1,000 feet and the maximum altitude of intended operation. The instrument must withstand an external case pressure of 50" Hg. absolute when installed properly and vented to an atmospheric pressure of approximately 29.92" Hg. absolute.

3.3 *Vibration.* The instrument must perform its intended function and must not be adversely affected when subjected to vibrations of the following characteristics:

Instrument panel mounted (vibration isolated)	Frequency cycles per second	Maximum double amplitude (inches)	Maximum acceleration
Reciprocating engine powered aircraft --	5-50	0.020	1.5
Turbine engine powered aircraft --	5-55 55-1000	0.020 -----	----- 0.25g

3.4 *Humidity.* The instrument must perform its intended function and must not be adversely affected following exposure to the extreme condition of relative humidity in the range from 0 to 95 percent at a temperature of approximately 70° C. for a period of 10 hours.

**4. Compliance Tests.**

As evidence of compliance with this standard, the manufacturer must perform evaluation tests on prototype instruments to demonstrate proper design, reliability in performance of its intended functions, and conformity with the performance standards of section 2. Tests must also be performed to demonstrate compliance with the environmental condition requirements specified in section 3.

**5. Individual Performance Tests.**

The manufacturer must conduct such tests as may be necessary on each instrument to assure that it will meet the minimum performance requirements of sections 2.3 (b) through 2.3 (h).

TABLE I

Speed knots	Impact pressure (qc) inches Hg at 25° C	Tolerance knots
50	0.1198	±4.0
*60	.1727	2.0
80	.3075	2.0
*100	.4814	2.0
120	.6950	2.0
*150	1.091	2.5
180	1.580	3.0
*200	1.959	3.0
230	2.610	3.0
*250	3.100	3.0
280	3.924	3.5
*300	4.534	3.5
320	5.195	3.5
*350	6.286	4.0
370	7.082	4.5
*400	8.385	5.0
430	9.826	5.5
*450	10.87	6.0
480	12.56	7.0
*500	13.78	7.0
520	15.07	7.0
*550	17.16	8.5
570	18.66	8.5
*600	21.07	9.0
630	23.71	9.5
*650	25.59	10.0

TABLE II

Altitude feet mercury	Pressure inches ± knots	Maximum speed pointer tolerance	
0	29.921	**4	
*5,000	24.896		
10,000	20.577		
*15,000	16.886		
20,000	13.750		
*25,000	11.104		
30,000	8.885		
*35,000	7.041		
40,000	5.538		
*45,000	4.355		
50,000	3.425		**4

\*\*From indicated airspeed corresponding to maximum equivalent airspeed or maximum mach whichever is the limiting factor.

**APPENDIX A**

**Relationships For Calibrating Maximum Allowable Airspeed Pointer**

(1) For altitudes from sea level to altitude where

$$V_{MO} = C_{SO} \sqrt{\frac{2}{k-1} \left\{ 1 + \frac{P}{P_0} \left[ \left( \frac{V^1 M}{5C_{SO}^2 \alpha} + 1 \right)^{\frac{k}{k-1}} - 1 \right]^{\frac{k-1}{k}} - 1 \right\}}$$

(2) For altitudes where  $M_{MO}$  is limited factor:

$$V_{MO} = C_{SO} \sqrt{\frac{2}{k-1} \left\{ \frac{P}{P_0} \left[ \left( 1 + \frac{k-1}{2} M_{MO}^2 \right)^{\frac{k}{k-1}} - 1 \right] + 1 \right\}^{\frac{k-1}{k}} - 1 \right\}}$$

Where:

- $V_{mo}$  = Maximum allowable indicated airspeed in knots.
- $M_{mo}$  = Maximum allowable mach.
- $k$  = Ratio of specific heats=1.40 for air.
- $P_0$  = Pressure at sea level in inches of Hg.
- $P$  = Ambient static pressure in inches of Hg.
- $C_{so}$  = Speed of sound at sea level=661.48 knots.
- $a$  = Density ratio at altitude.
- $V_m$  = Maximum equivalent airspeed in knots

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** PRESSURE INSTRUMENTS - FUEL, OIL AND HYDRAULIC

### **1 - Applicability**

This ETSO gives the requirements which fuel, oil and hydraulic pressure instruments that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the SAE Aerospace Standard (AS) document: AS-408A „Pressure Instruments-Fuel, Oil and Hydraulic, dated December 15, 1954.“

#### 3.2 - Specific

None

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2; in lieu of the weight, the range shall be shown.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** CARBON MONOXIDE DETECTOR INSTRUMENTS

### **1 - Applicability**

This ETSO gives the requirements which carbon monoxide detector instruments that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the SAE Aerospace Standard AS-412A „Carbon Monoxide Detector Instruments“, dated December 15, 1956.

##### 3.1.2 - Environmental Standard

As indicated in AS-412A.

#### 3.2 - Specific

None

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject :** ELECTRIC TACHOMETER: MAGNETIC DRAG (INDICATOR AND GENERATOR)

### **1 - Applicability**

This ETSO gives the requirements which electric tachometers: magnetic drag (indicator and generator) that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the SAE Aerospace Standard (AS) document: AS 404B dated February 1, 1959, and reconfirmed May 1991, as amended and supplemented by this ETSO:

Exceptions.

- (i) The following specifically numbered parts in AS-404B do not concern minimum performance and therefore are not essential to compliance with this paragraph: Parts 3.1, 3.1.1, 3.1.2, 3.2, 3.2(a)(b)(c)(d)(e)(f), 4.1.3.1, 4.1.3.2, 4.1.3.3, 4.1.3.4, and 4.1.3.5.
- (ii) In lieu of part 7 in AS-404B, it is a requirement that tachometers covered by this paragraph be capable of successfully passing the tests in parts 7.1 through 7.8.

##### 3.1.2 - Environmental Standard

As prescribed in AS 404B.

##### 3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2

#### 3.2 - Specific

None.

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2; in addition, range and rating shall be shown.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** AUDIO SELECTOR PANELS AND AMPLIFIERS

### **1 - Applicability**

This ETSO gives the requirements which audio selector panels and amplifiers that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in EUROCAE document ED 18 (1985) (RTCA DO-170(1980)) „Audio Equipment“. In addition to paragraph 5.0 of EUROCAE document ED 18, all materials used except small parts (such as knobs, fasteners, seals, grommets and small electrical parts) that would not contribute significantly to the propagation of a fire, must be self-extinguishing when tested in accordance with applicable requirements of and JAR 25.1359(d) Appendix F.

##### 3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1.

##### 3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2.

#### 3.2 - Specific

None.

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** FLIGHT DIRECTORS

### **1 - Applicability**

This ETSO gives the requirements which flight director equipment, primarily for use in reciprocating engine powered aircraft, that is manufactured on or after the date of this ETSO must meet, in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the SAE Aerospace Standard SAE AS8008 „Flight Director Equipment“, as reaffirmed May 1991.

##### 3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1.

##### 3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2.

#### 3.2 - Specific

None.

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** FUEL AND ENGINE OIL SYSTEM HOSE ASSEMBLIES

### 1 - Applicability

This ETSO gives the requirements which fuel and engine oil system hose assemblies that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### 2 - Procedures

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### 3 - Technical Conditions

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

(1) Minimum performance standards are hereby established for the following types of fuel and engine oil system hose assemblies:

- (i) Type A. Non-fire-resistant „normal“ temperature hose assemblies which are intended to be used in locations outside fire zones where the fluid and ambient air temperatures do not exceed 121°C.
- (ii) Type B. Non-fire-resistant „high“ temperature hose assemblies which are intended to be used in locations outside fire zones where the fluid and ambient air temperatures do not exceed 232°C.
- (iii) Type C. Fire-resistant „normal“ temperature hose assemblies which are intended to be used in locations within fire zones where the fluid and ambient air temperatures do not exceed 121°C.
- (iv) Type D. Fire-resistant „high“ temperature hose assemblies which are intended to be used in locations within fire zones where the fluid and ambient air temperatures do not exceed 232°C.

Each type shall comply with the following requirements. Three samples of each size shall be tested.

- (1) Type A hose assemblies shall comply with the „3.3 Performance“ paragraph requirements of Specification MIL-H-8795A, dated July 25, 1958, except as noted in sub-paragraph (2) of this paragraph. The hose incorporated therein shall conform to „3.6 Performance“ paragraph of Specification MIL-H-8794A, dated July 25, 1958, except as noted in sub-paragraph (2) of this paragraph.
- (2) Type B hose assemblies shall comply with the „3.6 Performance“ paragraph requirements of Specification MIL-H-25579 (USAF), dated March 19, 1959, except as noted in sub-paragraph (2) of this paragraph.
- (3) Type C hose assemblies shall comply with the above requirements for type A hose assemblies and in addition shall pass the fire test described in sub-paragraph (3) of this paragraph.

- (4) Type D hose assemblies shall comply with the above requirements for Type B hose assemblies and in addition shall pass the fire test described in subparagraph (3) of this paragraph.
- (2) Exceptions.
  - (i) Type A hose assemblies are not required to comply with paragraphs 3.6.1.2 and 3.6.2.7 of Specification MIL-H-8794A. The operating and proof pressures referred to in Table 1 of that specification shall be those values listed in the „Fuel“ column thereof. The burst pressures to be utilized shall be twice the proof pressures listed in the „Fuel“ column in Table 1. The foregoing shall likewise apply in showing compliance with Specification MIL-H-8795A.
  - (ii) Type B hose assemblies are not required to comply with paragraphs 3.6.5, 3.6.7 and 3.6.10 of Specification MIL-H-25579 (USAF). The burst pressures to be utilized shall be twice the proof pressures listed in Table 1 of that specification.
- (3) Fire test procedure and requirements. A description of the standard fire test apparatus and its use is in FAA „Standard Fire Test Apparatus and Procedure“ (Power Plant Engineering Report N°3). The use of a protective sleeve over the hose and/or end fittings is permitted to facilitate compliance with the fire test requirements. Sleeves or covers shall be secured to the hose assembly so fire-resistant properties will be maintained.
  - (i) Oil pressure during fire test: Type C hose assemblies - the operating pressure specified in the „Fuel“ column of Table 1 in Specification MIL-H-8795A. Type D hose assemblies - the operating pressure specified in Table 1 of Specification MIL-H-25579 (USAF).
  - (ii) Oil flow rate:  $5X(\text{Hose assembly actual ID in inches})^2$ . (Example: Flow rate for -16 size =  $5X(7/8)^2=3.8\text{GPM}$ )
  - (iii) Duration: 5 minutes.
  - (iv) Criteria for acceptability: The hose assembly shall be considered acceptable if it complies with these test conditions without evidence of leakage.

3.1.2 - Environmental Standard

As per paragraph 3.1.1 above.

3.1.3 – Computer Software

None

3.2 - Specific

None.

**4 - Marking**

4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

4.2 - Specific

None.

**5 - Availability of Referenced Document**

- See CS-ETSO Subpart A paragraph 3.

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** STALL WARNING INSTRUMENTS

### 1 - Applicability

This ETSO gives the requirements which stall warning instruments that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### 2 - Procedures

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### 3 - Technical Conditions

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the SAE Aeronautical Standard AS 403A issued 15/10/1952. revised 15/7/1958 with exceptions and additions to the standard listed in the following sub-paragraph:

Exceptions and additions

- (i) The following specifically numbered parts in AS 403A do not concern minimum performance and therefore are not essential to compliance with this paragraph: Parts 3.1; 3.1.1.; 3.1.2; 3.2(a), (b), (c) (d), (e), and (f).
- (ii) In lieu of Part 7 of AS 403A, it is a requirement that stall warning instruments covered by this paragraph be capable of successfully passing the tests in Parts 7.1 through 7.7 of AS 403A.
- (iii) Thermal shock: This test shall apply to any hermetically sealed component. The component shall be subjected to four cycles of exposure to water at  $85^{\circ}\pm 2^{\circ}\text{C}$  and  $5^{\circ}\pm 2^{\circ}\text{C}$  without evidence of moisture penetration or damage to coating or enclosure. Each cycle of the test shall consist of immersing the component in water at  $85^{\circ}\pm 2^{\circ}\text{C}$  for a period of 30 minutes and then within 5 seconds of removal from the bath, the component shall be immersed for a period of 30 minutes in the other bath maintained at  $5^{\circ}\pm 2^{\circ}\text{C}$ . This cycle shall be repeated continuously, one cycle following the other until four cycles have been completed. Following this test, the indicator shall be subjected to the Sealing test specified in (iv). No leakage shall occur as a result of this test.
- (iv) Sealing: This performance test shall apply to each hermetically sealed instrument. The instrument shall be immersed in a suitable liquid such as water. The absolute pressure of the air above the liquid shall then be reduced to approximately 34 hPa (1 inch of mercury (Hg)) and maintained for 1 minute or until air bubbles cease to be given off by the liquid, whichever is longer. The absolute pressure shall then be increased by 85 hPa (2 1/2 inches Hg). Any bubbles coming from within the indicator case shall be considered as a leakage and shall be cause for rejection. Bubbles which are the result of entrapped air in the various exterior parts of the case shall not be considered as a leakage. Other tests methods which provide evidence equal to the immersion test of the integrity of the instrument's

seals may be used. If the instrument incorporates non hermetically sealed appurtenances such as a case extension, these appurtenances may be removed prior to the sealing test.

- (v) Power malfunction indication: Means shall be incorporated in the instrument to indicate when adequate power (voltage and/or current) is not being made available to all phases required for the proper operation of the instrument. The indicating means shall indicate a failure or a malfunction in a positive manner, and be readily discernible under any lighting condition normally encountered in aircraft.

3.1.2 - Environment Standard

As indicated in AS 403A document.

3.1.3 – Computer Software

None

3.2 - Specific

None

**4 - Marking**

4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

4.2 - Specific

None.

**5 -Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** FUEL AND OIL QUANTITY INSTRUMENTS (RECIPROCATING ENGINE AIRCRAFT)

### **1 - Applicability**

This ETSO gives the requirements which fuel and oil quantity instruments that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the SAE Aerospace Standard (AS) 405B „Fuel and oil quantity Instruments“, dated July 15, 1958 as amended and supplemented by this ETSO:

- (i) Conformance with the following paragraphs of AS 405B is not required: 3.1; 3.1.1, 3.1.2, 3.2 and 4.2.1.
- (ii) Substitute the following for paragraph 7: „Performance tests: The following tests, in addition to any others deemed necessary by the manufacturer, shall be the basis for determining compliance with the performance requirements of this standard“.

##### 3.1.2 - Environmental Standard

As specified in the SAE Aerospace Standard AS 405B.

##### 3.1.3 – Computer Software

None

#### 3.2 - Specific

None.

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** ENGINE-DRIVEN DIRECT CURRENT GENERATORS/STARTER-GENERATORS

### 1 - Applicability

This ETSO gives the requirements which engine-driven D.C. generators/starter-generators that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### 2 - Procedures

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### 3 - Technical Conditions

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the Society of Automotive Engineers, Inc., (SAE) Aerospace Standard (AS) 8020 „Engine-Driven D.C. Generators/Starter-Generators and Associated Voltage Regulators“, dated January 1980.

##### 3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1.

##### 3.1.3 – Computer Software

None

#### 3.2 - Specific

None.

### 4 - Marking

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2; In addition to this marking, the following information shall be legibly and permanently marked on the equipment:

- (1) The environmental categories in which it has been qualified to operate in accordance with the applicable SAE document; however this marking is not necessary when the alternative is used as described in EUROCAE/RTCA document ED-14D/DO-160D.
- (2) The digital computer software version (if applicable) and the environmental categories over which it has been tested.
- (3) Indicate D.C. generator or starter generator.
- (4) Nominal power output (electrical voltage and watts).
- (5) Mechanical power input requirements (pad requirements).

#### 4.2 - Specific

None.

### 5 - Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** HEADSETS AND SPEAKERS

### **1 - Applicability**

This ETSO gives the requirements which headsets and speakers that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in EUROCAE document ED 18 (1985) (RTCA DO-170(1980)) „Audio Equipment“.

##### 3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1

##### 3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2

#### 3.2 - Specific

None.

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** AIRCRAFT MICROPHONES (EXCEPT CARBON)

### **1 - Applicability**

This ETSO gives the requirements which aircraft microphones (except carbon) that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in EUROCAE document ED18(1985) (RTCA DO-170(1980)) „Audio Equipment“.

##### 3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1

##### 3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2

#### 3.2 - Specific

None.

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** AIRBORNE SELECTIVE CALLING EQUIPMENT

### **1 - Applicability**

This ETSO gives the requirements which airborne selective calling equipment that is manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in RTCA document DO-93 „Minimum Performance Standards - Airborne Selective Calling Equipment“ dated February 10, 1959.

##### 3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1.

#### 3.2 - Specific

None.

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2;.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** AIRBORNE AREA NAVIGATION EQUIPMENT USING LORAN C INPUTS

### **1 - Applicability**

This ETSO gives the requirements which airborne area navigation equipment using Loran C inputs that is manufactured on or after the date of this ETSO, must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in Radio Technical Commission for Aeronautics (RTCA) Document DO-194 "Minimum Operational Performance Standards for Airborne Area Navigation Equipment Using Loran C Inputs," dated November 17, 1986 as amended and supplemented by this ETSO in particular as specified in appendix 1.

##### 3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1

##### 3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2

#### 3.2 - Specific

None.

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

## APPENDIX 1

- (i) **Waypoint Storage.** Add the following requirement to paragraph 2.2.1.6 of RTCA DO-194 :  
 If the equipment has an approach mode it shall store the complete sequence of waypoints for a selected approach. The sequence of waypoints shall consist of at least the following:  
 initial approach fix  
 final approach fix  
 missed approach point  
 missed approach holding point  
 The receiver must be designed in such a manner that waypoint coordinate data entry will not be possible when the approach mode has been selected. Waypoint coordinates, GRI, triad and TD correction factors may be included in the equipment data base or manually input as specified in paragraphs 2.2.1.5 and 2.2.1.13.
- (ii) **Holding Pattern Manoeuvring.** Add the following requirement to the RTCA/DO-194:  
 The equipment shall provide the capability to proceed to a selected waypoint and hold on a specified inbound course to the waypoint with repeated crossing of the selected waypoint.
- (iii) **Failure/Status Indications.** Add the following requirement to paragraph 2.2.1.10 of RTCA/DO-194:  
 In the approach mode, the lack of adequate navigation signals or sources shall be annunciated by means of a flag displayed on the primary navigation display. In other modes, an appropriately located annunciator may be used to satisfy this requirement.  
 In lieu of the loss of signal and cycle slip requirements specified paragraphs 2.2.1.10(b)(2) and (3) of RTCA/DO-194, substitute the following requirements:  
 (2) Loss of signal - The equipment shall detect loss of signal within 30 seconds for en route and terminal and 10 seconds for approach.  
 (3) Cycle slip - The equipment shall detect or correct a cycle slip within 10 minutes with a 90% probability after occurrence for en route and terminal mode operation, and shall present an alarm or correct a cycle slip within 10 seconds in the approach mode. In addition if the equipment encounters a cycle slip for a station and is switched to approach mode using that station for navigation, the equipment shall, within 10 seconds, present an alarm or have that station back in proper track.
- (iv) **Table 2-IB, 2D RNAV Loran C equipment Accuracy Requirements and Total System Error Evaluation.** In lieu of the oceanic accuracy requirements specified in Table 2-IB of RTCA/DO-194, substitute the following requirement:

Error Type	Oceanic	
	XTK	ATK
Equipment (nmi)	12.6	12.6
FTE (nmi)	2.0	N/A
Total (nmi)	12.8	12.6

- (v) **Envelope-to-Cycle Discrepancy (ECD)** In lieu of paragraph 2.2.3.2 of RTCA/DO-194, substitute the following requirement:  
 The equipment shall be able to properly acquire and track signals with an ECD of 0 to -2.4 microseconds at signal-to-noise ratios from -6 to -16 dB, and an ECD of -2.4 to +3.5 microseconds at signal-to-noise ratios above -6 dB.
- (vi) **Table 2-6. Loran Signal Test Conditions.** In lieu of Table 2-6 of RTCA/DO-194, substitute the following requirement:

TABLE 2-6 LORAN SIGNAL TEST CONDITIONS

Test	Test	GRI	Groundwave Noise									CRI			CWI	
			Sm	Sx	Sy	Sn	Taw*	Saw*	ECDm	ECDx	ECDy	Scr	F1	S1	F2	S2
1	Dyn. Range	4990	110	30	30	30			+3.5	0	-2.4					
2	ECD		40	40	40	46			0	0	0					
3			40	40	40	46			0	-2.4	0					
4			40	40	40	56			0	-2.4	-2.4					
••5	Skywave		40	40	40	56	35	46	0	0	0					
6			40	40	40	56	37.5	50	0	0	0					
7			40	40	40	56	40	50	0	0	0					
8			40	40	40	56	42.5	55	0	0	0					
9		btwn 7980 and 9990	40	40	40	56	45	60	0	0	0					
10			40	40	40	56	50	60	0	0	0					
11			40	40	40	56	55	65	0	0	0					
12			40	40	40	56	35	46	-2.4	-2.4	-2.4					
13			40	40	40	56	37.5	50	-2.4	-2.4	-2.4					
14			40	40	40	56	40	50	-2.4	-2.4	-2.4					
15			40	40	40	56	42.5	55	-2.4	-2.4	-2.4					
16			40	40	40	56	45	60	-2.4	-2.4	-2.4					
17			40	40	40	56	50	60	-2.4	-2.4	-2.4					
18			40	40	40	56	55	65	-2.4	-2.4	-2.4					
19	CWI		60	60	60	60			0	0	0		88.0	80	76.3	80
20			60	60	60	60			0	0	0		119.85	80	124	80
21			60	60	60	60			0	0	0		76.3	80	134	80
22			50	50	50	50			0	0	0		48.5	110	214	110
23			80	50	50	50			+1.5	-2.4	-2.4					
24	CRI 3/	7980	110	50	0	40			0	-2.4	-2.4	110				
25	4/	7930	40	40	40	40			0	0	0	40				
26	ECD	4990	30	110	30	30			-2.4	+3.5	0					

Definitions:

- Sm, Sx, Sy Signal strength in dB microvolts per meter of the Master, X and Y stations
- Sn Signal strength of atmospheric noise in dB microvolts per meter (see paragraph (a)(1)(vii) of TSO C60b)
- Taw Skywave delay with respect to groundwave
- Saw Signal strength of skywave in dB microvolts per meter
- Scr Cross-rate signal strength in dB microvolts per meter 3/
- F1 Frequency of the i-th CW interferer
- S1 Signal strength of the i-th CW interferer in dB microvolts per meter

\* Skywave and signal strength are for secondary signals only, zero for master.

\*\* For cases 5 thru 18, the skywave delay is from the ground wave cycle zero crossing to the skywave cycle zero crossing and the skywave ECD is equal to 0.

3/ Cross-rate GRI = 9960 master

4/ Cross-rate GRI = 7970 master and four secondaries

## NOTES FOR TABLE 2-6:

- (1) dB microvolts per meter equals dB above 1 microvolt per meter.
- (2) The interference frequencies contained in Table 2-6 are based upon the existing environment at the time of publication. It is recognized that this environment could change over time, including the possible need for more than four notch filters. The manufacturer may select different/additional interference test frequencies (using the criteria of paragraph 2.2.3.3) if it is shown that the sequences specified in Table 2-6 are inappropriate.
- (vii) 2D Failure Indication. Add the following requirements to paragraph 2.5.2.6 of RTCA/DO-194:  
 Demonstrate that the equipment displays appropriate warning annunciations whenever accuracy or other status indication (blink, cycle slip, low SNR, loss of signal, etc.) requirements applicable to the selected mode of operation cannot be assured. Test conditions applicable to the particular equipment being evaluated, including limiting SNR and station geometry considerations, shall be established by the equipment manufacturer to verify proper operation. Should the equipment manufacturer establish an operating SNR lower than -16 dB, the noise signal level (Sn) of Table 2-6, test cases 4 thru 18, shall be increased to obtain the selected lower SNR level for all tests using these cases.
- (viii) Acquisition Under Combined Conditions. In lieu of paragraph 2.5.2.7 of RTCA/DO-194, substitute the following requirement:  
 The capabilities identified in paragraphs 2.2.3.1 through 2.2.3.5 shall be demonstrated by subjecting the equipment to the following test.  
 Establish each of the conditions of Table 2-6 for a simulated chain of a master and two secondaries. For each of these conditions have the equipment acquire the signal 10 times. For Tests Nos. 5 thru 23, acquisition on the proper cycle shall be achieved within 450 seconds in 9 out of 10 trials and within 600 seconds in 10 out of 10 trials. For Test Nos. 1 thru 4 and 24 thru 26, acquisition on the proper cycle shall be achieved in 10 of 10 trials within 450 seconds.  
 Proper acquisition may be determined by observing TD values or Lat/Long output displayed by the equipment, and is considered successful if the signal is correctly acquired within the specified time period. Acquisition on the incorrect cycle is considered a failure.  
 If the equipment uses previous position data as an aid in acquisition, at least 50% of the acquisition tests shall be accomplished without the benefit of this data.
- (ix) Cycle Slip. In lieu of paragraph 2.5.2.12 of RTCA/DO-194, substitute the following requirement:  
 Establish the conditions of Table 2-6, test cases 4 thru 23, with the en route mode selected and simulated chain of a master and two secondaries. Raise the noise level 20 dB for 10 seconds and during this same interval also change one of the TDs by  $\pm 10$  microseconds. Observe that within 10 minutes there is an alarm or that the 10 microsecond tracking error has been corrected. The TD change shall be accomplished by altering the TD + 10 microseconds 5 times and -10 microseconds 5 times for each test case for a total of 200 trials. The test must be successful (result in an alarm or correction of the error) in at least 9 of 10 trials for each test case with no more than 5 failures overall.  
 Establish the conditions of Table 2-6 test cases 4, 5, 17 and 23 with the enroute mode selected and a simulated chain of a master and two secondaries. Turn off one secondary signal for 10 seconds and during the same interval change that secondary TD by  $\pm 10$  microseconds. Observe that within 10 minutes there is either an alarm or that the 10 microseconds tracking error has been corrected. The TD change shall be accomplished by altering the TD + 10 microseconds 5 times and -10 microseconds 5 times for each test case, for a total of 40 trials. The test must be successful (result in an alarm or correction of the error) in at least 39 of the 40 trials.  
 Set up the equipment as indicated in Figure 2-3, accelerate one secondary station signal while maintaining a known reference. Set the following conditions:
- GRI = 7980  
 TD<sub>1</sub> = 28 417 microseconds  
 TD<sub>2</sub> = 11 128 microseconds  
 SNR = The lower of -14 dB or 2 dB above any lower operating SNR established by the equipment manufacturer

Using the signal test conditions of Table 2-6 test case 4, with Sn adjusted to establish the required SNR, accelerate TD<sub>2</sub> at 0.0567 microsecond/second/second or more until TD<sub>2</sub> = 11.133 microseconds then decelerate at the same rate until TD<sub>2</sub> = 11,138 microseconds. After zero velocity is reached wait 10 minutes. Observe that the signal is being tracked on the proper cycle or that there is an alarm. Repeat this procedure with TD<sub>2</sub> values decreasing to 11,118 microseconds using the same method. Repeat this test a sufficient number of times to establish its success (result in an alarm or correction of the error) 90% of the time with a 95% confidence level. A 95% confidence level can be achieved by conducting 30 trials (each 10 microsecond TD variation constitutes a trial) with zero failures, 48 trials with 1 failure, 63 trials with 2 failures etc. If the equipment has an approach mode:

Establish the conditions of Table 2-6 test cases 1, 2 and 23 with a simulated chain of a master and two secondaries. Raise the noise level 35 dB for 10 seconds and during this interval also change one of the TDs by ± 10 microseconds. Wait five minutes. Switch to approach mode. Observe that within 10 seconds there is either an alarm or that the 10 microsecond tracking error has been corrected. The TD change shall be accomplished by altering the TD + 10 microseconds 10 times and -10 microseconds 10 times for each test case for a total of 60 trials. All trials must be successful.

Establish the conditions of Table 2-6 test cases 1 and 2 with a simulated chain of a master and two secondaries. Turn off one secondary signal for 10 seconds and during the same interval change that secondary TD by ± 10 microseconds. Wait 5 minutes. Switch to approach mode. Observe that within 10 seconds there is either an alarm or that the 10 microsecond tracking error has been corrected. The TD change shall be accomplished by altering the TD + 10 microseconds 10 times and -10 microseconds 10 times for each test case, for a total of 40 trials. All trials must be successful

Establish the conditions of Table 2-6, test cases 1, 2 and 23 with the approach mode selected and simulated chain of a master and two secondaries. Raise the noise level 35 dB for 10 seconds and during this interval also change one of the TDs by + 10 microseconds. Observe that within 10 seconds there is either an alarm or that the 10 microsecond tracking error has been corrected. The TD change shall be accomplished by altering the TD + 10 microseconds 10 times and -10 microseconds 10 times for each test case for a total of 60 trials. All trials must be successful.

- (x) Atmospheric Noises Model. In demonstrating compliance with this TSO, the following model may be used to simulate atmospheric noise. The applicant may select a different model provided adequate substantiation is submitted to establish validity of the selected model.

Atmospheric noise is basically composed of two components, one a very weak component which has a Gaussian distribution. This first component may be simulated as follows: Simulated random noise (Gaussian) will be considered to have a uniform power spectral density prior to filtering. After filtering by a single resonator L-C filter having a center frequency of 100 kHz and a 3 dB bandwidth of 30 kHz, the noise level is the voltage generated across a 50-ohm resistive load measured on a true rms voltmeter; this noise level is defined as the rms noise level, denoted by X. This component is taken as 15.85% of the total noise power. The remaining 84.15% of the noise power is composed of the second component. This second component is simulated by pulses of 100 kHz, 30 microseconds wide, the rms value of which is A times X. The average number of pulses per second (P) is nominally 50 and lies in the range 40-60. The pulses (tone bursts) are randomly distributed (Poisson) in time. The linear addition of these two components is the simulated atmospheric noise with level N.

$$(1) \quad N^2 = \text{total noise power} = X^2 + (30 \times 10^{-6})PA^2X^2$$

$$(2) \quad \text{Since } (30 \times 10^{-6}) PA^2 = 84.15 = 5.309$$

$$15.85$$

Using P = 50 pps and solving (2)  
for A gives A = 59.5

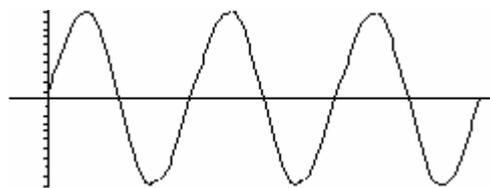
- N<sup>2</sup> = total noise power
- X = rms value of Gaussian noise
- A = relative amplitude of 100 kHz pulse
- P = number of pulses per second

Signal strength in dB microvolts per meter referenced in Table 2-6 and elsewhere shall be converted to voltages at the space coupling node of Figure 2-1 by multiplying by the effective electrical height (in meters) of the simulated antenna. Atmospheric noise in dB microvolts per meter,  $S_n$ , is converted to voltage by the expression

$$S_n \text{ (voltage)} = 10^{\left[ \frac{S_n(\text{dB}) \times \text{effective antenna height (meters)}}{20} \right]}$$

Set this value equal to the total noise power,  $N^2$ , in the atmospheric noise model and solve equation (1) for  $X$ . The result is the desired rms value of Gaussian noise measured across the 50-ohm resistive load.

$$\sqrt{2AX}$$



100 kHz Tone Burst

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** AIRCRAFT TYRES

### **1 - Applicability**

This ETSO gives the requirements which tyres excluding tailwheel tyres that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the attached Appendix 1: „Federal Aviation Administration Standard for Aircraft Tyres“ dated September 7, 1990.

##### 3.1.2 - Environmental Standard

As stated in the Federal Aviation Administration Standard.

##### 3.1.3 – Computer Software

None

#### 3.2 - Specific

None.

### **4 - Marking**

#### 4.1 - General

In lieu of the marking requirements of CS-ETSO Subpart A paragraph 1.2, a tyre must be legibly and permanently marked at least with the following:

- (1) Brand name or registered trademark of the manufacturer responsible for compliance.
- (2) Speed rating, load rating, size, skid depth, serial number, date, manufacturer's part number and plant code, and nonretreadable, if appropriate.
- (3) Applicable ETSO number.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



9/7/90

TSO-C62d  
Appendix 1APPENDIX 1. FEDERAL AVIATION ADMINISTRATION STANDARD FOR AIRCRAFT TIRES  
DATED SEPTEMBER 7, 1990

1.0 Purpose. This document contains minimum performance standards for new and requalified aircraft tires, excluding tailwheel tires, that are to be identified as meeting the standards of TSO-C62d.

2.0 Scope. These minimum performance standards apply to aircraft tires having speed and load ratings that are established on the basis of the speeds and loads to which the tires have been tested.

3.0 Material requirement. Materials must be suitable for the purpose intended. The suitability of the materials must be determined on the basis of satisfactory service experience or substantiating dynamometer tests.

4.0 Design and construction.

4.1 Unbalance. The moment (M) of static unbalance in inch-ounces may not be greater than the value determined using the formula, moment (M) =  $0.025D^2$ , rounded off to the next lower whole number: where D = maximum outside diameter of the tire in inches.

4.2 Balance marker. A balance marker, consisting of a red dot, must be affixed on the sidewall of the tire immediately above the bead to indicate the lightweight point of the tire. The dot must remain for any period of storage plus the original tread life of the tire.

4.3 Overpressure. The tire shall withstand for at least 3 seconds a pressure of at least 4.0 times the rated inflation pressure (as specified in paragraph 5.2) at ambient temperature.

4.4 Temperature.

4.4.1 Ambient. It shall be substantiated by applicable tests or shown by analysis that the physical properties of the tire materials have not been degraded by exposure of the tire to the temperature extremes of not higher than -40°F and not lower than +160°F for a period of not less than 24 hours at each extreme.

4.4.2 Wheel rim heat. It must be substantiated by the applicable tests or shown by analysis that the physical properties of the tire materials have not been degraded by exposure of the tire to a wheel-bead seat temperature of not lower than 300°F for at least 1 hour, except that low-speed tires or nose-wheel tires may be tested or analyzed at the highest wheel-bead seat temperatures expected to be encountered during normal operations.

4.5 Tread design. Moved. (See paragraph 7.0)

4.6 Slippage. A tire tested in accordance with the dynamometer tests provided in paragraph 6.0 may not slip on the wheel rim during the first five dynamometer cycles. Slippage that subsequently occurs may neither damage the gas seal of the tyre bead of a tubeless tire nor otherwise damage the tube or valve.

4.7 Leakage. After an initial 12-hour minimum stabilization period, the tire must be capable of retaining inflation pressure with a loss of pressure not exceeding 5 percent in 24 hours from the initial pressure equal to the rated inflation pressure.

5.0 Ratings.

5.1 Load ratings. The load ratings of tyres shall be established. The applicable dynamometer tests in paragraph 6.0 must be performed at the selected rated load.

5.1.1 Load rating (helicopter tires). Airplane tires qualified in accordance with provisions of this standard may also be used on helicopters. In such cases, the maximum static load rating may be increased by 1.5 with a corresponding increase in rated inflation pressure without any additional qualification testing.

5.2 Rated inflation pressure. The rated inflation pressure shall be established at an identified ambient temperature on the basis of the rated load as established under paragraph 5.1.

5.3 Loaded radius. The loaded radius is defined as the distance from the axle centerline to a flat surface for a tire initially inflated to the rated inflation pressure and then loaded to its rated load against the flat surface. The nominal loaded radius, the allowable tolerance on the nominal loaded radius, and the actual loaded radius for the test tire shall be identified.

6.0 Dynamometer test requirements. The tyre may not fail the applicable dynamometer tests specified herein or have any signs of structural deterioration other than normal expected tread wear except as provided in paragraph 6.3.3.3.

6.1 General. The following conditions apply to both low-speed and high-speed tires when these tires are subjected to the applicable dynamometer tests:

6.1.1 Tire test load. Unless otherwise specified herein for a particular test, the tire must be forced against the dynamometer flywheel at not less than the rated load of the tire during the entire roll distance of the test.

6.1.2 Test inflation pressure. The test inflation pressure must be the pressure required at an identified ambient temperature to obtain the same loaded radius against the flywheel of the dynamometer at the loaded radius for a flat surface as defined in paragraph 5.3. Adjustments to the test inflation pressure may not be made to compensate for increases created by temperature rises occurring during the tests.

6.1.3 Test specimen. A single tire specimen must be used in the applicable dynamometer tests specified herein.

6.2 Low-speed tire. A tire operating at ground speeds of 120 mph or less must withstand 200 landing cycles on a dynamometer at the following test temperature and kinetic energy and using either test method A or test method B.

6.2.1 Test temperature. The temperature of the gas contained in the tire or of the carcass measured at the hottest point of the tire may not be lower than 105°F at the start of at least 90 percent of the test cycles. For the remaining 10 percent of the test cycles, the contained gas or carcass temperature may not be lower than 80°F at the start of each cycle. Rolling the tire on the flywheel is acceptable for obtaining the minimum starting temperature.

6.2.2 Kinetic energy. The kinetic energy of the flywheel to be absorbed by the tire must be calculated as follows:

$$\text{K.E.} = \text{CWV}^2 = 162.7W = \text{Kinetic energy in foot-pounds.}$$

where:

$$C = 0.0113,$$

W = Load rating of the tire in pounds, and

$$V = 120 \text{ mph.}$$

6.2.3 Test method A - variable mass flywheel. The total number of dynamometer landings must be divided into two equal parts having speed ranges shown below. If the exact number of flywheel plates cannot be used to obtain the calculated kinetic energy value or proper flywheel width, a greater number of plates must be selected and the dynamometer speed adjusted to obtain the required kinetic energy.

6.2.3.1 Low-speed landings. In the first series of 100 landings, the maximum landing speed is 90 mph and the minimum unlanding speed is 0 mph. The landing speed must be adjusted so that 56 percent of the kinetic energy calculated under paragraph 6.2.2 will be absorbed by the tire. If the adjusted landing speed is calculated to be less than 80 mph, the following must be done: the landing speed must be determined by adding 28 percent of the kinetic energy calculated under paragraph 6.2.2 to the flywheel kinetic energy at 64 mph, and the unlanding speed must be determined by subtracting 28 percent of the kinetic energy calculated under paragraph 6.2.2 from the flywheel kinetic energy at 64 mph.

6.2.3.2 High-speed landings. In the second series of 100 landings, the minimum landing speed is 120 mph and the nominal unlanding speed is 90 mph. The unlanding speed must be adjusted as necessary so that 44 percent of the kinetic energy calculated under paragraph 6.2.2 will be absorbed by the tire.

6.2.4 Test method B - fixed mass flywheel. The total number of dynamometer landings must be divided into two equal parts having speed ranges indicated below. Each landing must be made in a time period,  $T_c$ , calculated so that the tire will absorb the kinetic energy determined under paragraph 6.2.2. The time period must be calculated using the equation:

$$T_c = \frac{KE_c}{\left[ \frac{KE_{W(UL)} - KE_{W(LL)}}{T_{L(UL)} - T_{L(LL)}} \right] - \left[ \frac{KE_{W(UL)} - KE_{W(LL)}}{T_{W(UL)} - T_{W(LL)}} \right]}$$

For the 90 mph to 0 mph test, the equation reduces to:

$$T_c = \frac{KE_c}{\left[ \frac{KE_{W(UL)}}{T_{L(UL)}} \right] - \left[ \frac{KE_{W(UL)}}{T_{W(UL)}} \right]}$$

Where:

$T_c$  = Calculated time, in seconds, for the tyre to absorb the required kinetic energy.

$KE_c$  = Kinetic energy, in foot pounds, the tyre is required to absorb during each landing cycle.

$KE_w$  = Kinetic energy, in foot pounds, of the flywheel at given speed.

$T_L$  = Coast down time, in seconds, with rated tyre load on flywheel.

$T_w$  = Coast down time, in seconds, with no tyre load on flywheel.

(UL) = Subscript for upper speed limit.

(LL) = Subscript for lower speed limit.

6.2.4.1 Low-speed landings. In the first series of 100 landings, the tire must be landed against the flywheel with the flywheel having a peripheral speed of not less than 90 mph. The flywheel deceleration must be constant from 90 mph to 0 mph in the time  $T_c$ .

6.2.4.2 High-speed landings. In the second series of 100 landings, the tire must be landed against the flywheel with the flywheel having a peripheral speed of not less than 120 mph. The flywheel deceleration must be constant from 120 mph to 90 mph in the time  $T_c$ .

6.3 High-speed tire. Except as provided in the alternate test, a tire operating at ground speeds greater than 120 mph must be tested on a dynamometer in accordance with paragraph 6.3.3. The curves to be used as a basis for these tests shall be established in accordance with paragraph 6.3.3.2. The load at the start of each test must be equal to the rated load of the tire. Alternate tests involving a landing sequence for a tire operating at ground speeds greater than 120 mph and not over 160 mph are set forth in paragraph 6.3.4.

6.3.1 Test temperature. The temperature of the gas contained in the tire or of the carcass measured at the hottest point of the tire may not be lower than 120°F at the start of at least 90 percent of the test cycles specified in paragraph 6.3.3.4 and at least 105°F at the start of the overload test (6.3.3.3) and of at least 90 percent of the test cycles specified in paragraphs 6.3.3.2 and 6.3.4. For the remaining 10 percent of each group of cycles, the contained gas or carcass temperature may not be lower than 80°F at the start of each cycle. Rolling the tire on the dynamometer is acceptable for obtaining the minimum starting temperature.

6.3.2 Dynamometer test speeds. Applicable dynamometer test speeds for corresponding maximum ground speeds are as follows:

Maximum Ground Speed of Aircraft, mph		Speed Rating of Tire, mph	Minimum Dynamometer Speed at $S_2$ , mph
Over	Not Over		
120	160	160	160
160	190	190	190
190	210	210	210
210	225	225	225
225	235	235	235
235	245	245	245

For ground speeds over 245 mph, the tire must be tested to the maximum applicable load-speed-time requirements and appropriately identified with the proper speed rating.

6.3.3 Dynamometer cycles. The test tire must withstand 50 take-off cycles, 1 overload take-off cycle, and 10 taxi cycles described below. The sequence of the cycles is optional.

6.3.3.1 Symbol definitions. The numerical values which are used for the following symbols must be determined from the applicable aircraft load-speed-time data:

- $L_0$  = Tire load at start of take-off, pounds (not less than rated load).
- $L_1$  = Tire load at rotation, pounds.
- $L_2$  = Zero tyre load (lift-off).
- RD = Roll distance, feet.
- $S_0$  = Zero tyre speed.
- $S_1$  = Tire speed at rotation, mph.
- $S_2$  = Tire speed at liftoff, mph (not less than speed rating).
- $T_0$  = Start of takeoff.
- $T_1$  = Time to rotation, seconds.
- $T_2$  = Time to liftoff, seconds.

6.3.3.2 Takeoff cycles. For these cycles the loads, speeds, and distance must conform to either Figure 1 or Figure 2. Figure 1 defines a test cycle that is generally applicable to any aircraft. If Figure 2 is used to define the test cycle, the loads, speeds, and distance must be selected based on the most critical takeoff conditions established by the applicant.

6.3.3.3 Overload takeoff cycle. The cycle must duplicate the takeoff cycles specified under paragraph 6.3.3.2 except that the tire load through the cycle must be increased by a factor of at least 1.5. Upon completion of the overload takeoff cycle, the tire must be capable of retaining inflation pressure with the loss of pressure not exceeding 10 percent in 24 hours from the initial test pressure. Good condition of the tire tread is not required after completion of this test cycle.

6.3.3.4 Taxi cycles. The tire must withstand at least 10 taxi cycles on a dynamometer under the following test conditions:

Number of Test Cycles	Minimum Tire Load, lbs.	Minimum Speed, mph	Minimum Roll Distance, ft.
8	Rated load.	40	35,000
2	1.2 times rated load.	40	35,000

6.3.4 Alternative dynamometer tests. For a tire with a speed rating of 160 mph, test cycles which simulate landing may be used in lieu of the take-off cycles specified in paragraphs 6.3.3.2 and 6.3.3.3. The tire must withstand 100 test cycles at rated load in accordance with paragraph 6.3.4.1 followed by 100 test cycles at rated load in accordance with paragraph 6.3.4.2.

6.3.4.1 Low-speed landings. In the first series of 100 landings, the test procedures for low-speed landings established under paragraph 6.2.3 or 6.2.4, as appropriate, must be followed.

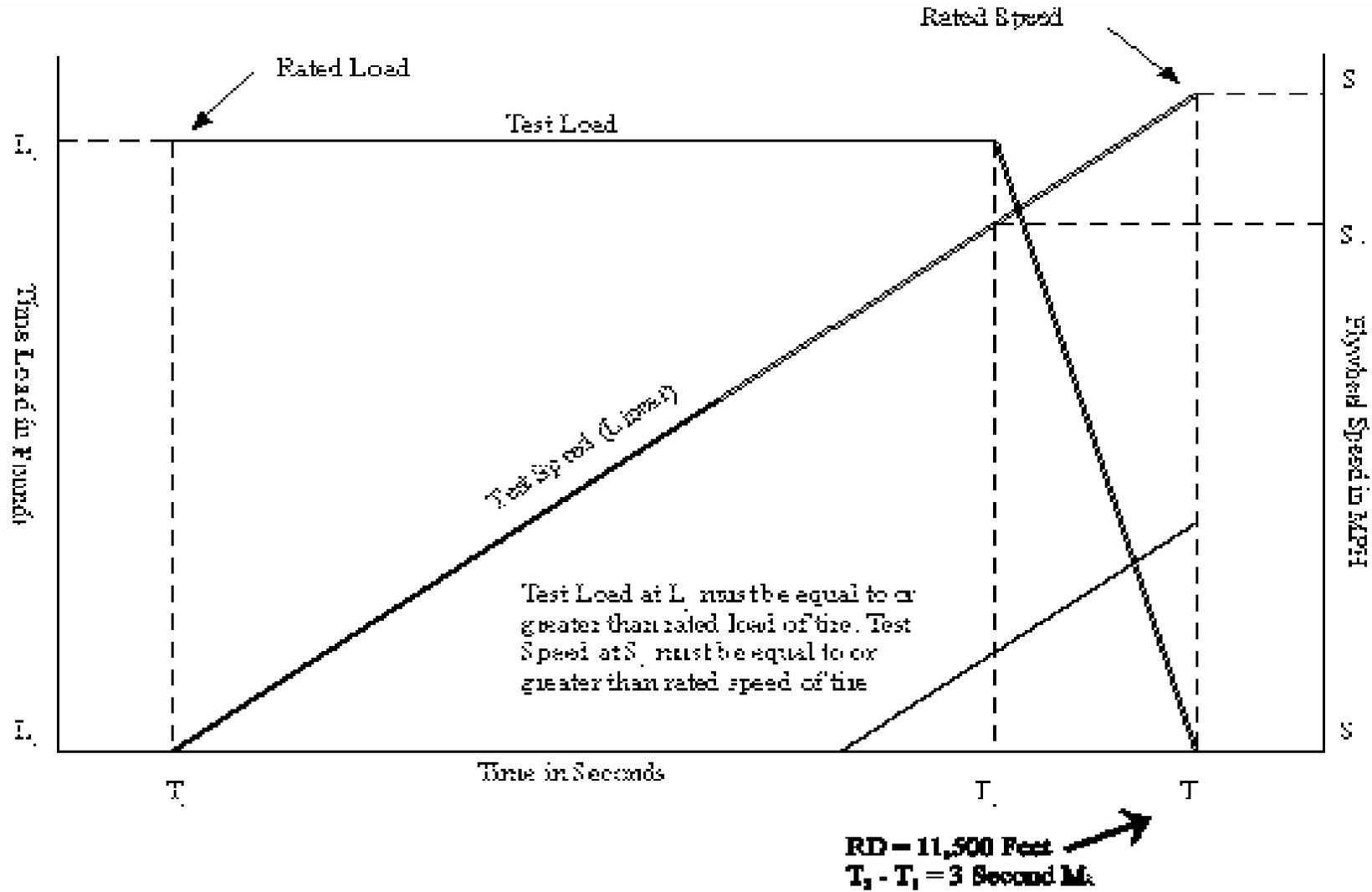
6.3.4.2 High-speed landings. In the second series of 100 landings, the test procedures for low-speed landings established under paragraph 6.2.3 or 6.2.4, as appropriate, must be followed, except that the tire must be landed against the flywheel rotating at a speed of 160 mph with the rated load applied for the duration of the test. The unlanding speed must be adjusted as necessary so that 44 percent of the kinetic energy, as calculated in paragraph 6.2.2, is absorbed by the tire during the series of tests.

7.0 Requalification tests. A tire shall be requalified unless it is shown that changes in materials, tire design, or manufacturing processes could not affect performance. Changes in materials, tire design, or manufacturing processes that affect performance or changes in number or location of tread ribs and grooves or increases in skid depth, made subsequent to the tire qualification, must be substantiated by dynamometer tests in accordance with paragraph 6.0. Requalification in accordance with paragraph 6.0 of a given load rated tire required as a result of a tread design or material change will automatically qualify the same changes in a lesser load rated tire of the same size, speed rating, and skid depth provided —

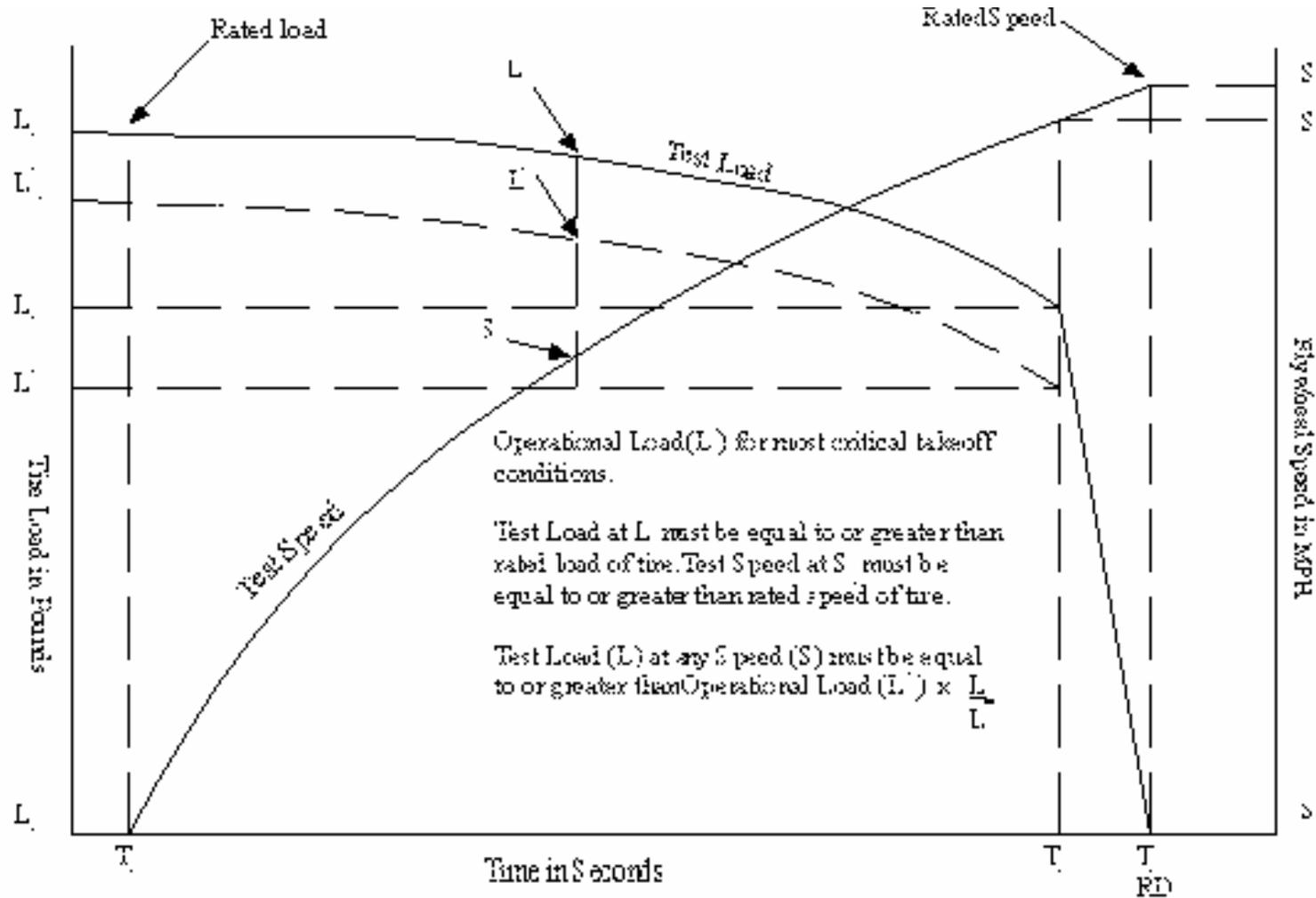
7.1 The lesser load rated tire has been qualified to the applicable requirements specified in this standard; and

7.2 The ratio of qualification testing load to rated load for the lesser load rated tire does not exceed the same ratio for the higher load rated tire at any given test condition.

**FIGURE 1**  
**GRAPHIC REPRESENTATION OF A UNIVERSAL LOAD-SPEED TIME TEST CYCLE**



**FIGURE 2**  
**GRAPHIS REPRESENTATION OF A RADIONAL LOAD-SPEED-TIME TEST CYCLE**





# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** OXYGEN MASK ASSEMBLY, CONTINUOUS FLOW, PASSENGER

### **1 - Applicability**

This ETSO gives the requirements which new models of oxygen mask, continuous flow, passenger, that is manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Minimum Performance Standard

Standards set forth in the Society of Automotive Engineers (SAE), Inc, Document Aerospace Standard (AS) no AS 8025, „Passenger Oxygen Mask“ dated 24 February 1988.

#### 3.2 - Specific

None.

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

The markings for each mask must, in addition to the requirement in the CS-TSO Subpart A, be marked with the performance classification number as specified in SAEAS 8025 Paragraph 2.3.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** AIRBORNE DOPPLER RADAR GROUND SPEED AND/OR DRIFT ANGLE MEASURING EQUIPMENT (FOR AIR CARRIER AIRCRAFT)

### 1 - Applicability

This ETSO gives the requirements which airborne doppler radar ground speed and/or drift angle measuring equipment that is manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### 2 - Procedures

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### 3 - Technical Conditions

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in EUROCAE document MPS/WG7C/1-74 (RTCA DO-158), as amended and supplemented by this ETSO:

In addition to paragraph 1.0, General Standards, of RTCA DO-158, all materials used except small parts (such as knobs, fasteners, seals, grommets and small electrical parts) that would not contribute significantly to the propagation of a fire, must be self-extinguishing when tested in accordance with applicable requirements of CS 25 Appendix F.

##### 3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1.

##### 3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2.

#### 3.2 - Specific

None

### 4 - Marking

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### 5 - Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** AIRBORNE AUTOMATIC DEAD RECKONING COMPUTER EQUIPMENT UTILIZING AIRCRAFT HEADING AND DOPPLER GROUND SPEED AND DRIFT ANGLE DATA (FOR AIR CARRIER AIRCRAFT)

### 1 - Applicability

This ETSO gives the requirements which airborne automatic dead reckoning computer equipment utilizing aircraft heading and doppler ground speed and drift angle data that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### 2 - Procedures

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### 3 - Technical Conditions

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in EUROCAE document MPS/WG7C/2-74, dated August 1974, „Airborne Automatic Dead Reckoning Computer Equipment Utilizing Aircraft Heading and Doppler Obtained Velocity Vector Data“.

In addition to Chapter 4 of EUROCAE document MPS/WG7C/2-74, all materials used except small parts (such as knobs, fasteners, seals, grommets and small electrical parts) that would not contribute significantly to the propagation of a fire, must be self-extinguishing when tested in accordance with applicable requirements of CS 25 Appendix F.

##### 3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1.

##### 3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2.

#### 3.2 - Specific

None

### 4 - Marking

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### 5 - Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.



# European Aviation Safety Agency

## European Technical Standard Order

Subject: EMERGENCY EVACUATION SLIDES, RAMPS, RAMP/SLIDES, AND SLIDE/RAFTS

### 1 - Applicability

This ETSO gives the requirements that new models of emergency evacuation slides, ramps, ramp/slides, and slide/rafts that are manufactured on or after the date of this ETSO must meet in order to be identified with applicable ETSO marking.

Type I- Inflatable Slide

Type II- Inflatable Slide/Raft

Type III- Inflatable Exit Ramp

Type IV- Inflatable Exit Ramp/Slide

### 2 - Procedures

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### 3 - Technical Conditions

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in Appendix 1, Federal Aviation Administration Standards for emergency evacuation slides, ramps, ramp/slides, and slide/rafts, as amended and supplemented by this ETSO.

Where applicable, instead of the referenced FAA documents/paragraph the corresponding IR, CS or ETSO document/paragraph shall be used, when available.

##### 3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1.

##### 3.1.3 - Computer Software

None.

#### 3.2 - Specific

None

### 4 - Marking

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

The component also must be marked with the applicable emergency evacuation device type: "Type I, Type II, Type III, or Type IV." Type II devices shall also be marked with the rated and overload capacities and the weight of the device including any accessories required by this ETSO.

### 5 - Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.

**APPENDIX 1. FEDERAL AVIATION ADMINISTRATION MINIMUM PERFORMANCE STANDARD  
FOR EMERGENCY EVACUATION SLIDES, RAMPS, RAMP/SLIDES, AND SLIDE/RAFTS**

**Note : Any reference made to US standards, regulations and organisations are for information purpose only and may be replaced, if applicable, by the European equivalent when acceptable to the Agency.**

1. Purpose. This standard provides the minimum performance standards for inflatable emergency evacuation slides, overwing exit ramps, ramp/slides, and slide/rafts. However, the deployment and erection characteristics for these devices, as installed on the aircraft, are specified in Title 14 of the Code of Federal Regulations (14 CFR) § 25.810 and must be complied with along with the requirements in this TSO.

2. Scope. This performance standard provides for the following types of emergency evacuation devices:

Type I- Inflatable slide suitable for assisting occupants in descending from a floor-level aircraft exit or from an aircraft wing.

Type II- Inflatable slide also designed to be used as a life raft, i.e. a slide/raft.

Type III- Inflatable exit ramp suitable for assisting occupants in descending to an aircraft wing from certain overwing exits.

Type IV- Combination inflatable exit ramp and wing-to-ground slide.

Further definitions of terms used in this TSO are given in appendix 2.

3. Materials. The materials used must be of a quality, which experience and/or tests have demonstrated to be suitable for use in emergency evacuation slides, ramps, ramp/slides and slide/rafts, i.e. emergency evacuation devices.

3.1 Nonmetallic Materials.

3.1.1 The finished device must be clean and free from any defects that might affect its function.

3.1.2 Coated fabrics and other items, such as webbing, which are subject to deterioration must have been manufactured not more than 18 months prior to the date of manufacture of the finished product. However, these materials may be re-qualified for an additional 18 months if they pass the requirements of paragraph 5.1 of this appendix.

3.1.3 The materials must not support fungus growth.

3.1.4 Materials used in the construction of flotation chambers and decks for Type II devices must be capable of withstanding the detrimental effects of exposure to fuels, oils, hydraulic fluids, and sea water.

3.1.5 Coated Fabric. Coated fabrics, including seams, which are subject to deterioration and used in the manufacture of the devices, must retain at least 90 percent of their original physical properties after these fabrics have been subjected to the accelerated aging test specified in paragraph 5.1 of this appendix.

3.1.5.1 Strength. Coated fabrics used for these applications must conform to the following minimum strengths after aging:

Tensile Strength (Grab Test)

Warp 190 pounds/inch

Fill 190 pounds/inch

Tear Strength (Trapezoid Test or Tongue Test)

Non walking/sliding surface: 13 x 13 pounds/inch (minimum)

Walking/Sliding surface: 50 x 50 pounds/inch (minimum)

Puncture Strength

Walking/Sliding surface: 67 pounds force

3.1.5.2 Adhesion. In addition to the strength requirements of paragraph 3.1.5.1 above, coated fabrics must meet the following minimum strengths after aging:

Ply Adhesion

5 pounds/inch width at 70 + 2 degrees F at a separation rate of 2.0 to 2.5 inches/minute

Coat Adhesion

5 pounds/inch width at 70 + 2 degrees F at a separation rate of 2.0 to 2.5 inches/minute

3.1.5.3 Permeability. For coated fabrics used in the manufacture of inflation chambers, the maximum permeability to helium may not exceed 10 liters per square meter in 24 hours at 77 degrees F, or its equivalent using hydrogen, using either of the permeability test methods specified in paragraph 5.1 of this appendix. The permeameter must be calibrated for the gas used. In lieu of either of these permeability tests, an alternate test may be used provided the alternate test has been approved as an equivalent to this permeability test by the manager of the FAA office having purview of the manufacturer's facilities, as required in paragraphs 3b, Deviations and 5a, Application Data, of this TSO.

3.1.5.4 Hydrolysis. Pressure holding coated fabrics, including seams, must be shown to be resistant to hydrolysis. It must be shown by tests specified in paragraph 5.1 of this appendix that the porosity of the basic pressure holding material is not increased as a result of the material being subjected to hydrolysis conditioning. Seam strength and coat adhesion must not be reduced more than 20 percent and still must not fall below the minimums prescribed in paragraphs 3.1.5.2 and 3.1.6 of this appendix as a result of hydrolysis conditioning.

3.1.6 Seam Strength and Adhesives. Seams used in the manufacture of the device must meet the following minimum strength requirements:

Shear Strength (Grab Test)

175 pounds/inch width at 75 degrees F

40 pounds/inch width at 140 degrees F

Peel Strength (Peel Test)

5 pounds/inch width at 70 degrees F

3.1.7 Seam Tape. If tape is used for seam reinforcement or abrasion protection of seams or both, the fabric used for the seam tape must have a minimum breaking strength (Grab Test) of 40 pounds/inch width in both the warp and fill directions. When applied to the seam area, the adhesion strength characteristics must meet the seam strength requirements in paragraph 3.1.6 above.

3.1.8 Canopy. Fabrics used for this purpose on Type II slide/rafts must be waterproof and resistant to sun penetration, must not affect the potability of collected water, and must meet the following minimum requirements in the applicable tests prescribed in paragraph 5.1 of this appendix, except that in lieu of meeting the tensile strength requirements, a fabricated canopy erected on the device may be demonstrated to withstand sustained wind velocities of 35 knots and 52-knot gusts:

Tensile Strength (Grab Test)

Warp 75 pounds/inch

Fill 75 pounds/inch

Tear Strength (Tongue or Trapezoid Test)

4 x 4 pounds/inch

#### Coat Adhesion of Coated Fabrics

3.5 pounds/inch width at 70±2 degrees F at a separation rate of 2.0 to 2.5 inches/minute

3.1.9 Flammability. The device (including carrying case or stowage container) must be constructed of materials which comply with the requirements of 14 CFR § 25.853(a), Appendix F, part I (a)(1)(ii) in effect on March 6, 1995.

3.1.10 Radiant Heat Resistance. The pressure holding materials in the device must meet the 90-second minimum time to failure requirement and the 180-second average time to failure requirement of the radiant heat resistance test specified in paragraph 5.3 of this appendix.

3.1.11 Molded Nonmetallic Fittings. Molded nonmetallic fittings must retain their physical characteristics when subjected to temperatures of -65 to +160 degrees F.

3.2 Metallic Parts. All metallic parts must be made of corrosion-resistant material or must be suitably protected against corrosion.

3.3 Protection. All inflation chambers and load carrying fabrics must be protected in such manner that non-fabric parts do not cause chafing or abrasion of the material in either the packed or the inflated condition.

#### 4. Detail Requirements.

4.1 Operation. The operation of the device must be simple enough so that brief, easily understood, posted instructions can be followed by the user.

4.2 Function. The device, including its inflation system, must be demonstrated to be capable of fully functioning when subjected to temperatures from -40 to +160 degrees F. If the device is intended for installation outside the pressurized cabin, the device must be capable of functioning after being stowed at -65 degrees F. The function of the device must be demonstrated in accordance with the hot and cold soak test procedures described in paragraph 5.9 of this appendix.

#### 4.3 Strength.

4.3.1 Beam Strength-Type I, II, & IV Devices. The structural integrity of the device during and after the dynamic challenge of multiple sand bag loading of the device (to simulate loading by three, tightly-bunched evacuees entering each lane of the device) must be shown by test to be adequate, as described in paragraph 5.5 of this appendix.

4.3.2 Attachment Means Strength. The means by which the device is attached to the aircraft, typically the girt, must not fail and must remain intact and suitably attached to both the aircraft and the device during and after the severe loading tests simulating normal evacuation. The device must withstand the static tensile load tests defined in this appendix in paragraphs 5.6, for girts, or 5.7, for non-girts, and 5.8, as appropriate, for evacuees inadvertently entering pontoon areas. Separate girt specimens may be used in the two tests required in paragraph 5.6 of this appendix.

4.4 Elimination of Static. The device and its fastening must be so constructed that static electricity will not be generated in sufficient quantity to cause a spark which would create a hazard if there is any fuel spillage nearby.

#### 4.5 Damage Resistance and Usage.

4.5.1 The device must be capable of resisting puncture and tear of the sliding and walking surfaces and supporting structure from objects normally carried or worn by passengers that could result in collapse of the device, prevent the device from performing its intended function, or both.

4.5.2 Type I, II & IV devices must be so constructed as to permit their use with ground personnel assistance as a noninflatable device in the event of puncture or tear which may render the device incapable of holding air and sustaining inflation.

4.5.3 If the device is of a multiple-inflatable compartment construction, loss of any one of these compartments must not render the device totally unusable.

4.6 Length. Type I, II & IV devices must be of such length after full deployment that the lower end is self-supporting on the ground. The device must provide safe evacuation of occupants to the ground when the aircraft is on the ground with the landing gear extended and after collapse of one or more legs of the landing gear.

4.7 Elimination of Encumbrances. Encumbrances which might be grabbed by evacuees must be kept to a minimum consistent with good design for maximum operational efficiency.

4.8 Hardware and Attaching Means Strength. All hardware, webbing and straps used to attach the device to the aircraft and all straps, grips, and handholds not associated with attachment to the aircraft must have a strength not less than 1.5 times the highest design load imposed in showing compliance with the strength requirements of paragraph 4.3 of this appendix and for Type II devices, in establishing the rated capacity under paragraph 4.26.1 of this appendix.

4.9 Use as Re-entry Device. If the device is designed with provisions for use as a means of re-entering the aircraft, these additional provisions must not interfere with the use of the device for evacuation.

#### 4.10 Evacuation Rate.

4.10.1 The device must be shown, by tests conducted under the conditions described in paragraph 5.4.1 of this appendix, to be capable of safely accommodating evacuees at a rate of at least 70 evacuees per minute per lane. The evacuees must exit the device without assistance.

4.10.2 Evacuation capability under the test conditions shown in paragraph 5.4.3 of this appendix must be demonstrated in order to confirm the acceptability of the device and its and/or the associated airplane's emergency lighting system for use by evacuees under dark-of-night conditions. An evacuation rate based upon the rating of the exit (see paragraph 5.4.3.10 of this appendix) to which the device will be attached must be achieved. A detailed test plan to meet these requirements should be submitted at least 60 days prior to the test to the FAA aircraft certification office having purview of the manufacturer's facilities. The test plan shall include, but not be limited to, the test protocol, a description of the test facilities, a description of the measurement and recording equipment and procedures, and the safety provisions for protecting test participants. The test plan must be approved by the manager of that FAA office prior to conduct of the test.

#### 4.11 Inflation.

4.11.1 The device must be demonstrated to meet the applicable automatic inflation requirements of 14 CFR § 25.810 (a)(1)(ii), (b), and/or (d)(4). See paragraph 4.12 below.

4.11.2 The device shall be designed to prevent its inflation out of proper sequence.

4.11.3 A manual means of actuating inflation must be provided. The manual means of actuation of the inflation system may be mechanical or electrical. However, the manual inflation actuating means must be neither visible nor presented for use until the device has been deployed. If the means is not an integral part of the device, details of its connection must be included in the installation limitations required in paragraph **5a, Application Data**.

#### 4.12 Inflation Time.

4.12.1 Type I floor-level exit slides and Type III devices must be fully erected in 6 seconds after actuation of the inflation controls has begun.

4.12.2 Type II devices must meet the requirements in paragraph 4.12.1 above and, if there are actions required to convert usage from slide mode to raft mode, the time required to complete those actions must not exceed 10 seconds after actuation of the conversion means.

4.12.3 Type IV devices and Type I wing-to-ground slides must be automatically erected in not more than 10 seconds after actuation of the inflation controls.

#### 4.13 Device Length Extensions.

4.13.1 The device extension must be capable of being inflated at any time after inflation of the basic device has been initiated. The time required to complete extension of the device must not exceed 4 seconds beyond the time required to inflate the basic device.

4.13.2 Inflation of the extension must be initiated by separate controls from those for the basic device. The controls must be clearly identified and must be located separately from the manual inflation actuation controls to minimize the possibility of inadvertent actuation.

4.13.3 The junction of the basic device and the extension must not impede evacuation.

#### 4.14 Manual Inflation Actuation Controls.

4.14.1 Inflation controls must be equipped with a rigid cross member as an actuation handle. The handle must be red in color, marked with the word "PULL" (or other appropriate instruction) in high visibility reflective letters at least 1/2-inch high and of a contrasting color. In addition, there must be a placard with the words "PULL TO INFLATE" (or other appropriate instruction) located as close to the handle as possible.

4.14.2 When the inflation actuation controls are exposed for use, they must be visible to an aircraft occupant, standing at the doorsill, under the minimum emergency lighting conditions specified in 14 CFR § 25.812 in effect at the time of application.

4.14.3 Unless a rational analysis is provided to locate them elsewhere, or if there is no girt attachment, inflation actuation controls must be on the right side of the girt as seen by an aircraft occupant looking out of the aircraft door.

4.14.4 Inflation actuation controls must be so designed that the maximum required pulling force will not pull the deployed device back into the doorway. The pulling force required must not exceed 30 pounds.

4.14.5 Inflation actuation controls must be constructed so they cannot trip or entangle evacuees.

4.14.6 When actuated, the manual inflation actuation controls must function in a manner which will not cause rotation or twist of the deployed assist means.

#### 4.15 Inflation System.

4.15.1 The inflation system must be connected to the evacuation device and ready for instant use. The inflation system must minimize leakage due to backpressure after inflation.

4.15.2 If an air aspirator system is used, the system must be constructed to prevent the ingestion of small foreign objects or to prevent failure or malfunction of the system as a result of ingestion of the small foreign objects.

4.15.3 Components must meet Department of Transportation (DOT) Specifications 3AA (49 CFR 178.37) or 3HT (49 CFR 178.44) in effect May 30, 1976, FRP-1 (49 CFR 178.AA) in effect February 1987, CFFC (49 CFR 178) in effect November 1996, or an equivalent specification approved by the manager of the FAA office having purview of the manufacturer's facilities, as required in paragraphs 3b, Deviations and 5a, Application Data of this TSO.

4.15.4 Inflation systems for Type II devices, in addition to meeting the above requirements of paragraph 4.15 of this appendix, shall be arranged so that failure of one inflatable chamber or manifold will not result in loss of gas from the other chamber. The inflation equipment shall be located so as not to interfere with boarding operations.

#### 4.16 Multiple Lane Devices.

4.16.1 A multiple lane device must provide space for evacuees sliding simultaneously in each lane. Each sliding surface, if separated by a raised divider not considered to be a part of the sliding surface, must be at least 20 inches wide. The combined width of two sliding surfaces not separated by a raised divider must be at least 42 inches. The width of a multiple lane device with no raised lane divider must be sufficient to enable evacuees to jump side-by-side into each slide lane simultaneously and reach the ground safely.

4.16.2 A multiple lane device must resist adverse twisting or deflecting when subjected to maximum asymmetrical loading represented by evacuees traversing each lane of the device individually at the evacuation rate prescribed in paragraph 4.10 of this appendix. Test conditions shall be as specified in paragraph 5.4 of this appendix except that only the normal sill height and nominal pressure shall be tested.

4.16.3 Where used, a raised divider or center median must be constructed so as to prevent injury to evacuees and not to throw from the device evacuees who jumped into it astraddle or partly astraddle the divider or median. Multiple lane devices, if canted, must provide for the avoidance of cross-flow effects due to the canting.

4.17 Side Guards. A single or multiple lane inflatable device must be equipped with side guards or other means to prevent evacuees from accidentally missing or falling from the device. The means must provide protection for an evacuee who crosses the aircraft emergency exit threshold at a horizontal velocity of approximately 6 feet per second and contacts the device installed at its steepest design angle.

4.18 Emergency Knife Location. If an emergency knife is provided, it must be so installed that it cannot injure persons using the evacuation device in a normal manner. For Type II devices, the knife must also meet the requirements of paragraph 4.39 of this appendix.

#### 4.19 Device Illumination.

4.19.1 Integral device illumination must be designed so the illumination means is activated automatically during deployment or inflation and the level of illumination meets the appropriate requirements in 14 CFR § 25.812 in effect at the time of application.

4.19.2 The illumination means must not interfere with the safe evacuation of persons using the device in a normal manner.

4.20 Wind. The device must be shown, in 25-knot winds directed from the most critical angle, to deploy and, with the assistance of only one person who has evacuated down the device, to remain usable after full deployment to evacuate occupants safely to the ground. The device shall be tested while it is properly attached to the exit or location on the airplane on which installation is intended or on an equivalent mock-up.

4.20.1 To determine the most critical angle, the wind shall be directed at the device from at least the following directions: aft along the centerline of the aircraft (0 degrees position) and then every 45 degrees on the same side of the fuselage as the device is intended for installation.

4.20.2 If the straight section of the descent portion of the device forms an angle greater than 10 degrees to a line perpendicular to the aircraft centerline, the wind shall be applied to the device from directions perpendicular to both sides (i.e., the edges of the device parallel to the straight section of the descent portion) and from every 45 degrees between these two directions on the same side of the fuselage as the device is intended for installation. For directions which are not tested, a rational analysis shall be presented to show why those directions are less critical than those tested.

#### 4.21 Device Surface.

4.21.1 The surfaces of the device, including its coating, must be suitable and safe for use in any weather condition, including a rainfall of 1 inch per hour. The evacuation rate achieved in demonstrating suitability and safety of the device sliding surface under rainfall conditions shall be no less than that shown in paragraph 5.4.3.10. Evacuees shall meet the requirements of paragraph 5.4.1.5 of this appendix.

4.21.2 Each device sliding lane, including its coating, must provide safe and rapid evacuation without detrimental erosion or deterioration for at least 200 adult persons without any rework of the surface.

4.22 Device Performance. At least five consecutive deployment and erection tests must be demonstrated without failure. At least three tests must be conducted using a single representative sample of the device.

4.23 Dynamic Pressure Retention Test. The device must maintain adequate pressure to satisfactorily accomplish its intended function throughout an emergency evacuation in which:

4.23.1 The device is installed at its critical angle (with respect to buckling);

4.23.2 The device is inflated by the inflation system designed for that purpose, the initial pressure of which is at the minimum of its design range;

4.23.3 The pressure relief valve(s), if installed, is unrestricted; and

4.23.4 At least 200 persons in no more than 10 separate demonstrations use each slide lane of the device at an average rate of not less than one person per second per lane.

4.24 Overpressure Tests. The device must be shown to withstand the overpressure test requirements of paragraph 5.2.2 of this appendix without damage.

4.25 Static Pressure Retention Test. The device must be shown to meet the pressure retention test requirements of paragraph 5.2.1 of this appendix.

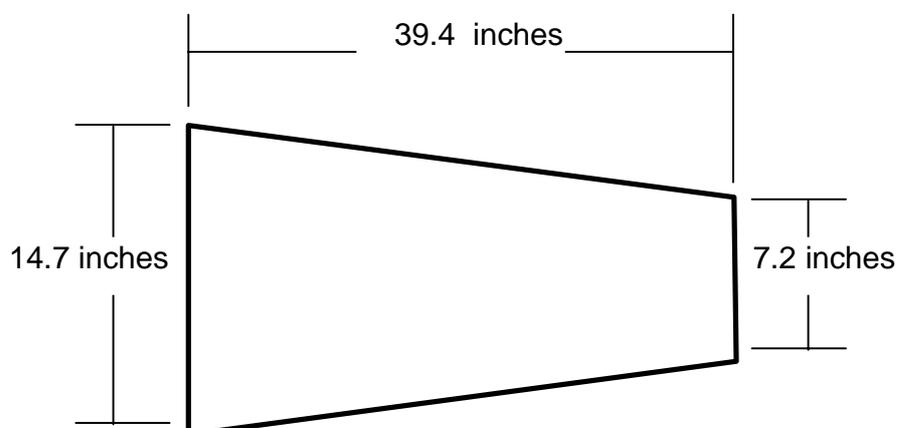
4.26 Raft Capacity-Type II Devices.

4.26.1 Rated Capacity. The rated capacity shall be the usable seating area on the deck/sliding surface of not less than 3.6 ft<sup>2</sup>/person.

4.26.2 Overload Capacity. The overload capacity shall be the usable seating area on the deck/sliding surface of not less than 2.4 ft<sup>2</sup>/person.

4.26.3 Capacity. Alternate Rating Methods. In lieu of the rated capacity prescribed in paragraph 4.26.1 above, one of the following methods may be used:

4.26.3.1 The rated capacity of a Type II device may be determined by the number of seating spaces which can be accommodated within the occupiable area exclusive of the perimeter structure (such as inflation/buoyancy tubes) without overlapping of the occupant seating spaces. The occupant seating spaces may not be less than the following size unless an equivalent size has been approved by the manager of the FAA office having purview of the manufacturer's facilities.



4.26.3.2 The rated capacity also may be determined on the basis of a controlled pool or fresh water demonstration which includes conditions prescribed under paragraph 5.2.3 of this appendix and the following:

4.26.3.2.1 The sitting area on the raft deck may not be less than 3.0 ft<sup>2</sup>/person.

4.26.3.2.2 At least 30 percent but no more than 50 percent of the participants must be female.

4.26.3.2.3 Except as provided below, all participants must select their sitting space without outside placement assistance. A raft commander, acting in the capacity of a crewmember, may direct occupant seating to the extent necessary to achieve reasonable weight distribution within the device.

4.26.3.2.4 All participants must not have practiced, rehearsed, or have had the demonstration procedures described to them within the past 6 months.

#### 4.27 Buoyancy.

4.27.1 Type I devices installed at main deck floor level exits shall be designed to have positive buoyancy when extended so that they can be used as emergency flotation devices.

4.27.2 Type II devices shall have two independent inflatable flotation tubes. If either tube is deflated, the other tube and the device floor shall be capable of supporting the rated and overload capacities in fresh water.

4.27.2.1 It shall be shown by tests in fresh water that the Type II device, loaded to rated capacity using an average weight of 170 lbs./person, has a freeboard of at least:

4.27.2.1.1 Twelve inches with both flotation tubes at minimum raft mode operating pressure; and

4.27.2.1.2 Six inches with the critical flotation tube deflated and the remaining flotation tube at minimum raft mode operating pressure. In lieu of meeting the 6-inch freeboard requirement of this paragraph, the buoyancy provided by the tubes only (disregarding buoyancy derived from the floor and inflatable floor support) shall be capable of supporting the rated capacity based on an average weight of at least 200 lbs./person.

4.27.2.2 It shall be shown by tests in fresh water that the Type II device loaded to its overload capacity and using an average weight of 170 lbs./person has a measurable freeboard with the critical flotation tube deflated.

Ballast in the form of sandbags or the equivalent may be used to achieve the 170-lb weight, provided the appropriate distribution within the device is maintained.

#### 4.28 Disconnect Means.

4.28.1 Type I devices' disconnect means must be a readily apparent, flexible cloth/webbing loop capable of being operated by untrained persons and covered until ready for use. The method of disconnecting the device from the aircraft must be conspicuously and clearly indicated by brief instruction placards.

4.28.2 Type II device release from an aircraft, whether by automatic or manual means, shall not be restricted by the critical conditions of: (a) floor sill height above the water, (b) wind velocity and direction, or (c) occupant load. Devices having aircraft mounted inflation systems shall have means for quick detachment from the inflation system so that separation cannot cause loss of raft buoyancy. Release means shall be a readily apparent flexible cloth/webbing loop capable of being operated by untrained persons and covered until ready for use. The method of disconnecting the device from the aircraft must be conspicuously and clearly indicated by brief instruction placards.

#### 4.29 Mooring Line.

4.29.1 Type I devices must be equipped with a nonrotting mooring line so that the deployed device automatically will remain secured to the aircraft when it is used as an emergency flotation platform. The mooring line shall not endanger the device, cause the device to spill occupants if the aircraft sinks, or interfere with the operation of the device. The mooring line shall have a minimum length of 20 feet and have a knotted breaking strength of not less than 500 lbs. The attachment to the evacuation device shall be stronger than the mooring line. The moored device shall be quickly and easily disconnected from the aircraft. The mooring release means shall be readily apparent and operable by untrained evacuees.

4.29.2 Type II devices, in addition to meeting the requirements of paragraph 4.29.1, shall have a mooring line capable of keeping the device, loaded to rated capacity, attached to a floating aircraft. The line may be equipped with a mechanical release linkage. The breaking strength of the line shall be 500 – 1000 pounds.

4.30 Lifeline. Type I and Type II devices shall be equipped with a nonrotting lifeline of a size greater than or equal to 3/8-inch diameter or 1/2-inch width, .060 minimum thickness and of a color that contrasts with the device. The lifeline shall be attached along at least 80 percent of the length of both sides of the device. The lifeline shall not adversely compromise the use of the device as a slide. The lifeline and its attachment must be capable of withstanding a minimum load of 500 lbs. and must not interfere with the device's inflation.

4.31 Capsize Resistance-Type II Devices. There shall be water pockets or other means to provide ballast to resist capsizing an empty or lightly loaded raft.

4.32 Righting-Type II Devices. Unless it is shown that there is no tendency for the device to become inverted during loading and release from the aircraft, the slide/raft must comply with the righting tests specified in paragraph 5.2.3.5 of this appendix.

4.33 Boarding Aids-Type II Devices. Boarding aids shall be provided at two opposing positions on the raft. Boarding aids shall permit unassisted entry from the water into the unoccupied raft and shall not at any time impair either the rigidity or the inflation characteristics of the raft. Puncturing of inflatable boarding aids shall not affect the buoyancy of the raft flotation chambers. Boarding handles and/or stirrups used in conjunction with the boarding aids shall withstand a pull of 500 pounds. Boarding aids must be shown to comply with the test requirements of paragraph 5.2.3.6 of this appendix.

4.34 Heaving-Trailing Line-Type II Devices. At least one, floating, heaving-trailing line, not less than 75 ft in length and at least 250 lbs. strength, shall be located on the main flotation tube near the sea anchor attachment. The attachment point of the line shall withstand a pull force of not less than 1.5 times the line rated strength without damage to the device.

4.35 Canopy-Type II Devices. A canopy shall be packed with or attached to the device. The erected canopy shall be capable of withstanding sustained wind velocities of 35 knots and 52-knot gusts in open water. The canopy shall provide adequate headroom, minimum 1 inch clearance, for the 95th percentile male (seated height) and shall provide openings 180 degrees apart. Means shall be provided to make the openings weather tight. If the canopy is not integral with the raft, it shall be capable of being erected by occupants following conspicuously posted, simple instructions. It shall be capable of being erected by one occupant of an otherwise empty raft and by occupants of a raft filled to rated capacity.

4.36 Color-Type II Devices. Except surfaces which have been treated for the purpose of reflecting radiant heat, the color of the device surfaces, including the canopy surface, visible from the air shall be an International Orange-Yellow or an equivalent high visibility color.

4.37 Sea Anchor-Type II Devices. A sea anchor, or anchors, or other equivalent means must be provided to maintain the raft, with rated capacity and canopy installed, on a substantially constant heading relative to the wind and must have the ability to reduce the drift to 2 knots when subjected to winds of 17 to 27 knots. Unless analysis and/or test data substantiating the adequacy of a lower breaking strength is approved by the manager of the FAA office having purview of the manufacturer's facilities as required in paragraphs **3b**, **Deviations**, and **5a**, **Application Data**, the line securing a sea anchor to the device shall have a breaking strength of 500 pounds or 40 pounds times the rated capacity of the raft, whichever is greater. The attachment of the line to the raft shall be capable of withstanding a load of 1.5 times the line-rated strength without damaging the device. The line shall be at least 25 feet in length and shall be protected to prevent it from being inadvertently cut by raft occupants.

4.38 Emergency Inflation Equipment-Type II Devices. A means readily accessible to occupants of the device shall be provided to manually inflate the device and maintain the raft mode minimum operating pressure. The emergency inflation means must have a displacement of at least 32 cubic inches per full stroke. Manual inflation valves, with a non-return opening adequate for the size and capacity of the inflation means, shall be located to permit inflation of all chambers. The inflation means and valves shall have provisions to prevent inadvertent removal and loss when either stowed or in use.

4.39 Knife-Type II Devices. A hook-type knife secured by a retaining line shall be sheathed and attached to the device adjacent to the point of mooring line attachment. This knife must also meet the requirements of paragraph 4.18 of this appendix.

4.40 Placards-Type II Devices. Suitable placards shall be provided in contrasting colors in waterproof paint which is not detrimental to the fabric, that denote use and location of the inflation systems, raft equipment, boarding aids, and righting aids. The letters used for such placarding shall be at least 2 inches high, except the details and miscellaneous instructions may be of smaller lettering. Applicable placarding shall take into account persons boarding or righting the raft from the water.

4.41 Emergency Lights-Type II Devices. At least one TSO-C85a, or the latest revision, approved survivor locator light shall be provided. The light shall be automatically activated upon device inflation in the water and shall be visible from any direction by persons in the water. The light shall be located at or near a boarding station.

4.42 Actuation Means-Type II Devices. If the device as a slide requires an additional operation to make it usable as a raft, the means for initiating the additional operation shall be designed to preclude inadvertent actuation but be readily available for use. If a pull motion is used, the force required must not be more than 30 pounds.

4.43 Sea Performance-Type II Devices. The device shall meet the seaworthiness requirements in paragraph 5.2.4 of this appendix and shall be capable with its equipment of withstanding a saltwater marine environment for a period of at least 15 days.

## 5. Tests.

5.1 Material Tests. Testing the material properties specified in paragraph 3, Materials, of this appendix must be conducted in accordance with the following test methods or other approved equivalent methods:

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Test Method

<u>Tests Required</u>	<u>Federal Test Method Standard</u>	<u>Other Test Method</u>
Accelerated Age	(1.) - Method 5850	Per Note (2.)
Tensile Strength (Grab Test)	(1.) - Method 5100	Per Note (8.)
Tear Strength (Trapezoid Test)	(6.) - Method 5136	
Tear Strength (Tongue Test)	(1.) - Method 5134 (Alternate to Trapezoid Test paragraph 3.1.5.1)	
Ply Adhesion	(1.) - Method 5960	Per Note (4.)
Coat Adhesion	(1.) - Method 5970	Per Note (9.)
Permeability	(6.) - Method 5460	Per Note (7.)
Seam Shear Strength	(1.)	Per Notes (3.) (8.)
Seam Peel Strength	(1.) - Method 5960	Per Note (4.)
Puncture Strength		Per Note(10.)
Hydrolysis Conditioning		Per Note (11.)
Porosity Test (Hydrolysis)		Per Note (12.)
Flammability (Vertical Burn Rate)		Per Note (5.)

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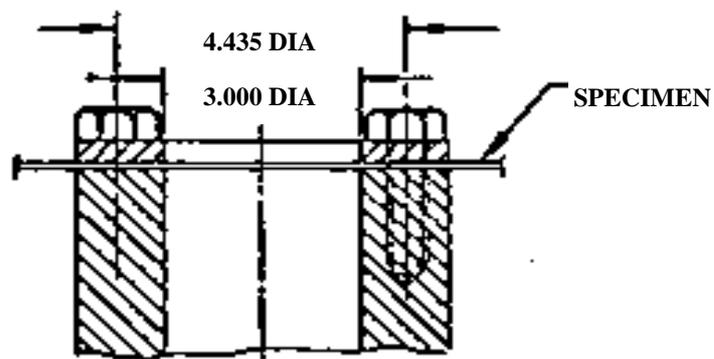
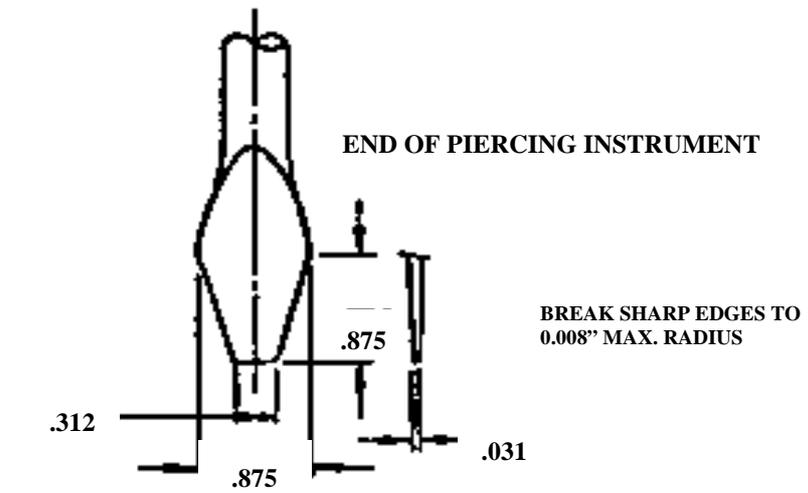
NOTES:

- (1) Federal Test Method Standard (FTMS) No. 191A dated July 20, 1978.
- (2) Samples for the accelerated aging tests must be exposed to a temperature of  $158 \pm 5$  degrees F for not less than 168 hours. After exposure, the samples must be allowed to cool to  $70 \pm 2$  degrees F for neither less than 16 hours nor more than 96 hours before determining their physical properties in accordance with paragraph 3.1 of this appendix.
- (3) Each sample shall consist of two strips 2 inches maximum width by 5 inches maximum length bonded together with an overlap of 3/4 inches maximum. The free ends must be placed in the testing machine described in FTMS 191A, Method 5100 and separated at a rate of  $12 \pm 0.5$  inches/minute. The average value of a minimum of three samples must be reported. Samples may be multilayered to ensure against premature material failure. Samples may be gripped across the full two inches of width.
- (4) Separation rate must be 2.0 to 2.5 inches/minute. Sample width shall be one inch.
- (5) The material must meet the flammability requirements of 14 CFR § 25.853(a), Appendix F, part I (a)(1)(ii) in effect March 6, 1995.
- (6) FTMS No. 191 in effect December 31, 1968.
- (7) ASTM Method D1434-82, Procedure V, approved July 30, 1982, is an acceptable alternate method.
- (8) Use of pneumatic grips for holding test samples is an acceptable alternate to the mechanical grips described in Method 5100.
- (9) The sample shall be prepared using the adhesive and construction methods used to manufacture the evacuation device. Separation rate must be 2.0 to 2.5 inches/minute.
- (10) The fabric shall be tested in a specimen holder constructed in accordance with figure 1. The fabric shall be clamped tightly in the specimen holder to present a wrinkle-free surface and prevent slippage during the test. A piercing instrument with its end conforming to figure 1 shall be forced against the fabric at approximately the

center of the area enclosed by the specimen holder. The force required to puncture the specimen shall not be less than the specified 67 pounds. The test shall be run using a crosshead speed of 12 inches/minute.

(11) Each sample shall be exposed to a temperature of  $136 \pm 4$  degrees F and a relative humidity of  $95 \pm 4$  percent for a period of 50 days.

(12) Porosity testing conducted for hydrolysis resistance shall be conducted with the test apparatus specified in paragraph 5.3 or an equivalent test method approved by the manager of the FAA having purview of the manufacturer's facilities, as required in paragraphs **3b, Deviations** and **5a, Application Data**, of this TSO. Note specimen size and mounting information of paragraphs 5.3.3.1 and 5.3.4.5 of this appendix. Tests should be conducted at the devices nominal operating pressure for a duration of 30 minutes. Porosity is indicated by a loss in chamber pressure during testing. Pressure loss for material specimens after hydrolysis conditioning shall not be greater than the pressure loss for the material before conditioning.



SPECIMEN HOLDER

DIMENSION IN INCHES

FIGURE 1. PIERCING INSTRUMENT AND SPECIMEN HOLDER

## 5.2 Functional Tests.

5.2.1 Pressure Retention. Under static conditions and when inflated and stabilized at the nominal operating pressure, the pressure in each inflatable chamber of a Type II device must not fall below the minimum raft mode operating pressure in less than 24 hours. For Type I, III & IV devices, the pressure in each inflatable chamber must not fall below 50 percent of the nominal operating pressure in less than 12 hours.

### 5.2.2 Overpressure Tests.

5.2.2.1 The device must withstand a pressure at least 1.5 times the maximum operating pressure for at least 5 minutes without sustaining damage.

5.2.2.2 At least one specimen of the inflatable device model must be shown by test to withstand a pressure at least 2 times the maximum operating pressure without failure for at least 1 minute. Devices so tested must be clearly identified.

5.2.3 Water Tests-Type II Devices. In either a controlled pool or fresh water the capacity and buoyancy of the device must be demonstrated as follows:

5.2.3.1 Both rated and overload capacities established in accordance with the requirements of paragraph 4.26 of this appendix must be demonstrated with inflation tubes at minimum raft mode operating pressure and with the critical buoyancy chamber deflated. The resultant freeboard in each case must meet the requirements of paragraph 4.27.2 of this appendix.

5.2.3.2 Persons used in the demonstration must have an average weight of not less than 170 pounds. Ballast in the form of sand bags or equivalent may be used to achieve proper loading provided the appropriate weight distribution within the device is maintained.

5.2.3.3 Persons used in the demonstration must wear FAA approved life preservers with at least one chamber inflated.

5.2.3.4 The raft equipment required by this TSO, plus one emergency locator transmitter or a weight simulating a transmitter, must be aboard the device.

5.2.3.5 Unless it can be shown that there is no tendency for the device to become inverted during loading and release from the airplane, it must be demonstrated that the device is self-righting or that it can be righted by one person in the water, or that while inverted it can be boarded and provide flotation for the normal rated capacity.

5.2.3.6 It must be demonstrated that the boarding aids are adequate for the purpose intended and that it is possible for male and female adults wearing inflated life preservers to board the raft unassisted.

5.2.4 Sea Trials – Type II Devices. The device must be demonstrated by tests or analysis, or a combination of both, to be seaworthy in an open sea condition with maximum sustained winds of 17 to 27 knots and waves of 6 to 10 feet. In tests, ballast in the form of sand bags or equivalent may be used to achieve proper loading provided the appropriate weight distribution within the raft is maintained. If analysis is used, the analysis must be approved by the manager of the FAA office having purview of the manufacturer's facilities as required in paragraph **5a, Application Data** of this TSO. For this seaworthiness demonstration, the following apply -

5.2.4.1 The raft must be boarded by the rated number of occupants to demonstrate the method of loading from a simulated aircraft sill installation.

5.2.4.2 The proper functioning of the means to separate the raft from the simulated aircraft installation must be demonstrated.

5.2.4.3 All equipment required by this TSO must be aboard and the proper functioning of each item of equipment must be demonstrated.

5.2.4.4 The canopy must be erected for a sufficient time to assess its resistance to tearing and the protection it affords. The method of erection must be shown to be accomplished by one occupant of an otherwise empty raft and by occupants of a raft filled to rated capacity.

5.2.4.5 The stability of the raft must be demonstrated when occupied at normal rated capacity and at 50 percent rated capacity.

5.3 Radiant Heat Test. The pressure holding materials in the emergency evacuation inflatable device shall be tested for resistance to radiant heat in accordance with this standard. If any of the outer surface of the pressure holding material is altered by marking, by lettering, by affixed overlay or underlying material, or in any other manner which affects radiant heat resistance, the altered material shall also be tested.

5.3.1 Criteria for Acceptance. For each material which requires testing, at least three specimens shall be tested at 1.5 Btu/ft<sup>2</sup>-sec (1.7 W/cm<sup>2</sup>), and the resulting times to failure averaged. The average time to failure may not be less than 180 seconds with no value less than 90 seconds. Time to failure is the time between first application of heat to the specimen and first drop in pressure below the maximum pressure attained in the test cylinder during the test.

5.3.2 Test Apparatus. The tests shall be conducted using the FAA Slide Material Radiant Heat Apparatus, or another equivalent test apparatus and test method approved by the manager of the FAA office having purview of the manufacturer's facilities as required in paragraphs **3b, Deviations**, and **5a, Application Data** of this TSO. The apparatus consists of a horizontally mounted cylinder closed at one end and fitted with a source of air pressure and pressure measurement. A specimen holder clamped over the open end seals the cylinder air tight with the material specimen acting as a pressure holding diaphragm. The cylinder and specimen holder are mounted on a pivot and slide bar, and can be positioned at varying distances from a 3-inch (76mm) diameter electric radiant heat furnace and a calorimeter. The test apparatus is described in figures 2 through 5 and paragraphs 5.3.2.1 through 5.3.2.6 of this appendix.

5.3.2.1 The pressure cylinder and specimen holder, as shown in figures 2, 3, and 4 of this appendix, consist of a 7-inch (178 mm) outside diameter (O.D.) by 6 1/2-inch (165 mm) inside diameter (I.D.) by 12 3/8-inch (314 mm) long aluminum tube. On one end of the tube is welded a 1/2-inch (13 mm) thick aluminum plate, drilled and tapped for a 1/4-inch American national pipe taper thread to facilitate air pressure and pressure recording hookups. On the other end of the tube is welded a 7-inch (178 mm) O.D. by 5 1/2-inch (140 mm) I.D. ring of 1/2-inch (13 mm) thick aluminum. This ring is drilled and tapped for 10-32 by 7/8-inch (22 mm) long studs. Another 6 3/4-inch (171 mm) O.D. by 5 1/2-inch (140 mm) I.D. by 1/2-inch (13 mm) thick aluminum ring and two neoprene rubber gaskets with matching clearance holes to fit over the studs provide a means for clamping and sealing the test specimen in place. Hinges and adjustable stops are welded to the sides of the cylinder, shown in figures 2, 3, and 4.

5.3.2.2 The electric furnace meeting the requirements of the FAA Fire Test Handbook is shown in figure 5 of this appendix. It has a 3-inch (76 mm) diameter opening to provide a constant irradiance on the specimen surface. An acceptable furnace, part number 680860025700, is available from Newport Scientific, Inc., 8246-E Sandy Court, Jessup, Maryland 20794-9632. Another acceptable furnace, part number 680860380000, is also available from Newport Scientific, Inc.

5.3.2.3 A 0-5 Btu/ft<sup>2</sup>-sec (5 W/cm<sup>2</sup>) calorimeter meeting the requirements of the FAA Fire Test Handbook is required. (Vatell thermogage calorimeter no. 1000-1B, available from Vatell, P.O. Box 66, Christiansbury, Virginia 24073, is acceptable.) The calorimeter is mounted in a 4 1/2-inch diameter by 3/4-inch insulating block and is hinged to one of the sliding bars of the framework. The surface of the calorimeter is flush with the surface of the insulating block and centered with the furnace. See figure 4 of this appendix. The calorimeter must be calibrated to a primary standard by NIST or calibrated per the requirements of appendix 4.

5.3.2.4 The pressure cylinder, calorimeter, and furnace are mounted on a framework as detailed in figure 4 of this appendix. Adjustable sliding stops are located on each of the bars for setting the cylinder and calorimeter at the desired distance from the opening of the furnace.

5.3.2.5 Compressed air is connected to the cylinder through a needle valve attached to the end of the framework. A tee on the outlet side of the valve provides for a 0-5 psig pressure gauge, transducer, and flexible tube to supply air to the rear plate of the pressure cylinder, as shown in figure 2 of this appendix.

5.3.2.6 The outputs of the calorimeter and pressure transducer are measured and recorded using a recording potentiometer or other suitable instrument capable of measurement over the range required.



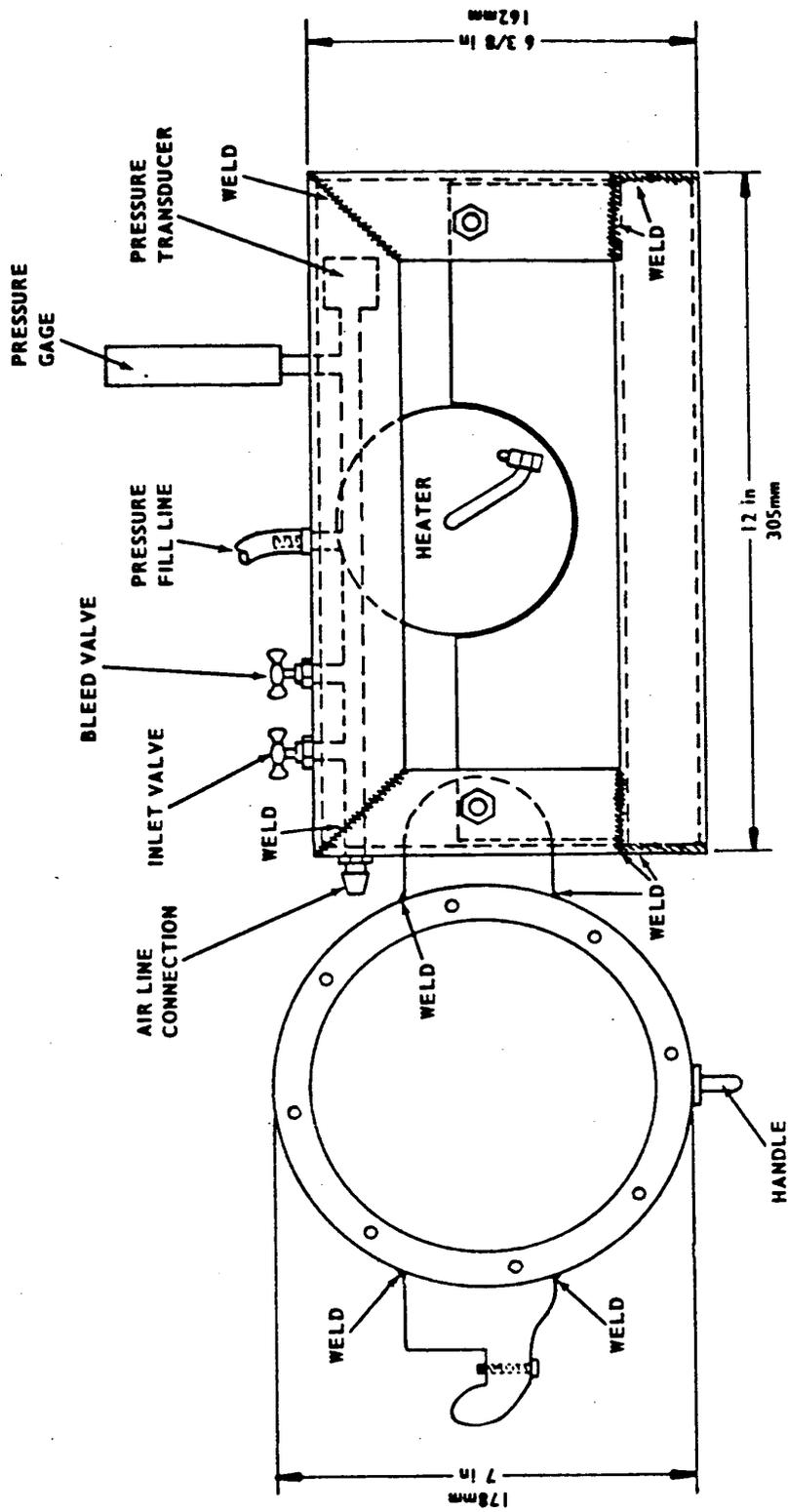


FIGURE 3. LABORATORY TEST



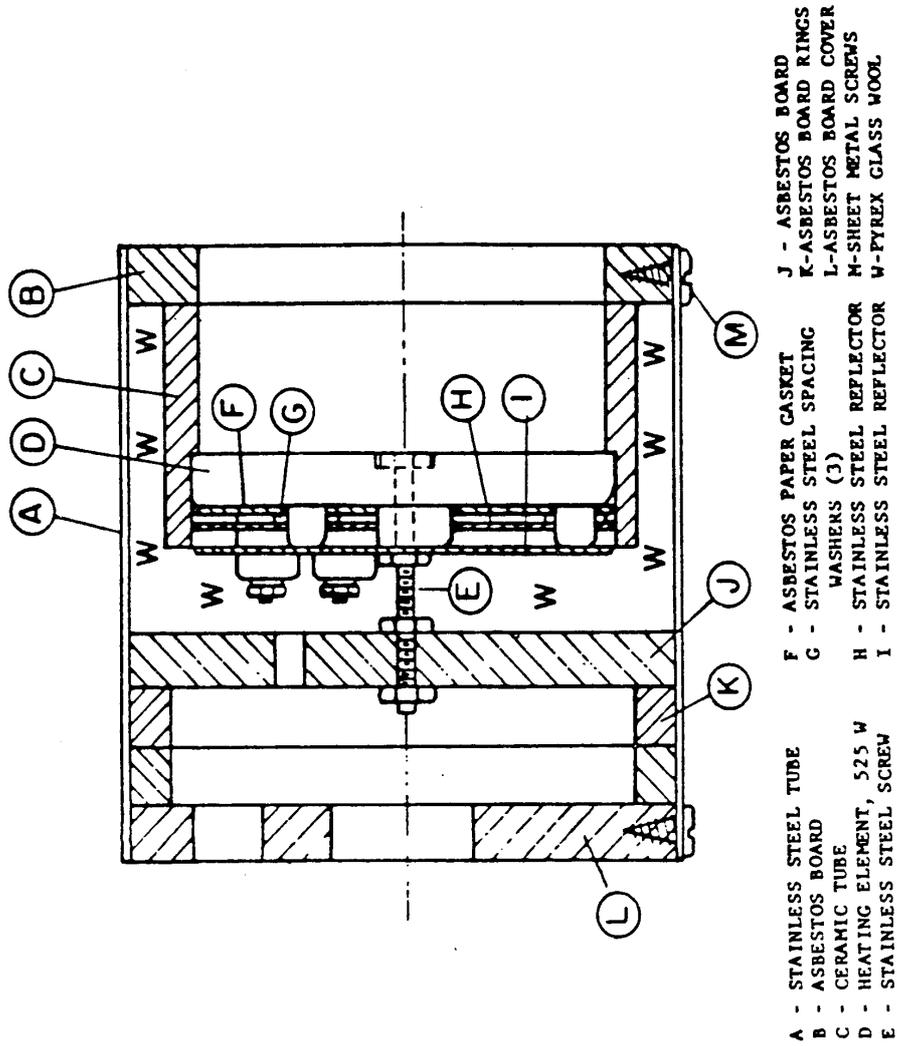


FIGURE 5. FURNACE SECTION

5.3.3 Test Specimens.

5.3.3.1 Test specimens 7 inches (178mm) in diameter with 1/4-inch (6mm) holes punched in the material to match the studs in the pressure cylinder must be cut from the material to be tested.

5.3.3.2 Test specimens must be conditioned at  $70 \pm 3$  degrees F ( $21 \pm 3$  degrees C) and  $50 \pm 5$  percent relative humidity for at least 24 hours prior to testing.

5.3.4 Test Procedures.

5.3.4.1 All tests must be conducted in a draft free room or enclosed space.

5.3.4.2 After turning on the radiant heat furnace and other required instrumentation, allow 1/2 to 3/4 hour to stabilize heat output and for instrumentation warm-up.

5.3.4.3 Adjust transformer to produce a radiant heat flux of 2 Btu/ft<sup>2</sup>-sec (2.3 W/cm<sup>2</sup>) when the calorimeter is positioned 1 1/2 inches (38mm) in front of the radiant heat furnace.

5.3.4.4 Find the location in front of the furnace for the test heat flux of 1.5 Btu/ft<sup>2</sup>-sec (1.7 W/cm<sup>2</sup>) by sliding the calorimeter on the horizontal bar and fixing the position with the sliding stop. Swing the calorimeter out of position.

5.3.4.5 Mount the specimen on the open end of the cylinder with a neoprene gasket on each side of the specimen with the reflective surface of the material facing the furnace. Place the aluminum ring on the studs and tighten the nuts so that an airtight seal made.

5.3.4.6 Pressurize the cylinder to the device nominal operating pressure. Check for leakage.

5.3.4.7 Check the distance from the radiant heat furnace to the surface of the test specimen. This distance is the same as the distance to the surface of the calorimeter.

5.3.4.8 Place the calorimeter in front of the radiant heat furnace and record the heat flux. An acceptable heat flux is 1.5 Btu/ft<sup>2</sup>-sec (1.7 W/cm<sup>2</sup>). Remove calorimeter.

5.3.4.9 Place the pressure cylinder and test specimen in front of the radiant heat furnace. Start timer or note starting time on the recorder.

5.3.4.10 Pressure is monitored from the time the specimen is placed in front of the furnace until initial pressure loss is observed.

5.4 Evacuation Rate Tests.

5.4.1 Basic Test Conditions. The following test conditions shall be applicable to tests run for showing compliance with paragraph 4.10.1 of this appendix:

5.4.1.1 The device shall be tested at normal sill height.

5.4.1.2 The device shall be tested at three different inflation pressures: minimum operating, maximum operating, and the nominal operating pressure.

5.4.1.3 The surface of the device shall be dry.

5.4.1.4 The test area may be illuminated to any level suitable for safe conduct of the test.

5.4.1.5 The evacuees may be of any age, gender, weight, or experience level suitable for safe conduct of the test, but each evacuee group must average a minimum of 170 pounds per person. Evacuees may participate in more than one test run.

5.4.1.6 Each device lane shall be traversed by a minimum of 20 evacuees per lane for each test run.

5.4.1.7 All test runs shall be on the same test article.

5.4.1.8 Each test run must have a rate of 60 evacuees/minute per lane or higher.

5.4.1.9 The combined average rate of all test runs must be 70 evacuees/minute per lane or higher. If different numbers of evacuees are used among the different test runs, the rates for each test run shall be mathematically weighted to ensure proper averaging.

5.4.2 Maximum and Minimum Sill Height Conditions. In addition to the tests in paragraph 5.4.1 above, the device shall be tested at the maximum and minimum sill heights. Three test runs shall be conducted on the same test article for both sill heights, one each at minimum operating, maximum operating, and the nominal operating pressure of the normal conditions pressure range. At maximum sill height, a minimum of five evacuees per lane per run shall use the device and be conveyed safely to the ground. At minimum sill height, a minimum of 20 evacuees per lane per run shall use the device. The evacuees shall meet the same requirements as in paragraph 5.4.1.5 of this appendix. No specific evacuation rate is required for the maximum sill height tests. However, at minimum sill height the rate shall be no less than that shown in paragraph 5.4.3.10.

5.4.3 Emergency Lighting Test Conditions. The following test conditions shall be applicable to tests run for showing compliance with paragraph 4.10.2 of this appendix:

5.4.3.1 The test shall be run on the airplane on which installation is intended or an approved, representative mock-up of the relevant section of the airplane.

5.4.3.2 The sill height used shall represent normal conditions for the airplane with all landing gear extended.

5.4.3.3 When using a mock-up, the exit cutout and the door (if necessary) shall be representative of the airplane. The passageway to the exit should be no greater than the minimum specified for that exit in 14 CFR § 25.813, e.g., 36 inches wide for a Type A or B exit, or 20 inches wide for a Type I, II or C exit. The assist space shall be per current FAA guidance contained in AC 25-17. Cabin features such as doors, cabinets, monuments, door hinges, or other impediments intruding into the exit path which may influence the evacuation rate shall be realistically simulated along the length of the passageway.

5.4.3.4 The device shall be installed, inflated to its nominal operating pressure and ready for use. Note: Emergency lights mounted on the device shall not be illuminated until test initiation, and shall be powered by batteries conditioned per 14 CFR § 25.812(i), or an equivalent power supply.

5.4.3.5 The surface of the device shall be dry.

5.4.3.6 The device shall be hidden from view of the evacuees prior to test initiation.

5.4.3.7 For a period of 5 minutes prior to the initiation of the test, the area holding the evacuees, i.e., the "cabin interior", shall be illuminated to a minimum level of 5 foot-candles, or the level which is representative of typical cabin lighting as measured on the centerline of the passageway floor, one foot inboard of the exit sill. The ambient illumination in the test area outside of the airplane or mock-up shall not exceed 0.005 foot-candles; measurements should be made at the ground end of the assisting means and at the exit, just outside of the fuselage. Provisions shall be made, where necessary, to prevent light reflecting off of surfaces in the outside test area, e.g., hangar walls, from providing visual references to the test participants. All illumination measurements shall be made with a light meter in current calibration, with an accuracy/resolution of at least 2 percent and 0.001 foot-candles.

5.4.3.8 Upon test initiation, the illumination of the "cabin interior" shall be reduced to the nominal light level provided by the airplane emergency lighting system (with batteries conditioned per 14 CFR § 25.812(i)) as measured as incident light on the centerline of the passageway floor, one foot inboard of the exit sill. The assist means lighting system(s) will be activated.

5.4.3.9 The evacuees shall not have participated in any test or demonstration involving airplane evacuation devices within the past year.

5.4.3.10 The evacuee group size shall be per the following table:

Exit type	Rating	Evacuees	Pass/fail criterion (in seconds)***
A	110	44 (22 per lane)	$30 + T_t$ ****
B	75	45 (22/23 per lane)	$45 + T_t$
C	55	22	$30 + T_t$
I	45	27	$45 + T_t$
II	40	24	$45 + T_t$
III	35	21	$45 + T_t$
III (dual*)	70	42 (21 per III)	$45 + T_t$
III (dual**)	70	39 (19/20 per III)	$45 + T_t$

\*Dual separated by  $\geq 3$  seat rows.

\*\*Dual separated by  $< 3$  seat rows.

\*\*\*The total time allowed from the start of the test, when the light level changes, as described in 5.4.3.8, until the last evacuee reaches the ground.

\*\*\*\* $T_t$  = Transit time ( $T_t$ ), determined by averaging the times required by five or more evacuees tested one at a time to traverse the descent route in factory ambient lighting conditions. Evacuees must meet the conditions in 5.4.3.9 and 5.4.3.11.

5.4.3.11 The age/gender mix of the evacuee group shall be as defined in the current version of Appendix J of 14 CFR part 25.

5.4.3.12 For floor level exits, a person trained to give verbal commands shall direct the evacuation from an assist space provided for the aircraft and may stop the test if conditions warrant. He/she should use procedures or techniques approved by the manager of the ACO having purview of the device manufacturer's facilities. These procedures and techniques shall not include physically assisting hesitant evacuees through the doorway.

5.4.3.13 The following information may be given to participants and the following procedures may occur during the briefings identified below:

5.4.3.13.1 Recruiting briefing:

- + Describe purpose of the test.
- + Identify possible hazards of the test.
- + Identify benefits for test participants.
- + Identify benefits to airline passengers.
- + Describe types of clothing/footwear required.

5.4.3.13.2 Orientation briefing:

- + Get subject characteristics.
- + Check for appropriate clothing and footwear.
- + Prepare paperwork (medical forms, etc.).
- + Give building safety information (fire evacuation plan, etc.).
- + Describe test and procedures.

- + Show pictures of the device from ground level in daylight.
- + Describe how to enter the device using pictures from ground level, if desired.
- + Get informed consent.

5.4.3.13.3 Final briefing:

- + Escort to test area.
- + Escort into test mock-up (also known as test module) to prepare for test.
- + Describe test procedures again.
- + Line up (position) evacuees at the exit(s) in single or dual lanes, as appropriate, for the test.
- + Begin test protocol.

5.5 Beam Strength Tests-Except Type III Devices.

5.5.1 Basic Test Conditions. The following test conditions shall be applicable to tests run to show compliance with paragraph 4.3.1 of this appendix.

5.5.1.1 Sand Bags.

5.5.1.1.1 Three sand bags, each weighing a minimum of 170 pounds, connected in series, are required for each and every lane of the device.

5.5.1.1.2 All sand bags shall be equal to each other in weight within 5.0 lbs.

5.5.1.1.3 A single 170-pound sand bag may be assembled from two or more smaller bags for ease of handling. The smaller bags need not be of equal weight.

5.5.1.1.4 The outer covering of the sand bag shall be a material having a coefficient of friction of at least 0.4 when tested per ASTM Standard D 1894-95. (This value is typical of some cotton and polyester/cotton material blends. Test data for the material used shall be included with the final test report.)

5.5.1.1.5 Filler materials other than sand may be used, however, liquids are not acceptable unless they are sufficiently constrained to prevent shifting within the bag.

5.5.1.1.6 The basic shape of a sand bag should be a rectangular solid with rounded corners and a minimum contact surface width of 15 inches. The bag should be longer than it is wide and the height should be less than the width.

5.5.1.1.7 Provisions to securely connect the three sand bags to each other shall be included on each bag. The interconnection provisions shall be designed to minimize any tendency for the bags to roll or tumble.

5.5.1.1.8 When connected, the three sand bags shall occupy an area not to exceed 7.5 feet by 2 feet.

5.5.1.2 Delivery System.

5.5.1.2.1 A delivery system shall be used to convey the sand bags to the beginning of the down-slide portion of the device and to release them so that they may slide down the device. The vertical offset of the end of the delivery system and the device at the point of delivery should be minimized to minimize tumbling of the sandbags.

5.5.1.2.2 The delivery system shall consist of a flat, rigid plane a maximum of 8 feet in length covered with material similar to that used on the sliding surface of the device.

5.5.1.2.3 The delivery system shall incorporate provisions for slowly elevating the rear portion of the plane until the sand bags will begin to move downward onto the sliding surface solely by the effect of gravity or until the plane is at the same angle as the sliding surface and acts as a seamless extension to it. Angles between these two points are acceptable, but in no case shall the angle of the plane exceed the angle of the sliding surface. The sand bags should be restrained until test initiation.

5.5.1.2.4 Where a straight delivery system design cannot be used because the device has a ramp or porch or is more than 20 degrees from being perpendicular to the fuselage, an alternate delivery system design may be used if approved in advance by the manager of the ACO having purview of the manufacturer's facilities.

#### 5.5.1.3 Device Configuration and Installation.

5.5.1.3.1 The device shall be in its production-deliverable configuration with all required equipment installed.

5.5.1.3.2 The sliding surface of the device shall be dry and new (i.e. never having been subjected to persons or sand bags sliding on its surface prior to the tests).

5.5.1.3.3 The pressure in each and every chamber of the device shall be its nominal operating pressure.

5.5.1.3.4 The device shall be installed at its normal sill height and with its normal attachment means. If the device is intended for use at more than one exit pair, it shall be tested at the normal sill height for each exit pair.

5.5.1.3.5 The width of the exit through which the sand bags are delivered shall be representative of the airplane exit to which the device will normally be attached and where the evacuees would normally enter the device. For devices not mounted at the exit sill, only the airplane structure which would control evacuee flow onto the device needs to be simulated.

#### 5.5.2 Testing.

5.5.2.1 For a multi-lane device, the sand bags for all lanes shall be launched simultaneously or as nearly so as possible. A single mechanism which will provide simultaneous release of all bags is recommended. In no case shall the sand bags be launched with an offset of more than one sand bag length difference among all the lanes. A case not conforming to this requirement shall be considered a non-test.

5.5.2.2 Sand bags shall not overlap or lie atop one another at test initiation.

5.5.2.3 Sand bags shall not roll or tumble more than 180 degrees either by force of launch or through action of movement down the device. Some tumbling of the sand bags at the bottom of the device due to the effects of the deceleration means is acceptable.

5.5.2.4 Sand bags shall not depart the device except at the bottom end where evacuee contact with the ground is intended.

5.5.2.5 Cross-over of the sand bags from one lane to another on a multiple lane device is acceptable.

#### 5.5.3 Success Criteria.

5.5.3.1 For the test article to be deemed acceptable, the test shall be completed successfully three consecutive times. (Tests which are aborted or considered non-tests, e.g., there is more than one sand bag offset between lanes during the start of a multiple lane device test, do not count against the goal of three consecutive successful tests.)

5.5.3.2 All sand bags in all lanes shall completely depart the end of the device, or shall be deemed to be likely to exit the device if not obstructed by bags which are partially on the ground and partially on the device.

5.5.3.3 The bottom of the sliding surface shall not contact the ground at any time.

5.5.3.4 The device, without repair, shall meet the requirements of paragraph 4.10.1 of this appendix after being subjected to this test.

5.5.4 Alternative Test Method. As an alternative to the test method (using sand bags) described in paragraph 5.5.1, a test using human subjects may be conducted as follows:

5.5.4.1 Test Subjects. Prior to testing, all test subjects shall be briefed on safety and test issues per paragraph 5.4.3.13 of this TSO. The briefing shall include instructions for required behavior while participating in the test. While test subjects may be experienced, they shall not behave in a prohibited manner. Prohibited behavior includes shifting of body weight and/or use of hands and/or feet to “propel oneself” along the slide surface in order to depart the end of the device.

5.5.4.2 Device Configuration and Installation.

5.5.4.2.1 The device shall be in its production-deliverable configuration with all required equipment installed.

5.5.4.2.2 The sliding surface of the device shall be dry and new (i.e. never having been subjected to persons or sand bags sliding on its surface prior to the tests).

5.5.4.2.3 The pressure in each and every chamber of the device shall be its nominal operating pressure.

5.5.4.2.4 The device shall be installed at its normal sill height and with its normal attachment means. If the device is intended for use at more than one exit pair, it shall be tested at the normal sill height for each exit pair.

5.5.4.2.5 The width of the exit through which the test subjects would pass before entering the device shall be representative of the airplane exit where the device will normally be attached and where the evacuees would normally enter the device. For devices not mounted at the exit sill, only the airplane structure which would control evacuee flow onto the device needs to be simulated.

5.5.4.3 Test Protocol. The following test protocol, which is applicable for single or multiple lane devices, shall be used:

5.5.4.3.1 The test subjects’ clothing which contacts the device surface shall be made of material with a coefficient of friction of at least 0.4 per ASTM Standard D1894-90 (typical of cotton or polyester/cotton blend).

5.5.4.3.2 Each test subject shall weigh at least 170 pounds.

5.5.4.3.3 For each lane of the device, three test subjects shall be seated “toboggan” style. The legs of the second and third person in each group shall straddle the person ahead. The first and second persons in the group shall grasp the legs of the person behind them.

5.5.4.3.4 The first person in the group should be located entirely on the downward portion of the device, i.e., he/she would slide if not holding onto the legs of the person behind. The second person in the group should be located either entirely on the downward portion of the device or at the transition point between the door sill or device ramp and the downward portion of the device. The third person should be on the door sill or device ramp, i.e., would not slide if not holding onto anything or being held by the legs by the second person in the group.

5.5.4.3.5 For each group, the distance from the front of the first test subject's torso to the back of the third test subject's torso shall not exceed 7.5 feet at the initiation of sliding by the third (last) person in the group.

5.5.4.3.6 At the test conductor's word "go", the test subjects in each lane will proceed down the slide together. For multiple lane devices, simultaneous push-off is required for all lanes, i.e., no more than a one-person offset is permissible among all lanes. Minor pushing off, particularly by the second and third persons in each group, is allowed to start the group sliding. Additional persons are allowed to gently push the last person in each group to start the sliding process.

5.5.4.3.7 After the third person in each group has started to slide, that person may signal the two others in the group to let go of the legs by yelling "OK" or "Let go."

5.5.4.3.8 Upon hearing that signal, the first two persons in the group should let go of the others' legs in order to provide freedom of movement for exiting the device and moving out of the way. After releasing the legs, the test subjects shall not engage in pushing, scooting or shifting of weight in order to exit the device. As soon as foot contact with the ground is made, the test subjects may stand immediately and move away quickly.

5.5.4.3.9 The first and second persons in the group are to stand and move away quickly when exiting the device to prevent blocking the person behind them.

5.5.4.3.10 As an alternative to paragraph 5.5.4.3.4, a delivery system can be used to convey the test subjects to the beginning of the down-slide portion of the device. See paragraph 5.5.1.2.2 through 5.5.1.2.4 for description of the delivery system.

#### 5.5.4.4 Success Criteria.

5.5.4.4.1 For the device to be deemed acceptable, the test must be completed successfully three consecutive times. (Tests which are aborted or considered non-tests, e.g., there is more than a one person offset between lanes during the start of a multiple lane device, do not count against the goal of three consecutive successful tests.)

5.5.4.4.2 The first two test subjects in each and every lane shall exit the end of the device with continuous motion. The third person should also exit the device with continuous motion, but may stay on the device if his/her motion was stopped by the person in front of him/her. Crossover of persons from one lane to another on a multiple lane device is acceptable; however, no more than one person may remain on the device in any lane.

5.5.4.4.3 The underside of the sliding surface shall not contact the ground at any time.

5.5.4.4.4 None of the test subjects shall perform prohibited movements (as described above).

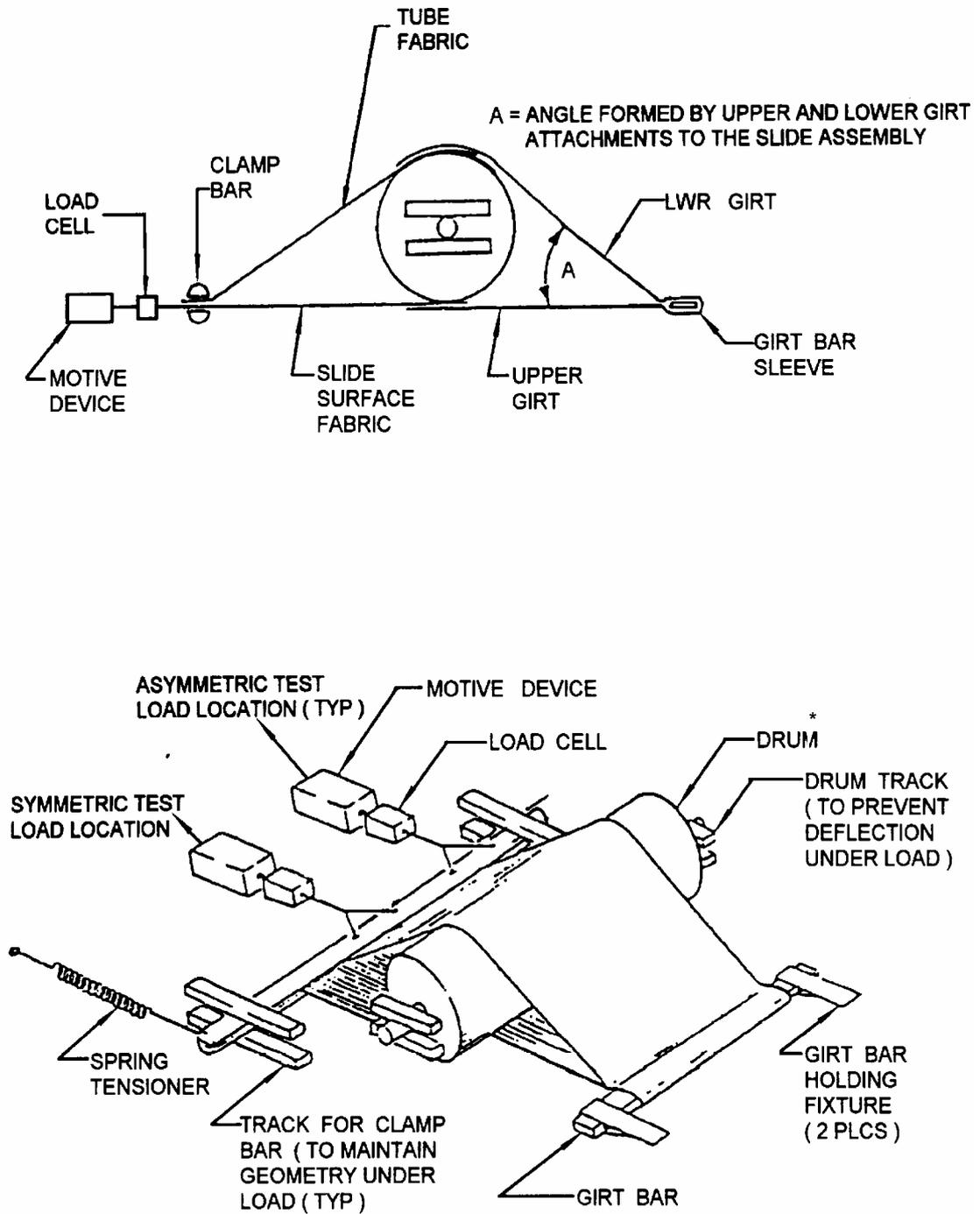
5.5.4.4.5 The device, without repair, shall meet the requirements of paragraph 4.10.1 of this appendix after being subjected to this test.

#### 5.6 Attachment Means Tests - Girt (See figure 6 of this appendix.).

5.6.1 Symmetric Girt Tensile Load Test. A representative production configuration girt including attachments to the device and the aircraft shall be installed to produce a symmetric load in a tensile test machine. The girt shall be attached on one end using the girt bar, or equivalent, and on the other end to the normal girt attachment means to the inflatable device. The slide fabric to which the girt attachment is bonded shall be fastened to a steel plate or around a cylinder designed to represent the inflatable to which the girt is attached (See figure 6 of this appendix). The girt shall be able to withstand a test load which is equal to the maximum expected in-use load

multiplied by a factor of 1.5 (as required by paragraph 4.8 of this appendix). The in-use load is a combination of all the loads acting on the girt attachments during any individual test run. The loads shall be established by instrumenting the girt attachment(s) to a test module simulating the aircraft fuselage and measuring the forces transmitted to the attachment(s) during deployment and use of the device. (The means for measuring the peak loads must be shown to be reliable, accurate, in calibration, and appropriate for the type of testing. If the means is a data acquisition system utilizing an analog-to-digital converter, see appendix 3 of this TSO for guidance.) The use conditions shall include, but not be limited to, those encountered in demonstrating compliance with the requirements of paragraphs 4.3.1, 4.10, 4.11, 4.12, 4.13, 4.20, 4.21, 4.22, 4.23, 4.28, 5.2.4 and 5.8 of this appendix. The test load shall be applied to the girt for 60 seconds. During the test, tearing of the girt is not acceptable. Deformation of the girt is acceptable if it would not prevent continued safe use of the device in an actual evacuation.

5.6.2 Asymmetric Girt Tensile Load Test. A representative production configuration girt shall be installed to produce an asymmetric load in a tensile test machine and an asymmetric load shall be applied. The girt shall be attached on one end using the girt bar, or equivalent, and on the other end to the normal girt attachment means to the inflatable device. The slide fabric to which the girt attachment is bonded shall be fastened to a steel plate designed to represent the inflatable to which the girt is attached (See figure 6 of this appendix). The girt shall be able to withstand a test load applied asymmetrically by pulling the steel plate away from the secured girt bar at a point even with the edge of the girt. The test shall be repeated for each side of the device girt. The test load(s) is equal to the maximum expected in-use load multiplied by a factor of 1.5 (as required by paragraph 4.8 of this appendix). The in-use load shall be established by instrumenting each girt attachment to the aircraft and measuring the forces transmitted to the attachment during deployment and use of the device. (The means for measuring the peak loads must be shown to be reliable, accurate, in calibration, and appropriate for the type of testing. If the means utilizes an analog to digital converter, see appendix 3 of this TSO for guidance.) The use conditions shall include, but not be limited to, those encountered in demonstrating compliance with the requirements of paragraphs 4.20, 4.21, 4.28, 5.2.4 and 5.8 of this appendix. The test load shall be applied to the edge of the girt for 60 seconds. During the test, tearing of the girt is not acceptable. Deformation of the girt is acceptable if it would not prevent continued safe use of the device in an actual evacuation.



\* DRUM SHALL RETAIN ITS SHAPE THROUGHOUT TEST LOADING AND SHALL BE OF SUFFICIENT DIAMETER TO ALLOW SIMULATION OF THE GIRT ATTACHMENT ANGLE, A.

Figure 6. Typical Girt Loading Test Set-Up

5.7 Attachment Means Tests - Other Than a Girt. When the attachment means is other than a girt, e.g., a number of narrow straps attached at different locations on the aircraft, only the straight tensile test is necessary for each of the straps. A representative production configuration of each of the straps, including its attachment to the device and to the airplane, shall be individually installed to produce a symmetric load in a tensile test machine. Each strap shall be able to withstand a test load which is equal to the maximum expected in-use load multiplied by a factor of 1.5 (as required by paragraph 4.8 of this appendix). The in-use load shall be established by instrumenting each strap attachment to a test module simulating the aircraft fuselage and measuring the forces transmitted to that attachment during deployment and use of the device. The use conditions shall include, but not be limited to, those encountered in demonstrating compliance with the requirements of paragraphs 4.3.1, 4.10, 4.11, 4.12, 4.13, 4.20, 4.21, 4.22, 4.23, 4.28, 5.2.4 and 5.8 of this appendix. The test load shall be applied to the strap for 60 seconds. During the test, tearing of the strap is not acceptable. Deformation of the strap is acceptable, if it would not prevent continued safe use of the device in an actual evacuation.

5.8 Attachment Means - Pontoon Loading Tests. If the device is equipped with outrigger pontoons (also known as sponsons) which can be inadvertently entered by evacuees during an emergency evacuation, the following test shall be conducted on each side:

5.8.1 The device shall be installed at normal sill height and inflated to the minimum value of the normal conditions pressure range.

5.8.2 Weights that represent 170 pound individuals shall be placed in the pontoon(s) at the bottom outside area on one side of the device. The number of individuals to be simulated shall be based on the length, in feet, of the occupiable portion of the pontoon divided by 4.5. Any remainder from the division may be discarded.

5.8.3 An evacuee group of twenty persons shall jump into the device at an average rate of 70 per minute (after the first jumper, the last 19 have 16 seconds to jump into the device). The evacuee group shall average at least 170 pounds per person. In the case of multi-lane devices, the evacuees will jump only into the lane adjacent to the loaded pontoon. The evacuees may be of any age, gender, and experience level.

5.8.4 To pass this test, the means of attachment to the aircraft shall not tear or rip, and no evacuee shall enter the pontoon area or fall off the device.

5.9 Hot & Cold Soak Test Protocol.

5.9.1 Stabilize the normally charged stored gas bottle to a temperature of  $70 \pm 5$  degrees F, then, for the cold test only, reduce the stored gas bottle pressure to the minimum dispatch pressure. As an alternate, the bottle may be charged directly to the minimum dispatch pressure for the cold test. However, for mixed-gas systems, the ratio of the gas mix must be maintained.

5.9.2 Thermally condition the device for at least 16 hours according to the following table:

<u>Condition</u>	<u>Temperature (degrees F)</u>
Hot Soak	=160 (for all devices)
Cold Soak	=-40 (for devices installed in the pressurized cabin)
Cold Soak	=-65 (for devices installed outside the pressurized cabin)

5.9.3 Deploy the device into ambient temperature conditions (typically defined as between 65 and 85 degrees F) from the appropriate airplane door or a suitable airplane door mock-up or module, within 10 minutes after removal from the conditioning chamber.

5.9.4 To be considered acceptable, the unit should deploy and inflate into a useable attitude and achieve minimum operating pressure in all inflation chambers but should not exceed the specified maximum operating pressure. The pressure reading should be taken as soon as possible but no later than one minute after deployment.

## APPENDIX 2. GLOSSARY OF TERMS

critical angle (with respect to buckling) – the angle which the device makes with the ground at which the maximum vertical load will be applied to the device by evacuees using it. The angle chosen should be sufficient to permit attaining an evacuation rate of one person per second per lane, but may not exceed 30 degrees from horizontal.

dark of night conditions - exterior lighting conditions in which the illumination measured normal to the direction of the incident light does not exceed 0.005 foot-candles.

girt - the typical means by which a device is attached to an airplane. It consists of a strong fabric wrapped around a girt bar which is usually installed at the sill of the exit. The girt may be attached to more than one of the device inflatable chambers.

high visibility color – international orange-yellow or a bright orange-yellow color similar to color numbers 28915 or 38903 of table X in Federal Standard 595, Colors.

maximum operating pressure - maximum pressure (in each/every chamber) that may be reached after the device has reached a usable attitude. Typically, this pressure is determined during the device developmental process when evaluating all test conditions.

maximum sill height - the maximum height above the ground of the exit sill with the collapse of one or more of the aircraft landing gear legs. Typically this is calculated using rational analysis.

minimum dispatch pressure - minimum actual pressure required in the inflation system for dispatch of the airplane. This inflation system pressure will inflate the device to at least minimum operating pressure under the cold soak conditions described in paragraph 5.9.2 of appendix 1 of this TSO.

minimum operating pressure - minimum pressure (in each/every chamber) at which the evacuation rate requirement of paragraph 4.10.1 of appendix 1 of this TSO can be met.

minimum raft mode operating pressure - minimum pressure required to meet the minimum design buoyancy requirements of paragraph 4.27.2 of appendix 1 of this TSO.

minimum sill height - lowest height above the ground of the exit sill with the collapse of one or more of the aircraft landing gear legs. Typically this is calculated using rational analysis.

most critical angle (wind) - the angle at which winds have the greatest adverse effect upon the device's ability to convey evacuees safely to the ground, e.g., where there is the greatest lateral and/or torsional displacement or buckling.

nominal operating pressure - the mid-point of the normal conditions pressure range.

normal conditions pressure range - the range of pressures attained during typical deployments conducted in accordance with paragraph 5b(1) of this TSO. The lower limit must not be lower than the minimum operating pressure. The upper limit must not be more than the maximum operating pressure.

normal sill height - the height of the exit sill above the ground with all aircraft landing gear extended.

### **APPENDIX 3. MEASUREMENT OF LOADS ON THE ATTACHMENT(S) TO THE AIRPLANE**

Data acquisition systems which utilize an analog-to-digital (A/D) converter to process the electronic signals from load cells must be configured to accurately record loads during a test. The following parameters are recommended for recording with an A/D converter system:

1. Sample Rate                      20 Hz minimum
2. Resolution                        12 bits minimum
3. Anti-aliasing pre-filter        5 Hz low pass (0 to -4 dB at 5 HZ),  
   -20 dB/decade rolloff at frequencies above 10 Hz

The signal amplifier should provide sufficient gain so that the expected full-scale, or highest anticipated value to be recorded, is at least 70 percent of the maximum input range of the analog-to-digital converter (A/D). No post acquisition digital filter, smoothing, or averaging algorithm may be applied to the data.

#### APPENDIX 4. CALORIMETER SPECIFICATION AND CALIBRATION PROCEDURE

1. **Scope.** This procedure shall be used to calibrate all circular foil heat flux transducers (Gardon gauges). Calibration establishes the value of this product to the user.
2. **Terminology.** For definitions of general terms, refer to ASTM Standard C168. Definitions specific to this procedure are:
  - a. Sensor Scale Factor – the ratio between the incident heat flux and the transducer output signal produced at the heat flux, expressed in W/cm<sup>2</sup>/mV or BTU/ft<sup>2</sup>-sec/mV.
  - b. Sensor Sensitivity – the ratio between the transducer output signal and the incident heat flux, expressed in mV/W/cm<sup>2</sup> or mV/BTU/ft<sup>2</sup>-sec.
  - c. Calibrated Heat Flux Level – the maximum heat flux reached during the calibration cycle.
  - d. Calibration Standard Scale Factor – the sensor scale factor for the reference standard transducer used in calibration, expressed in W/cm<sup>2</sup>/mV or BTU/ft<sup>2</sup>-sec/mV.
  - e. Emissivity – the ratio between total radiant energy absorbed by a plane surface and total radiant energy incident on that surface, expressed as a value between 0.0 and 1.0.
3. **Calorimeter Specifications.**
  - a. One inch diameter, cylindrical, water-cooled, Gardon gauge.
  - b. Calibration range approximately 0 - 5 watts.
  - c. Foil diameter shall be 0.25 in. +/- 0.005.
  - d. Foil thickness shall be 0.0005 in. +/- 0.0001.
  - e. Foil material shall be thermocouple grade constantan.
  - f. Temperature measurement shall be a copper-constantan thermocouple.
  - g. Copper center wire diameter of 0.0005 in. +/- 0.0001.
  - h. The entire face of the calorimeter shall be lightly coated with high temperature paint having an emissivity of 0.94 or higher.
4. **Equipment and Supplies.** Calibrations shall be performed using a 50 kW flat plate heater furnace. The furnace shall be equipped with transducer mountings, water cooling lines and an exhaust system of sufficient capacity to remove the heat of calibrations at 50 kW input power to the plate. The heater shall be a graphite plate 0.125"±0.0625 thick, and 1.50" minimum width by 1.50" minimum length. Electric current shall be conducted through the longest dimension of the plate. An X-Y recorder with adjustable gains that has been calibrated against NIST standards shall be mounted on a shelf on the front of the furnace. A reference transducer of approximately the same full scale range as the test transducer shall be prepared and calibrated against a NIST calibrated transducer. The coating on the surface of the reference transducer shall be high temperature paint, applied and cured according to the standard coating procedure for an emissivity of 0.94 or higher.
5. **Preparations for Calibration.** The flat plate heater shall be prepared for calibrations as follows:
  - a. pyrolytic graphite transitions shall be attached to both ends of the flat plate heater with rubber cement and the heater shall be centered and clamped evenly in the furnace;
  - b. the exhaust fan shall be turned on;
  - c. the heater shall be gradually heated electrically until all rubber cement burns away and a good bond is achieved at both ends;
  - d. the heater shall be energized with sufficient electric current to produce a dull red heat; and

- e. uniformity of the flat plate temperature from side to side and top to bottom shall be observed on both sides.

If the flat plate temperature is non-uniform, clamping forces shall be adjusted and, if necessary the transitions reattached to achieve uniformity. The reference transducer shall be mounted on one side of the flat plate heater, centered over the face of the heater and 1/8" to 3/8" from the heater surface. The distance shall be set with a thickness gauge. Water cooling lines shall be connected. The test transducer shall be coated with high temperature paint cured for an emissivity of 0.94 or higher. It shall be mounted on the other side of the flat plate heater, centered over the face of the heater and an equal distance from the heater surface. The distance shall be verified with the same thickness gauge. Water cooling lines shall be connected. The water supply system shall be leak tested and reconnected if necessary. The output signal of the reference transducer shall be connected to the Y-axis input of the X-Y recorder. The output signal of the test transducer shall be connected to the X-axis input. Recorder gains shall both be set to 1.00.

#### 6. Calibration Procedure.

- a. A fresh sheet of graph paper shall be mounted in the X-Y recorder. X and Y zeros shall be adjusted. The cooling water pump shall be turned on, but not the exhaust fan.
- b. If the full scale range of the test transducer is 50 BTU/ft<sup>2</sup>-sec or less, the potentiometer control of the furnace shall be adjusted to approximately 150 percent of the full scale heat flux value for the test transducer. After a few seconds to stabilize temperatures, the pen shall be dropped on the recorder, and the heat flux gradually reduced to zero. A straight line trace from the upper right quadrant of the graph to the zero for both X and Y should be recorded.
- c. If the full scale range of the test transducer is greater than 50 BTU/ft<sup>2</sup>-sec the recorder pen shall be dropped and then the control of the furnace shall be slowly adjusted to approximately 150 percent of the full scale value for the test transducer. After this the pen shall be lifted and the furnace control quickly reduced to zero. A straight line trace from the zero for both X and Y to the upper right quadrant should be recorded.

#### 7. Analysis.

- a. The analysis will relate the sensitivity and scale factor of the test transducer to those of the reference transducer, based on the slope of the graph recorded in step 6.
- b. A straight line shall be drawn from X=0, Y=0 on the graph to fit the recorded trace. If this line intercepts the right-hand edge of the graph, the test transducer scale factor shall be calculated by multiplying the intercept by the reference transducer scale factor. If the line intercepts the top edge of the graph, the test transducer scale factor shall be calculated by multiplying the reference transducer scale factor by 7 (the graph is 7 units high) and dividing that result by the intercept.
- c. The test transducer sensitivity shall be obtained by inverting the test transducer scale factor.
- d. The maximum heat flux level used in calibration shall be calculated from the X-axis excursion on the graph. The scale factor of the reference transducer shall also be recorded. The reference transducer measures incident heat flux, so the calibration will always be in terms of incident heat flux.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** AIRBORNE STATIC („DC TO DC“) ELECTRICAL POWER CONVERTER (FOR AIR CARRIER AIRCRAFT)

### **1 - Applicability**

This ETSO gives the requirements which airborne static („DC to DC“) electrical power converters that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the attached FAA Standard for „Airborne Static („DC to DC“) Electrical Power Converter“, dated April 15, 1961.

##### 3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1.

##### 3.1.3 – Computer Software

None

#### 3.2 - Specific

None

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

April 15,1961

**FAA STANDARD  
FOR  
AIRBORNE STATIC („DC TO DC“) ELECTRICAL POWER CONVERTER  
INTRODUCTION**

This paper sets forth the minimum performance standards for airborne static („DC to DC“) electrical power converter equipment then used as a part of a navigation or communication system.

Compliance with these standards is required as a means of assuring that the equipment will satisfactorily perform its intended function under

all conditions normally encountered in routine aeronautical operations.

Inasmuch as the measured values of a radio equipment performance characteristics may be a function of the method of measurement, standard test conditions and methods of test are also recommended in this paper.

**MINIMUM PERFORMANCE STANDARDS  
FOR  
AIRBORNE STATIC („DC TO DC“) ELECTRICAL POWER CONVERTER**

**1.0 GENERAL STANDARDS**

**1.1 Ratings of Components**

The equipment shall not incorporate its design any component of such rating that, when the equipment is operated throughout the range of the specified environmental test, the ratings established by the manufacturer of the component is exceeded.

**1.2 Effects of Test**

The design of the equipment shall be such that the application of the specified test produces no discernable condition which would be detrimental to the reliability of equipment manufactured in accordance with such design.

**2.0 MINIMUM PERFORMANCE STANDARDS UNDER STANDARD TEST CONDITIONS**

The test procedures applicable to a determination of the performances of the airborne static („DC to DC“) electrical power converter equipment are set forth in Appendix „A“ of this paper.

**2.1 Nominal Output Voltage and Current**

The nominal output voltage and current shall not be less than that specified by the manufacturer's ratings. Further, the equipment shall be capable of delivering at least 10% more output power than the manufacturers specified rating for a period of two (2) hours.

**2.2 Regulation**

Regulation under standard conditions shall not exceed 12%. For the purpose of this standard, regulation is defined as:

$$\% \text{ Reg} = \frac{(\text{Voltage at 20\% of load}) - (\text{Voltage at maximum rated load})}{\text{Voltage at maximum rated load}} \times (100\%)$$

**2.3 Ripple**

Ripple in the output DC voltage at maximum rated output load shall not exceed 1/10% of the output voltage when shunted by a 2 mfd capacitor and the ripple on the DC input leads is equal to 2 volts peak to peak at a frequency of 400 cps. For equipment designed for operation on 13.75 volts DC, the ripple on the input leads need not exceed 1 volt peak to peak.

**2.4 Over Voltage**

There shall be no permanent damage to any of the solid state devices (transistors) or the components when the power converter is delivering full rated output power and is subjected to the following over voltage conditions:

- (a) The input DC voltage is increased to 50% above the standard operating voltage for a duration of not less than five minutes.

**2.5 Short Circuit Conditions**

There shall be no degradation of the power converter or its components as a result of a sustained short circuit applied separately to each

## FAA Standard associated with ETSO-C71

April 15,1961

output of a multiple output power converter, or simultaneously to all DC outputs for a period of not less than one minute. Within five minutes after removal of the short circuit condition, the equipment shall be capable of continuous operation at the manufacturer's rated output load for a period of eight hours without, degradation of performance.

### 2.6 Emission of Radio Frequency Energy

The emission of radio frequency energy at discreet frequencies within the range of 90 kc to 1500 Mc shall not exceed 200 microvolts between any cable terminal to ground.

*Note:* It is recognized that the radio frequency emissions having a level considerably less than the maximum permitted by the above standard are capable of interfering with the operation of other electronic equipment in an aircraft installation. It is also recognized that the method of reducing the level of emission of radio frequency energy to much lower values are known. However, at the present state of the art, large and expensive filters are often required in addition to the exercise of care in the mechanical and electrical design of equipment. The end result is often a compromise between what is desired and cost.

In view of the above, the emission standards were set at a level which can be met by the exercise of reasonable care in design and yet effect the reduction in the present overall interference problem. Lower emission levels are desirable and it is, therefore, recommended that the equipment manufacturers make a determined effort to reduce the level of emission from electronic equipment, to the lowest practicable value below that specified above.

### 2.7 Dielectric Strength

The equipment shall withstand without evidence of damage the application of a sinusoidal voltage between each transformer output winding and frame for a period of five seconds. The RMS value of the sinusoidal voltage applied shall be either five times the maximum operating voltage existing across that winding during operation when delivering full rated output, or 500 volts, whichever is greater. During the application of this test, all diodes, transistors, and capacitors may be disconnected.

### 3.0 MINIMUM PERFORMANCE STANDARDS UNDER ENVIRONMENTAL TEST CONDITIONS

The test procedure applicable to a determination of the performance of radio equipment under environmental test conditions are set, forth in RTCA Paper 100-54/D0-60, „Environmental Test Procedures -Airborne Radio Equipment,“ and amendment Paper 256-58/ EC-366 dated November 13, 1958. This paper outlines environmental test procedures for equipment designed to operate under three environmental test conditions as specified therein under Procedures A, B, and C. Only airborne static („DC to DC') electrical power converter equipment which meets the operating requirements outlined under Procedure A or Procedure B of this paper, as amended, is applicable under this standard.

The applicable electrical test procedures are set forth in Appendix „A“ of this standard.

#### 3.1 Low Temperature Test

When the equipment is subjected to the low temperature test and, with primary power voltage 10% less than standard test voltage applied, the following requirements shall be met:

- (a) The output voltage shall not vary more than 12½% from that obtained at standard test conditions.
- (b) The requirements of paragraph 2.3 shall be met.

#### 3.2 Altitude Test

When the equipment is subjected to the altitude test, the requirements of paragraphs 2.1, 2.2, and 2.3 shall be met.

#### 3.3 Humidity Test

After subjection to humidity and within fifteen (15) minutes from the time primary power is applied, the requirements of 2.1, 2.2, and 2.3 shall be met.

#### 3.4 High Temperature Test

When the equipment is subjected to the high temperature test and with primary power voltage 10% higher than standard test voltage applied, the following requirements shall be met:

- (a) The output voltage shall not vary more than 12½% from that obtained at standard test conditions.
- (b) The requirements of paragraphs 2.1, 2.2, and 2.3 shall be met.

## FAA Standard associated with ETSO-C71

April 15,1961

### 3.5 *Temperature Variation Test*

When the equipment is subjected to the temperature variation tests, the requirements of paragraphs 2.2 and 2.3 shall be met.

### 3.6 *Vibration Test*

When the equipment is subjected to the vibration test, the requirements of paragraphs 2.2 and 2.3 shall be met.

### 3.7 *Shock Test*

(a) Following the application of 15 G shocks, the requirements of paragraphs 2.2 and 2.3 shall be met.

(b) Following the application of 30 G shocks, the power converter shall have remained in its mounting by its intended means and no parts of the equipment or its mounting shall have become detached and free from the equipment.\*

### 3.8 *Low Voltage Test*

(a) When the primary power voltage(s) is 80% of the standard test, voltage(s), the equipment shall operate electrically.

(b) Gradual reduction of the primary voltage(s) from 80% to 50% of standard test voltage(s) shall produce no condition detrimental to the reliability of the equipment.

(c) Gradual reduction of the primary power voltage(s) from 50% to 0%, of standard test, voltage(s) shall produce no evidence external to the equipment of the presence of fire or smoke.\*

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\*Test tests may be conducted after other tests are completed.

April 15,1961

## APPENDIX A

### TEST PROCEDURES

#### AIRBORNE STATIC („DC TO DC“) ELECTRICAL POWER CONVERTER

**A. Power Input Voltage** Unless otherwise specified, all tests shall be conducted with the power input voltage adjusted to the design voltage within  $\pm 2\%$ . The input voltage shall be measured at the power converter input terminals.

*Note:* Design voltages in use as of the date of this report are 13.75 VDC and 27.5 VDC and defined as standard condition.

**B. Adjustment of Equipment.** The equipment under test shall be properly adjusted in accordance with the manufacturer's recommended practices prior to the application of the specified tests.

**C. Test Equipment Precautions.** Due precautions shall be taken during the conduct of these tests to prevent the introduction of error resulting from the improper connection of voltmeters, oscilloscopes and other test instruments across the input and output impedances of the equipment under test.

**D. Ambient Conditions.** Unless otherwise specified, all its shall be conducted under conditions of ambient room temperature, pressure and humidity. However, the room temperature shall not be lower than 10° C.

**E. Warm-up Period.** Unless otherwise specified, all tests shall be conducted after a warm-up period of not less than fifteen (15) minutes.

**F. Connected Loads.** Unless otherwise specified, all tests shall be performed with the equipment connected to loads having the impedance value for which it is desired.

#### TEST PROCEDURES

The test procedures set forth below are satisfactory for use in determining the performance of airborne static („DC to DC“) electrical power converter equipment. Test procedure's which provide equivalent information may also be used.

#### **T-1 Power Output**

##### EQUIPMENT REQUIRED

*Voltmeter* – Weston Model 931 or equivalent.

*Ammeter* – Weston Model 931 or equivalent.

##### MEASUREMENT PROCEDURE

Connect the power converter to the appropriate input power source with the ammeter in series with the output and the voltmeter connected across the output. The manufacturer's specified load shall be connected across the output(s). The output load impedance should be adjusted to the manufacturer's specified rating.

Determine that the nominal output voltage and current is at least that specified by the manufacturer and that the equipment is capable of delivering at least 10% more output power than the manufacturer's specified rating for a period of two (2) hours.

#### **T-2 Regulation**

##### EQUIPMENT REQUIRED

*Voltmeter* – Weston Model 931 or equivalent.

*Ammeter* – Weston Model 931 or equivalent.

##### MEASUREMENT PROCEDURE

Connect the power converter to the appropriate input power source with the ammeter in series with the output and the voltmeter connected across the output. The manufacturer's rated load should be connected across the output(s).

Vary the load impedance from maximum rated load to 20% of maximum rated load and note the output voltage(s) at these two load settings. Calculate the percent regulation using the formula specified in paragraph 2.2.

#### **T-3 Ripple**

##### EQUIPMENT REQUIRED

Hewlett Packard Oscilloscope Model 150A or equivalent.

##### MEASUREMENT PROCEDURE

Connect the power converter to the appropriate input power source with the power

## FAA Standard associated with ETSO-C71

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converter delivering maximum rated load. Also connect a two (2) microfarad capacitor of the proper DC working voltage across the output under test.

Using the oscilloscope as a peak to peak voltage indicating device, measure the ripple on the output power source and all output voltage(s) when ripple on the DC input leads is equal to 2 volts peak to peak at a frequency of 400 cps or 1 volt peak to peak, whichever is applicable.

### ***T-4 Overvoltage***

#### **EQUIPMENT REQUIRED**

Perkins Power Supply Model MR 1040-30A or equivalent.

#### **MEASUREMENT PROCEDURE**

(a) Connect the equipment to the Perkins Model MR 1040-30A power supply with the equipment delivering full rated output power. Increase the output voltage from the Model MR 1040-30A power supply to 50% greater than the input voltage for which the equipment is designed for a duration of five (5) minutes.

(b) Following this, determine that the output voltage and current is the same as that prior to the application of the overvoltage.

### ***T5 Short Circuit Conditions***

#### **EQUIPMENT REQUIRED**

*Voltmeter* – Weston Model 931 or equivalent.

*Ammeter* – Weston Model 931 or equivalent.

#### **MEASUREMENT PROCEDURE**

With the power converter connected to the appropriate input power source and the equipment delivering full rated output power, apply a sustained short circuit separately to each output of multiple output power converters or simultaneously to all DC outputs for a period of not less than one (1) minute.

Following this, determine that the equipment is capable of delivering the manufacturer's rated output power for a period of at least eight (8) hours.

This test shall be conducted after the overvoltage test specified in *T-4, Overvoltage*, is completed.

### ***T-6 Emission of Radio Frequency Energy***

#### **EQUIPMENT REQUIRED**

Noise and Field Strength Meters as follows:

Stoddard models NM-20B, NM-5A, AM-10A, and NM-50A or equivalent.

#### **MEASUREMENT PROCEDURE**

Connect the power converter to the appropriate input power source with the equipment delivering full rated output power. The input power leads shall be from 10 to 12 feet in length, normally terminated and cabled, and shall not be enclosed in conduit.

With the noise meter, measure the rf voltage developed between ground and each of the primary input and power output leads, tuning the noise meter throughout the range of frequencies from 90 kc to 1500 Mc.

### ***T-7 Dielectric Strength***

#### **EQUIPMENT REQUIRED**

Variable AC power source.

#### **MEASUREMENT PROCEDURE**

(a) Apply an a-c voltage, at the frequency used in normal operation, between each transformer output winding and frame for a period of five (5) seconds. The RMS value of the sinusoidal voltage applied shall be either five (5) times the maximum operating voltage existing across that winding during operation voltage delivering full rated output, or 500 volts, whichever is greater.

(b) Following this, determine that the output voltage and current under full load conditions is the same as that prior to the application of the tests.

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** INDIVIDUAL FLOTATION DEVICES

### 1 - Applicability

This ETSO gives the requirements which individual flotation devices that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### 2 - Procedures

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### 3 - Technical Conditions

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the attached Federal Aviation Administration Standard „Individual Flotation Devices“.

Where applicable, instead of the referenced FAA documents/paragraph the corresponding IR, CS or ETSO document/paragraph shall be used, when available.

##### 3.1.2 - Environmental Standard

As given in the FAA Standard.

##### 3.1.3 – Computer Software

None

#### 3.2 - Specific

None

### 4 - Marking

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### 5 - Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.

FEDERAL AVIATION ADMINISTRATION STANDARD  
Individual Flotation Devices

1.0 Purpose.

To specify minimum performance standards for individual flotation devices other than life preservers defined in the TSO-C13 Series.

2.0 Types and Description of Devices.

This standard provides for the following two categories of individual flotation devices:

- a. Inflatable types (compressed gas inflation).
- b. Noninflatable types.

2.0.1 Description of Inflatable Types. Inflation must be accomplished by release of a compressed gas contained in a cartridge into the inflation chamber. The cartridge must be activated by a means readily accessible and clearly marked for its intended purpose. The flotation chamber must also be capable of oral inflation in the event of failure of the gas cartridge.

2.0.2 Description of Noninflatable Types. Seat cushions, head rests, arm rests, pillows, or similar aircraft equipment are eligible as flotation devices under this standard provided they fulfil minimum requirements for safety and performance. Compression through extended service use, perspiration and periodic cleaning must not reduce the buoyancy characteristics of these devices below the minimum level prescribed in this standard.

2.1 Instructions for Use. Where the design features of the device relative to its purpose and proper use are not obvious to the user, clear instructions must be visible under conditions of emergency lighting.

3.0 Definitions.

The following are definitions of terms used throughout the standard:

- a. Buoyancy. The amount of weight a device can support in fresh water at 85° F.
- b. Flame Resistant. Not susceptible to combustion to the point of propagating a flame beyond safe limits after the ignition source is removed.
- c. Corrosion Resistant. Not subject to deterioration or loss of strength as a result of prolonged exposure to a humid atmosphere.

4.0 General Requirements.

4.0.1 Materials and Processes. Materials used in the finished product must be of the quality which experience and tests have demonstrated to be suitable for the use intended throughout the service life of the device. The materials and process must conform to specifications selected or prepared by the manufacturer which will insure that the performance strength and durability incorporated in the prototype are continued or exceeded in subsequently produced articles.

4.0.2 Fungus Protection. Materials used in the finished product must contain no nutrient which will support fungus growth unless such materials are suitably treated to prevent such growth.

4.0.3 Corrosion Protection. Metallic parts exposed to the atmosphere must be corrosion resistant or protected against corrosion.

4.0.4 Fire Protection. If the device is not used as part of a seat or berth, materials used in the device, including any covering, must meet Paragraph 6.0.2 of this standard. If the device is to be used as part of a seat or berth, all materials used in the device must meet Paragraph 7.0.3 of this standard.

4.0.5 Temperature Range. Materials used in the construction of the device must be suitable for the intended purpose following extended exposures through a range of operating temperatures from -40° F. to +140° F.

#### 4.1 Design and Construction.

4.1.1 General. The design of the device, the inflation means if provided, and straps or other accessories provided for the purpose of donning by the user must be simple and obvious thereby making its purpose and actual use immediately evident to the user.

4.1.2 Miscellaneous Design Features. The devices must be adaptable for children as well as adults. The devices must have features which enable the users to retain them when jumping into water from a height of at least 5 feet. Attachment straps must not pass between the user's leg for retention or restrict breathing or blood circulation.

#### 5.0 Performance Characteristics.

5.0.1 Buoyancy Standard. The device must be shown by the tests specified in paragraph 7.0.1 to be capable of providing not less than 14 pounds of buoyancy in fresh water at 85° F. for a period of 8 hours.

5.0.2 Utilization. The device must be capable of being utilized by the intended user with ease.

5.0.3 Function Under Temperature Limits. The device must function from -40° F. to +140° F.

#### 6.0 Standard Tests.

6.0.1 Salt Spray Test Solution. The salt used must be sodium chloride or equivalent containing on the dry basis not more than 0.1 percent of sodium iodide and not more than 0.2 percent of impurities. The solution must be prepared by dissolving  $20 \pm 2$  parts by weight of salt in 80 parts by weight of distilled or other water containing not more than 200 parts per million of total solids. The solution must be kept free from iron solids by filtration decantation, or any other suitable means. The solution must be adjusted to be maintained at a specific gravity of from 1.126 to 1.157 and a PH of between 6.5 and 7.2 when measured at a temperature in the exposure zone maintained at 95° F.

6.0.2 Flame Resistance. Except for devices required to be tested in accordance with 7.0.3 the following applies: Three specimens approximately 4 inches wide and 14 inches long must be tested. Each specimen must be clamped in a metal frame so that the two long edges and one end are held securely. The frame must be such that the exposed area of the specimen is at least 2 inches wide and 13 inches long with the free end at least 1/2 inch from the end of the frame for ignition purposes. In case of fabrics, the direction of the weave corresponding to the most critical burn rate must be parallel to the 14-inch dimension. A minimum of 10 inches of the specimen must be used for timing purposes, and approximately 1 1/2 inches must burn before the burning front reaches the timing zone. The specimen must be long enough so that the timing is stopped at least 1 inch before the burning front reaches the end of the exposed area.

The specimens must be supported horizontally and tested in draft free conditions. The surface that will be exposed when installed in the aircraft must face down for the test. The specimens must be ignited by the Bunsen or Tirrell burner. To be acceptable, the average burn rate of the 3 specimens must not exceed 4 inches per minute. Alternatively, if the specimens do not support combustion after the ignition flame is applied for 15 seconds or if the flame extinguishes itself and any subsequent burning without a flame does not extend into the undamaged areas, the material is also acceptable.

## 7.0 Test Requirements.

7.0.1 Buoyancy Testing. The flotation device, including all dress covers, fire blocking layer (if used) and straps that would normally be used by a survivor in an emergency, must be tested in accordance with either sub-paragraph (a) or (b) of this paragraph, as applicable, or an equivalent test procedure. The test may be conducted using nonfresh water, or at a temperature other than 85° F., or both, provided the result can be converted to the standard water condition specified in Paragraph 5.0.1. The test may be conducted in open (ocean or lake) or restricted (swimming pool) water. The test specimen of noninflatable devices, such as pillows or seat cushions, must either be preconditioned to simulate any detrimental effects on buoyancy resulting from extended service or an increment must be added to buoyancy standard in Paragraph 5.0.1 sufficient of offset any reduction in buoyancy which would result from extended service use.

a. Test Procedures Applicable to Inflatable Device and to Noninflatable Devices made from Closed Cell Material. The device must be tested by submerging it in water so that no part of it is less than 24 inches below the surface. It must be shown that the buoyancy of the device is at least equal to the value specified in paragraph 5.0.1 after submersion for at least 8 hours, except that the test may be discontinued in less than 8 hours if buoyancy measurements taken at 4 successive 30 minutes intervals show that the buoyancy of the device has stabilized at a value at least equal to the value specified in Paragraph 5.0.1.

b. Test Procedure Applicable to Noninflatable Devices made from Cell Material. The device must be completely submerged and must either support a human subject or be attached to a mechanical apparatus that simulates the movements characteristic of a nonswimmer. During the test, the device must be subjected to a squeezing action comparable to that caused by the movements characteristic of a nonswimmer. It must be shown that the buoyancy of the device is at least equal to the value specified in Paragraph 5.0.1 after testing for at least 8 hours, except that the test may be discontinued in less than 8 hours if the buoyancy measurements taken at 4 successive 30-minute intervals show that the buoyancy of the device has stabilized at a value at least equal to the value specified in Paragraph 5.0.1.

7.0.2 Salt Spray Testing. All metallic operating parts must be placed in an enclosed chamber and sprayed with an atomized salt solution for a period of 24 hours. The solution must be atomized in the chamber at a rate of 3 quarts per 10 cubic feet of chamber volume per 24-hour period. At the end of the test period, it must be demonstrated that the parts operate properly.

7.0.3 Test for Fire Protection of Materials. Materials used in flotation devices that are to be used as part of a transport category aircraft seat or berth must comply with the self-extinguishing fire protection provisions of § 25.853(b) of FAR Part 25. In all other applications, the materials in the flotation devices must be tested in accordance with Paragraph 6.0.2 of this standard to substantiate adequate flame resistant properties.

7.0.3.1 Test for Fire Blocking of Seat Cushions. Tests must be conducted in accordance with Appendix F, Part II of FAR Part 25.

7.0.4 Extreme Temperature Testing. Tests must be performed to demonstrate that the device is operable throughout the temperature range specified in Paragraph 5.0.3. In performing these tests, preconditioning of test specimens must be accomplished to simulate conditions of immediate use of the device following an aircraft takeoff.

Note: An acceptable procedure for preconditioning may involve storage of the device for 8 hours at the extreme temperatures specified, followed by exposure to room temperature conditions for a period of time not to exceed 10 minutes.

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** STATIC ELECTRICAL POWER INVERTER

### **1 - Applicability**

This ETSO gives the requirements which static electrical power inverters that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the attached Federal Aviation Administration Standard, „Airborne Static Electrical Power Inverters“ dated July 25, 1963.

##### 3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1.

##### 3.1.3 - Computer Software

None

#### 3.2 - Specific

None

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2; in addition to the markings required by this paragraph, the instrument must be marked to indicate:

- rated terminal voltage, frequency and number of phases
- rated power in volts amperes
- output load power factor
- maximum operating altitude.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

**FAA Standard associated with ETSO-C73**

FEDERAL AVIATION AGENCY  
WASHINGTON, D.C.

**MINIMUM PERFORMANCE STANDARDS FOR  
AIRBORNE STATIC ELECTRICAL POWER INVERTERS**

JULY 25, 1963

# FAA Standard associated with ETSO-C73

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MINIMUM PERFORMANCE STANDARDS FOR  
AIRBORNE STATIC ELECTRICAL POWER INVERTERS

**1.0 GENERAL STANDARDS**

1.1 *Purpose:* To specify the minimum requirements for airborne static electrical power inverters.

1.2 *Scope:* This standard provides the minimum performance criteria under environmental test conditions for static electrical power inverters intended to be used as a source of continuous or emergency alternating current power.

1.3 *Types of Inverters:* This standard applies to static electrical power inverters with a nominal input of 28 volts d.c. and an output of 115 volts, 400 cycles per second.

1.4 *Definitions:* The following are definitions of terms used throughout this standard:

a. Static electrical power inverter - An equipment made of solid state electrical components which produces an alternating current from a direct current source.

1.5 *Ratings of Components.* The equipment shall not incorporate in its design any components of such rating that when the equipment is operated throughout the range of the specified test, the ratings established by the manufacturer of the component are exceeded.

1.6 *Proof of Reliability.* The design of the equipment shall be such that the application of the specified test produces no condition which would be detrimental to the reliability of equipment manufactured in accordance with such design.

**2.0 REQUIRED PERFORMANCE UNDER ENVIRONMENTAL TEST CONDITIONS**

The environmental test procedures applicable to a determination of the performance of the airborne static electrical power inverter are set forth in Appendix A of this standard.

2.1 *Power Output:* With rated input voltage, the power output shall not be less than that specified in the manufacturer's rating. In specifying the equipment rating the manufacturer shall establish the following:

- a. Minimum output load power factor.
- b. Any special temperature control requirements.
- c. Conditions of electrical loading including tolerance limits.

The inverter shall be capable of delivering at least 10 percent more output than the specified rating for a period of two hours without damage.

The inverter under the conditions of paragraph 2.2b. shall deliver 90 percent of the rated load for a period of 5 minutes.

2.2 *Voltage Input:* The rated input voltage, as measured at the inverter input terminals, shall be 28 volts d.c. The inverter shall:

a. Be capable of continuous operation under full load without degradation of performance over an input voltage range of  $\pm 2$  volts.

b. Operate electrically at an input voltage of 20 volts.

c. Withstand, without damage, input voltage transients of 88 volts for a time period of 1 millisecond.

NOTE : For complex electrical systems the specified transient overvoltage can rise to much higher values over the time period of 1 millisecond or longer. For such applications conservative values of transient overvoltage are recommended.

2.3 *Frequency:* The frequency of the inverter under all conditions of load and test environment shall be 400 cycles per second  $\pm 1$  percent at the input voltages specified in 2.2a. and 2.2b.

2.4 *Voltage Output:* The average phase output voltage, under the conditions of input specified in 2.2a. and 2.2b. and under all conditions of test environment, shall be 115 volts a.c. +5 percent -7 percent

2.5 *Waveform:* The output waveform shall be substantially sinusoidal and contain less than 7 percent harmonic distortion under all load conditions not exceeding 110 percent rated output

2.6 *Phase Balance:* Output phase voltages, for three phase units, shall not be unbalanced by more than  $\pm 5$  percent when applied to balanced loads within a power factor range of 0.80. Displacement between phases shall be within the limits of  $120^\circ \pm 5^\circ$ .

2.7 *Overload Capacity:* The inverter shall be capable of withstanding, without damage, a current overload of at least 150 percent for a time duration of 5 minutes.

2.8 *Input Overvoltage:* The inverter shall be capable of withstanding, without damage, input overvoltage up to 130 percent of the rated input voltage for a time period of 5 minutes while supplying full rated output power.

2.9 *Short Circuit Conditions:* The inverter shall be capable of withstanding, without damage, an output short circuit applied separately to each phase or simultaneously to all phases for a time period of one minute. Within 5 minutes after removal of the short circuit condition, the unit shall be energized and run continuously for a period of at least 20 hours. During this period the unit shall, without degradation of performance, deliver the specified output.

2.10 *Dielectric Strength:* The equipment shall withstand, without damage, the application of 1,500 volts r.m.s. 60 cycles between windings and between each winding and frame for a time period of 1 minute.

NOTE : If this method of testing is not feasible, dielectric tests may be conducted on components prior to

## FAA Standard associated with ETSO-C73

final assembly or with the critical components disconnected.

2.11 *Altitude:* The inverter shall provide continuous rated power, voltage, and frequency at the maximum declared operating altitude for a period of 24 hours. Inverters intended for locations in pressurized cabin areas also shall provide rated performance at an altitude of 40,000 ft. for a time period of two minutes without damage.

a. For inverters intended to be installed in pressurized areas, the minimum acceptable declared operating altitude is 10,000 feet.

b. For inverters intended to be installed in unpressurized areas, the minimum acceptable declared operating altitude is 30,000 feet.

2.12 *Emission of Spurious Radio Frequency Energy:* The levels of conducted and radiated spurious radio frequency energy emitted by the inverter shall not exceed those levels specified in Appendix A of RTCA Paper 120-61/DO-108-Environmental Test Procedures-Airborne Electronic Equipment dated July 13, 1961, for Category A equipment.<sup>1</sup>

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<sup>1</sup>Copies of this paper may be obtained from the RTCA Secretariat, 'Room 1072, T-5 Building 16th and Constitution Avenue, N.W., Washington, D.C., at a cost of 75 cents per copy.

## APPENDIX a

### ENVIRONMENTAL TEST PROCEDURES: ELECTRICAL EQUIPMENT ELECTRICAL POWER INVERTERS

#### A. TEST EQUIPMENT STANDARDS

1. *Test Facilities:* The apparatus used in conducting the tests described in this Appendix should be capable of producing the specified environmental conditions. The equipment under test should not occupy more than 50 percent of the volume of the test chamber. Heat sources should be disposed so that radiant heat does not fall directly on the equipment under test.

2. *Measurement Tolerances:* Allowable tolerances on test condition measurements are as follows:

- a. Temperature: Plus or minus 4° F.
- b. Altitude: Plus or minus 5 percent.
- c. Humidity: Plus or minus 5 percent relative.
- d. Vibration  
Amplitude: Plus or minus 5 percent.
- e. Vibration  
Frequency: Plus or minus 2 percent.

3. *Temperature stabilization:* Temperature stabilization may be checked by a temperature sensing device in good thermal contact with the largest centrally-located internal mass in the equipment under test.

4. *Deterioration:* Deterioration or corrosion of any internal or external components which could in any manner prevent the continued safe operation of the equipment during its service life will constitute failure to meet the environmental test to which the equipment was subjected.

#### B. TEST PROCEDURES

1. *High Temperature Test:* The equipment shall be placed within the test chamber and the internal temperature of the chamber raised to 160° F. with an internal relative humidity of not more than 5 percent. The item of equipment shall be maintained at 160° F. for a period of 50 hours. While still at this temperature, the equipment shall be operated to determine compliance with the requirements of paragraphs 2.1 through 2.10. The temperature shall then be reduced to prevailing room conditions and a visual examination conducted in accordance with paragraph A.4.

2. *Low Temperature Tests:*

a. *Method I* - The item of equipment shall be placed within the test chamber and the chamber cooled to and maintained at a temperature of -65° F. until temperature stabilization (See paragraph A.3) or the equipment is reached. While at this temperature, the equipment shall be operated to determine compliance with the requirements of paragraphs 2.1 through 2.10.

b. *Method II (alternate to Method I)* - The equipment shall be placed within the test chamber

and the chamber cooled to and maintained at a temperature of -80° F. for a period of 48 hours, at which time the equipment shall be examined in accordance with paragraph A.4. The temperature of the chamber shall then be raised to 65° F. and maintained for an additional 24-hour period, or until temperature stabilization is reached (See paragraph A.3), whichever is the longer. At the conclusion of this exposure period, while at this temperature, the equipment shall be operated to determine compliance with the requirements of paragraphs 2.1 through 2.10 and visually examined in accordance with paragraph A.4.

3. *Temperature shock Tests* -

a. *Method I*- The equipment shall be placed within a test chamber wherein a temperature of 185° F. is maintained. The equipment shall be subjected to this temperature for a period of 4 hours, at the conclusion of which, and within 5 minutes, the equipment shall be transferred to a chamber having an internal temperature of -40° F. The equipment shall be subjected to this temperature for a period of 4 hours. This completes one cycle. The equipment may be restored to room temperature before starting the next cycle. The number of complete cycles shall be three. At the conclusion of the third cycle, the equipment shall be removed from the test chamber and a within a period of one hour shall be operated to determine compliance with the requirements of paragraphs 2.1 through 2.10. A visual examination shall then be completed in accordance with paragraph A.4.

b. *Method II (alternate to Method I)*-The equipment shall be placed within the test chamber and maintained for a period of at least one hour or until the equipment performance stabilizes at a temperature of  $77^{\circ} \pm 27^{\circ}$  F. The chamber temperature shall then be reduced to -67° F. and maintained at this condition for at least one hour or until the equipment performance stabilizes. The internal temperature of the chamber shall then be increased to 160° F. and maintained at this condition for at least one hour or until the equipment performance stabilizes. The internal temperature shall then be returned to  $77^{\circ} \pm 27^{\circ}$  F. The equipment shall then be operated to determine compliance with the requirements of paragraphs 2.1 through 2.10.

4. *Humidity Tests*-

a. *Method I* - The equipment shall be placed in the test chamber and set up to simulate installed conditions. The chamber temperature shall be between 68° F. and 100° F. with uncontrolled humidity. During the first 2-hour period the temperature shall be gradually raised to 160° F. The 160° F. temperature shall be maintained during the next 6-hour period. During the following 16-hour period, the temperature in the chamber shall be gradually reduced to between 68° F. and 100° F,

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which constitutes one cycle. The relative humidity throughout the cycle shall be not less than 95 percent. The cycle shall be repeated a sufficient number of times to extend the total time of the test to 240 hours (10 cycles). At the conclusion of the 240-hour period, the equipment shall be operated to determine compliance with the requirements of paragraphs 2.1 through 2.10 and a visual examination made in accordance with paragraph A.4. Distilled or demineralized water having a pH value of between 6.5 and 7.5 at 77° F. shall be used to obtain the desired humidity. The velocity of the air throughout the test area shall not exceed 150 feet per minute.

b. *Method II (alternate to Method I)* - The equipment shall be placed in the test chamber and set up to simulate installed conditions. The temperature in the chamber shall be 120° F. and the relative humidity not less than 95 percent. The test conditions shall be maintained for 360 hours. At the conclusion of this period, the equipment shall be operated to determine compliance with the requirements of paragraphs 2.1 through 2.10. An examination in accordance with paragraph A.4 shall then be made.

5. *Altitude Test:* The equipment shall be placed within the test chamber and the internal pressure reduced to the manufacturer's declared operated altitude. The ambient temperature in the chamber (irrespective of the test altitude) shall be -65° F. The equipment shall be maintained at this condition until the temperature stabilizes (See paragraph A.3). while at this condition, the equipment shall be operated to determine compliance with the requirements of paragraphs 2.1 through 2.10.

6. *Vibration Tests:*

a. *Method I* - (Applies to equipment which mounts directly on the structure of aircraft powered by reciprocating, turbo-jet or turbo-propeller engines and to equipment which mounts directly on gas turbine engines) - The test specimen shall be mounted on the apparatus in a manner which is dynamically similar to the most severe condition likely to be encountered in service. The test specimen shall be performing its function during the entire test period whenever practicable. At the end of the test period, the test specimen shall be inspected thoroughly for damage or defects resulting from the vibration tests. The amplitude or acceleration for the frequency cycling test shall be within ±10 percent of the specified values. Vibration tests shall be conducted under both resonant and cycling conditions according to the following vibration test schedule (Table I):

TABLE 1 - VIBRATION TEST SCHEDULE

	Vibration at		
	Room Temp. (Minutes)	160° F (Minutes)	-65° F (Minutes)
Resonance	60	15	15

Cycling	60	15	15
---------	----	----	----

(i) *Resonance* - Resonant frequencies of the test specimen shall be determined by varying the frequency of applied vibration slowly through the specified range of frequencies at vibratory accelerations not exceeding those shown in Figure I. Individual resonant frequency surveys shall be conducted with vibration applied along each of any set of three mutually perpendicular axes of the test specimen.

Whenever practicable, functioning of the test specimen should be checked against the requirements of paragraphs 2.1 through 2.10 concurrently with the operation of scanning the frequency range for resonant frequencies. The test specimen shall be vibrated at the indicated resonant conditions for the periods shown in the vibrations test schedule (Table I) and with the applied double amplitude or vibratory acceleration specified in Figure I. These periods of vibration shall be accomplished with vibration applied along each of three mutually perpendicular axes of vibrations. When more than one resonant frequency is encountered with vibration applied along any one axis, the test period may be accomplished at the most severe resonance or the period may be divided among the resonant frequencies, whichever is considered most likely to produce failure. However, in no instance shall the specimen be vibrated on any resonant mode for periods less than half as long as those shown for resonance in the vibration test schedule. When resonant frequencies are not apparent within the specified frequency range, the specimen shall be vibrated for periods twice as long as those shown for resonance in the vibration test schedule (Table I) at a frequency of 55 c.p.s. and an applied double amplitude of 0.060 inch.

(ii) *Cycling* - For test specimens mounted on vibration isolators, a vibration test shall be conducted with a constant applied double amplitude of 0.060 inch and the frequency cycling between 10 and 55 c.p.s. in one-minute cycles. Vibration shall be applied along each of three mutually perpendicular axes according to the vibration test schedule (Table I). For specimens which are to be installed in aircraft without vibration isolators, a vibration test shall be conducted with the frequency cycling between 10 and 500 c.p.s. in 15-minute cycles at an applied double amplitude of 0.036 inch or an applied acceleration of ± 10 g, whichever is the limiting value. Vibration shall be applied along each of three mutually perpendicular axes according to the vibration test schedule (Table I).

b. *Method II* - (Apply to equipment which mounts directly to reciprocating engines) - The test specimen shall be mounted on the apparatus in a position dynamically similar to the most severe mounting likely to be used in service. Resonant frequencies of the test specimen shall be determined by varying the frequency of applied vibration slowly through the specified frequency range at vibratory accelerations not exceeding those shown in Figure I. Individual resonant frequency surveys shall be

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conducted with vibration applied along each of any set of three perpendicular axes of the test specimen. Whenever practicable, the functioning of the test specimen should be checked against the requirements of paragraphs 2.1 through 2.10 concurrent with the operation of scanning the frequency range resonant frequencies. If resonant frequencies are encountered, the test specimen shall be vibrated successively along each of three mutually perpendicular axes for four hours at the resonant conditions with the applied double amplitude or vibratory acceleration shown in Figure I. When more than one resonant frequency is encountered with vibration applied along any one axis, the test period may be carried out at the most likely severe resonance, or the period may be divided uniformly among the resonant frequencies, whichever procedure is considered most likely to produce failure. When clearly defined resonant frequencies are not encountered with the specified frequency range, the test specimen shall be vibrated for 12 hours along each of its mutually perpendicular axes at an applied double amplitude or 0.018 inch and a frequency of 150 cycles per second.

The test specimen shall be performing its function during the entire test period whenever practicable. At the end of the test period the test specimen shall be inspected thoroughly for damage or defects resulting from the vibration tests.

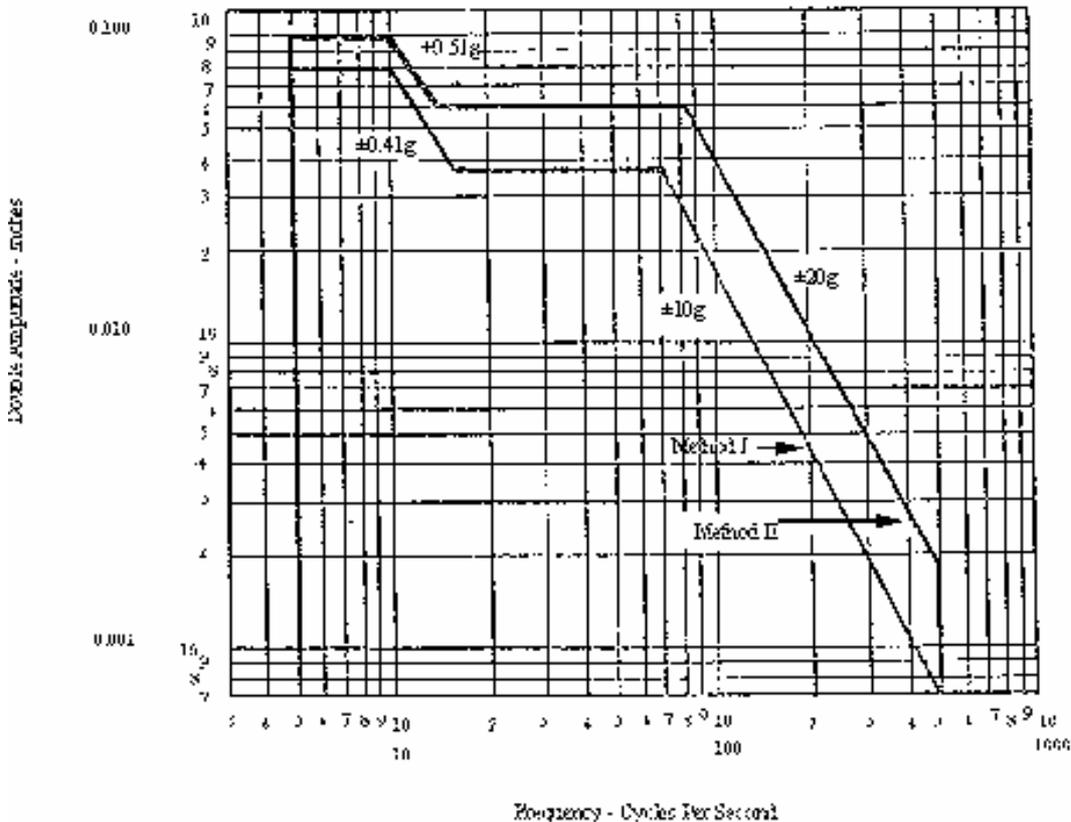
7. *Shock Test:* The equipment shall be subjected to the shock conditions as normally used in service, including any shock mount assembly. A Shock Testing Machine conforming to Military Specification MIL-S-4456 is suitable for this test.

The test specimen should be subjected to 18 impact shocks of 10 g, each shock impulse having a time duration of  $11 \pm 1$  milliseconds. The intensity should be within  $\pm 10$  percent when measured with a filter having a band width of 5 to 100 cycles per second. The maximum g should be reached in approximately  $5\frac{1}{2}$  milliseconds. The shock should be applied in the following directions:

- a. Vertically, 3 shocks in each direction.
- b. Parallel to the major horizontal axis, 3 shocks in each direction.
- c. Parallel to the minor horizontal axis, 3 shocks in each direction.

The test specimen should not suffer damage.

The equipment shall be operated to determine compliance with the requirements of paragraphs 2.1 through 2.10.



**Figure I – Range Curves for Vibration Tests**

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** AIRBORNE ATC TRANSPONDER EQUIPMENT

### **1 - Applicability**

This ETSO gives the requirements which airborne ATC transponder equipment that is manufactured on or after the date of this ETSO, must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

- (i) Equipment marked as Class 1A must be equipment intended for installation in aircraft that operate at altitudes above 15000 feet and must meet the minimum performance standards of the attached „Federal Aviation Standard, Airborne ATC Transponder Equipment“ as amended and supplemented by this ETSO.
- (ii) Equipment marked as Class 1B must be equipment intended for installation in aircraft that operate at altitudes not exceeding 15000 feet and must meet the minimum performance standards of „Federal Aviation Standard, Airborne ATC Transponder Equipment“ set forth in appendix of this ETSO as amended and supplemented by this ETSO.
- (iii) Equipment marked as Class 2A must be equipment intended for installation in aircraft that operates at altitudes above 15,000 feet and must meet the minimum performance standards set forth in Section II of Part Two of EUROCAE document 1/WG9 (1971) with amendments 1 (April 1974) and 2 (January 2000) as amended and supplemented by this ETSO.
- (iv) Equipment marked as Class 2B must be equipment intended for installation in aircraft that operate at altitudes not exceeding 15,000 feet and must meet the minimum performance standards set forth in Section II of Part II of EUROCAE document 1/WG9 (1971) ) with amendments 1 (April 1974) and 2 (January 2000) as amended and supplemented by this ETSO:

#### Exceptions

- (i) In lieu of the requirements in sub-paragraph II A.9.a of Part II of RTCA document DO-144, the reply characteristics apply over a received signal amplitude range between minimum triggering level and a level of -21dbm.
- (ii) The requirements specified in sub-paragraph II A.8.c of Part II of RTCA document DO-144 need not to be complied with:
- (iii) The requirements specified in sub-paragraph II A.16.b (2) and (3) of Part II of RTCA document DO-144, in so far as they pertain to pressure altitude information pulses, must be complied with only if complete altitude reporting capability is provided.

- (iv) The requirements specified in sub-paragraph II A.16.b (4), (5) and (6) of Part II of RTCA document DO-144, must be complied with only if complete altitude reporting capability is provided.

3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1

3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2

3.2 - Specific

None

**4 - Marking**

4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

4.2 - Specific

None.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

FAA Standard associated with ETSO-C74c

FEDERAL AVIATION ADMINISTRATION STANDARD  
Airborne ATC Transponder Equipment

**1.0 General Standards.**

1.1 *Operation of Controls.* The design or the equipment must be such that the controls intended for use during flight cannot be operated in any possible position combination, or sequence that would result in a condition detrimental to the continued performance of the equipment. Controls that are not normally adjusted in flight must not be readily accessible in flight.

1.2 *Operating Controls.* In addition to such other operating controls as are necessary, controls must be provided to accomplish the following functions:

- a. Selection of reply codes
- b. Selection of „standby“ condition.
- c. Selection of Modes 3/A and C combined.
- d. Activation of identification feature.
- e. Removal of all information pulses on the Mode C reply.

1.3 *Effects of Test.* Unless otherwise stated, the design of the equipment must be such that the application of the specified tests produces no discernible condition that would be detrimental to the continued performance of equipment manufactured in accordance with such design.

**2.0 Minimum Performance Standards Under Standard Conditions.**

The test conditions and definitions of terms applicable to a determination of the performance of airborne ATC transponder equipment are set forth in Appendix A.

2.1 *Receiver Operating Frequency and Bandwidth.*

- a. The receiver nominal center frequency must be 1030 MHz.
- b. With an input signal level 3 db above the minimum triggering level, the receiver bandwidth must be such that the receiver accepts pulses as outlined in Appendix A with an interrogating center frequency drift of  $\pm 0.2$  MHz.
- c. The skirt bandwidth must be such that the sensitivity of the receiver is at least 60 db down at  $\pm 25$  MHz and beyond.

2.2 *Receiver Sensitivity and Dynamic Range.*

a. The minimum triggering level (MTL) of the transponder must be such that replies are generated to 90 percent of the interrogation signals when-

1. The two pulses P<sub>1</sub> and P<sub>2</sub> constituting an interrogation are of equal amplitude and P<sub>2</sub> is not detected; and
2. The amplitude of these signals received at the antenna end of the transmission line of the transponder is nominally 71 db below 1 milliwatt with limits between 69 and 77 db below 1 milliwatt.

b. With the transponder adjusted to comply with paragraph a, the random triggering rate (squitter) must not be greater than five reply pulse groups or

suppressions per second averaged over a period of at least 30 seconds.

c. The variation of the minimum triggering level between modes must not exceed 1 db for nominal pulse spacings and pulse widths.

d. The reply characteristics apply over a triggered signal amplitude range between minimum triggering level and 50 db above that level .

e. The standards of this section assume a transmission line loss of 3 db and an antenna performance equivalent to that of a simple quarter wave antenna. In the event that these assumed conditions do not apply, the equipment must be adjusted as necessary to provide a sensitivity equivalent to that specified.

2.3 *Spurious Responses.* All spurious responses, including response to image frequencies, must be such that the response to such signals is at least 60 db down from the normal sensitivity of the receiver.

2.4 *Interrogation.* The equipment must accept and reply to interrogations on at least Modes 3/A and C.

NOTE-Interrogation Modes B and D as defined in Figure 1 have been agreed upon internationally and their use may be specified for certain flight operations. These modes may be provided as optional features on transponder equipment.

2.5 *Side-lobe Suppression.* The equipment must provide side-lobe suppression.

2.6 *Decoding Performance.*

a. *Conditions Under Which Transponder Must Reply.* When selected to reply to a particular interrogation mode, and with a signal amplitude range from the minimum triggering level to 50 db above that level, the transponder must reply to at least 90 percent of the interrogations when all of the following conditions are met:

(1) Either the received amplitude of P<sub>1</sub> is in excess of a level of 9 db above the received amplitude of P<sub>2</sub> or no pulse is received  $2 \pm 0.7$  microsecond following P<sub>1</sub>.

(2) The received amplitude of P<sub>2</sub> is in excess of a level 1 db below the receiver amplitude of P<sub>3</sub> but no greater than 3 db above the received amplitude of P<sub>1</sub>.

(3) The received amplitude of a proper interrogation is more than 10 db above the received amplitude of random pulses where the latter are not recognized by the transponder as P<sub>1</sub>, P<sub>2</sub> or P<sub>3</sub>.

b. *Conditions Under Which Transponder Must Not Reply.* Over the signal amplitude from the minimum triggering level to 50 db above this level, the transponder must not reply to more than 10 percent of the interrogations under either of the following conditions:

(1) The interval between interrogation pulse P<sub>1</sub> and P<sub>3</sub> differ from the specified spacing for the particular mode setting by more than  $\pm 1.0$  microsecond.

(2) The interrogations consist of single pulses. However, this does not apply to those combinations of single pulses that occur at the selected interrogation spacing or to single pulses that have

amplitude variations approximating a normal interrogation condition.

c. *Side-lobe Suppression.* The transponder must be suppressed for a period of  $35 \pm 10$  microseconds following receipt of a pulse pair of proper spacing and amplitude indicative of side-lobe interrogation. This suppression action must be capable of being reinitiated for the full duration within 2 microseconds after the end of any suppression period. The transponder must be suppressed with a 99 percent efficiency over a received signal amplitude range between 3 db above minimum triggering level and 50 db above that level and upon receipt of properly spaced interrogations when the received amplitude of P2 is equal to or in excess of the received amplitude of P1 and spaced  $2.0 \pm 0.15$  microsecond from P3.

2.7 *Transponder Discrimination and Desensitization.*

a. *Pulse Width Discrimination.* Received signals of amplitude between minimum triggering level and at least 6 db above this level, and of a duration less than 0.3 microsecond, must not cause the transponder to initiate more than 10 percent reply or suppression action. With the exception of pulses having amplitude variations approximating a normal interrogation or suppression pulse pair condition, any pulse of a duration more than 1.5 microseconds must not cause the transponder to initiate reply or suppression action over the signal amplitude range from the minimum triggering level to 50 db above that level.

b. *Echo Suppression and Recovery.*

(1) *Echo suppression desensitization.* Upon receipt of any pulse more than 0.7 microsecond in duration (desensitization pulse), the receiver must be desensitized by an amount that is within at least 9 db of the amplitude of the desensitizing pulse but must at no time exceed the amplitude of the desensitizing pulse except for overshoot during the first microsecond following the desensitizing pulse.

(2) *Recovery.* Following desensitization, the receiver must recover sensitivity (within 3 db of minimum triggering level) within 15 microseconds after reception of a desensitizing pulse having a signal strength up to 50 db above minimum triggering level. Recovery must be nominally linear at an average rate not exceeding 3.5 db per microsecond.

(3) *Narrow pulses.* Single pulses of duration less than 0.7 microsecond must not cause desensitization of duration or amount greater than that permitted in subparagraphs (1) or (2).

c. *Dead Time.* (1) After reception of a proper interrogation, the transponder must reply to no other interrogation for the duration of the reply pulse train. This dead time must end no later than 125 microseconds after the transmission of the last reply pulse of the group.

(2) The dead time of the transponder created by means other than normal interrogations shall not exceed a period or more than 2,500 microseconds duration at a maximum duty cycle of 4.5 percent.

d. *Reply Rate Control.* A sensitivity-reduction type reply rate control must be provided. The range

of this control must permit adjustment of the reply rate to any value between 500 replies per second and the maximum rate of which the transponder is capable, or 2,000 replies per second, whichever is the lesser, without regard to the number of pulses in each reply. Sensitivity reduction in excess of 3 db must not take effect until 90 percent of the selected reply rate is exceeded. The sensitivity must be reduced by at least 30 db when the rate exceeds the selected value by 50 percent. The reply rate limit must be set at 1,200 replies per second or the maximum value below 1,200 replies per second of which the transponder is capable.

2.8 *Transponder Reply Rate Capability.*

a. For equipment intended for installation in aircraft that operate at altitudes above 15,000 feet, the reply rate capability must be at least 1,200 reply groups per second for a 15 pulse coded reply.

b. For equipment intended for installation in aircraft that operate at altitudes not exceeding 15,000 feet, the reply rate capability must be at least 1,000 reply groups per second for a 15 pulse coded reply.

2.9 *Transponder Reply Code Capability.* Transponders must provide the following code capability:

a. Framing pulses (see par. 2.13a.).

b. Information pulses in all combinations of the A, B, C and D subscript groups, to create 4096 codes (see para. 2.13b.).

c. Special position identification pulse (SPI) (see par. 2.13c.).

2.10 *Reply Transmission Frequency.* The center frequency of the reply transmission must be  $1090 \pm 3$  MHz.

2.11 *Transmitter Power Output*

a. For equipment intended for installation in aircraft which operate at altitudes above 15,000 feet, the peak pulse power available at the antenna end of the transmission line of the transponder must be at least 21 db and not more than 27 db above 1 watt at any reply rate up to 1,200 per second for a 15-pulse coded reply.

b. For equipment intended for installation in aircraft which operate at altitudes not exceeding 15,000 feet, the peak pulse power available at the antenna end of the transmission line of the transponder must be at least 18.5 db and not more than 27 db above 1 watt at any reply rate up to 1,200 per second for a 15-pulse coded reply.

c. The standards of this section assume a transmission line loss of 3 db and an antenna performance equivalent to that of a simple quarter wave antenna. In the event that these assumed conditions do not apply, the equipment must be adjusted as necessary to provide a transmitter power output equivalent to that specified.

2.12 *Reply Delay and Jitter*

a. The time delay between the arrival, at the transponder input, of the leading edge of P3 and the transmission of the leading edge of the first pulse of the reply must be  $3 \pm 0.5$  microseconds.

b. The jitter or the reply pulse code group with respect to P<sub>3</sub> must not exceed ±0.1 microsecond for receiver input levels between 3 and 50 db above the minimum triggering level.

c. Delay variations between modes on which the transponder is capable of replying must not exceed 0.2 microseconds.

2.13 Reply Transmission Pulse Characteristics.

a. *Framing Pulses.* The reply function must employ a signal comprising two framing pulses spaced 20.3 microseconds measured leading-edge to leading-edge at half-voltage points, as the most elementary code.

b. *Information Pulses.* Information pulses spaced at intervals of 1.45 microseconds measured leading-edge to leading-edge at the half-voltage points with the first pulse positioned 1.45 microseconds after the first framing pulse must be provided. The designation of these pulses and their position with respect to the first framing pulse is as follows:

PULSE	POSITION (MICROSECONDS)
C <sub>1</sub>	1.45
A <sub>1</sub>	2.90
C <sub>2</sub>	4.35
PULSE	POSITION (MICROSECONDS)
A <sub>2</sub>	5.80
C <sub>4</sub>	7.25
A <sub>4</sub>	8.70
X*	10.15
B <sub>1</sub>	11.60
D <sub>1</sub>	13.05
B <sub>2</sub>	14.50
D <sub>2</sub>	15.95
B <sub>4</sub>	17.40
D <sub>4</sub>	18.85

\* The X pulse is referenced here for possible future use.

NOTE.-Details and nomenclature of the transponder reply pulse codes are set forth in Appendix A.

c. *Special Position Identification Pulse (SPI).* In addition to the information pulses provided, a special position identification pulse, which may be used with any of the other information pulses upon request, must be provided at a spacing 4.35 microseconds following the last framing pulse. When replying to any mode of interrogation to which the transponder is capable, except Mode C, the selection of the SPI pulse must be initiated by an IDENT switch. Upon activation of the IDENT switch, the SPI pulse must be transmitted for a period between 15 and 30 seconds and must be repeatable at any time.

d. *Reply Pulse Shape.* All reply pulses and SPI pulses must be 0.45 ±0.10 microsecond in duration and have rise times of from 0.05 to 0.1 microsecond and decay times of from 0.05 to 0.2 microsecond. The pulse amplitude variation of one pulse with respect to any other pulse in a reply train must not exceed 1 db. The rise and decay time may be less providing the sideband radiation is no greater than that which would be produced theoretically by a

trapezoidal wave having the stated rise and decay time.

e. *Reply Pulse Spacing Tolerances.* The pulse spacing tolerances for each pulse (including the last framing pulse) with respect to the first framing pulse of the reply group must be ±0.10 microsecond. The pulse spacing tolerance of the special position identification pulse with respect to the last framing pulse of the reply group must be ±0.10 microsecond. The pulse spacing tolerance of any pulse in the reply group with respect to any other pulse (except the first framing pulse) must be no more than ±0.15 microsecond.

2.14 *Pressure-Altitude Transmission.* The equipment must have the capability for automatic pressure altitude transmission in 100-foot increments on Mode C when operated in conjunction with a pressure altitude encoder (digitizer). The equipment must be capable of automatic reply to Mode C interrogations with combinations of information pulses coded in binary form in 100-foot increments necessary for the equipment to operate up to design maximum altitude. The transponder must be provided with a means to remove the information pulses from the Mode C reply when requested by Air Traffic Control. The transponder must continue transmitting the framing pulses on Mode C when the information pulses have been removed or are not provided. Automatic pressure altitude transmission codes pulse position assignment are set forth in figure 2.

2.15 *Self Test and Monitor.* If a self test feature or monitor is provided, the devices that radiate test interrogation signals or prevent transponder reply to proper interrogation during the test period, must be limited to intermittent use which is no longer than that required to determine the transponder status. The test interrogation rate must not exceed 450 per second and the interrogation signal level at the antenna end of the transmission line must not exceed a level of -40 dbm.

2.16 *Antenna.* The equipment antenna radiation pattern must be predominantly vertically polarized and be essentially omnidirectional in the horizontal plane with a nominal vertical beam width of at least ±30 degrees from the horizontal plane. The voltage standing wave ratio (VSWR) produced on the antenna transmission line by the antenna must not exceed 1.5:1 when operating on the radio frequencies of 1030 and 1090 MHz.

2.17 *Interference Suppression Pulse Response.* If the equipment is designed to accept and respond to suppression pulses from other electronic equipment in the aircraft (to disable it while the other equipment is transmitting), the equipment must regain normal sensitivity, within 3 db, not later than 15 microseconds after the end of the applied suppression pulse.

2.18 *Emission of Spurious Radiofrequency Energy.* The levels of conducted and radiated spurious radiofrequency energy emitted by the equipment must not exceed those levels specified in Appendix A of RTCA Document No. DO-138 entitled

„Environmental Conditions and Test Procedures for Airborne Electronic/ Electrical Equipment and Instruments,“ dated June 27, 1968.

### 3.0 Minimum Performance Standards Under Environmental Conditions.

Unless otherwise specified, the test procedures applicable to a determination of the performance of airborne ATC transponder equipment under environmental conditions are set forth in RTCA Document No. DO-138 entitled „Environmental Conditions and Test Procedures for Airborne Electronic/Electrical Equipment and Instruments,“ dated June 27, 1968.

#### 3.1 Temperature-Altitude

##### a. Low Temperature.

(1) When the equipment is subjected to this test, the standards of the following paragraphs must be met: 2.1a; 2.2, except that at temperatures below -15°C., the sensitivity must not be less than -69 dbm and the variation of sensitivity of the receiver between any mode on which it is capable of operating must be less than 2 db; 2.6a(1); 2.6b(1); 2.6c; 2.7b; 2.7c; 2.10; 2.11; 2.12. except that at temperatures below -15°C., the delay variation between modes on which the transponder is capable of replying must be less than 0.4 microsecond; 2.13c; 2.13d; and 2.13e.

(2) Following the low temperature test, the requirements of paragraph 2.16 must be met.

##### b. High Temperature.

(1) When the equipment is subjected to the high short-time operating temperature test, the equipment must operate electrically and mechanically.

(2) When the equipment is subjected to the high operating temperature test, standards of the following paragraphs must be met: 2.1a : 2.2. except that at temperatures above +40°C., the sensitivity must not be less than -69 dbm and the variation of sensitivity of the receiver between any mode on which it is capable of operating must be less than 2 db; 2.6a(1); 2.6b(1); 2.6c; 2.7b 2.7c; 2.10; 2.11; 2.12, except that at temperatures above +40°C., the delay variation between modes on which the transponder is capable of replying must be less than 0.4 microsecond; 2.13c; 2.13d; and 2.13e.

(3) Following the high temperature test, the requirements of paragraph 2.16 must be met.

##### c. Altitude.

(1) When the equipment is subjected to this test, the standards of the following paragraphs must be met: 2.1a and b; 2.10; 2.11; and 2.13d.

(2) Following the altitude test, the requirements of paragraph 2.16 must be met.

d. *Decompression (when required).* When the equipment is subjected to this test, the standards of paragraphs 2.1a and b; 2.10; 2.11: and 2.13a must be met.

e. *Overpressure (when required).* When the equipment is subject to this test, the standards of paragraphs 2.1a and b; 2.10; 2.11; and 2.13a must be met.

3.2 *Humidity.* After being subjected to this test, the equipment must meet the following:

a. Within 15 minutes from the time primary power is applied, the receiver sensitivity must be within 3 db of that specified in paragraph 2.2, transmitter power output must be within 3 db of that specified in paragraph 2.11, and the requirements of 2.1a; 2.1b; and 2.10 must be met.

b. Within 4 hours from the time primary power is applied, the standards of paragraphs 2.1.a and b: 2.2; 2.10; 2.11; and 2.16 must be met.

#### 3.3 Shock.

a. Following the application of the 6G shocks, the standards of the following paragraphs must be met: 2.1a; 2.2; 2.6a(1); 2.6c; 2.7b; 2.7c: 2.10; 2.11; 2.12; 2.13c; 2.13d; 2.13e; and 2.16.

b. Following the application of the 15G shocks, the equipment must have remained in its mounting and no parts of the equipment or its mounting become detached and free of the shock test equipment. The application of the 15G shock test may result in damage to the equipment. Therefore, this test may be conducted after the other tests are completed.

#### 3.4 Vibration.

a. When the equipment is subjected to this test, the standards of the following paragraphs must be met: 2.1a; 2.2; 2.6a (1); 2.6b (1); 2.6c; 2.7b; 2.7c; 2.10; 2.11; 2.13c; 2.13d; and 2.13e.

b. Following the vibration test, the requirements of paragraph 2.16 must be met.

#### 3.5 Temperature Variation.

a. When the equipment is subjected to this test, the standards of the following paragraphs must be met: 2.1a; 2.2. except that at temperatures below -15° C. and above +40° C. the sensitivity must be not less than -69 dbm and the variation of sensitivity of the receiver between any mode on which it is capable of operating must be less than 2 db; 2.6a(1); 2.6b(1); 2.6c; 2.7b; 2.7c: 2.10; 2.11; 2.12, except that at temperatures below -15° C. and above +40° C. the delay variation between modes on which the transponder is capable of replying must be less than 0.4 microsecond; 2.13c; 2.13d; and 2.13e.

b. Following the temperature variation test, the requirement of paragraph 2.16 must be met.

3.6 *Power Input Variation.* When the equipment is subjected to this test, the standards of the following paragraphs must be met 2.1a; 2.2; 2.6a; (1); 2.6b (1); 2.6c; 2.7b; 2.7c; 2.10; 2.11; 2.12; 2.13c; 2.13d; and 2.13e.

#### 3.7 Low Voltage.

a. When the primary power voltage(s) of d.c. operated equipment is 80 percent and when that of a.c. operated equipment is 87<sup>1</sup>/<sub>2</sub> percent of design voltage(s), the equipment must operate electrically and mechanically.

b. D.c. operated equipment must meet the standards of paragraphs 2.1a and b; 2.2: 2.10; and 2.11 within two (2) minutes upon returning the primary power voltage(s) to design voltage, after the gradual reduction of the primary voltage(s) from 80 percent to 50 percent of design voltage(s).

c. The gradual reduction of the primary power voltages of d.c. operated equipment from 50 percent to 0 percent of design voltage(s) must produce no

evidence of the presence of fire or smoke. Paragraph 1.2 does not apply.

3.8 *Conducted Voltage Transient*. When the equipment is subjected to this test, the standards of paragraphs 2.1.a and b; 2.2; 2.10; and 2.11 must be met.

3.9 *Conducted Audiofrequency Susceptibility*. When the equipment is subjected to this test, the standards of paragraphs 2.1.a and b; 2.2; 2.10; and 2.11 must be met.

3.10 *Audiofrequency Magnetic Field Susceptibility*. When the equipment is subjected to this test, the standards of paragraphs 2.1.a and 2.2b; 2.2; 2.10; and 2.11 must be met.

3.11 *Radiofrequency Susceptibility (radiated and conducted)*. When the equipment is subjected to this test, the standards of paragraphs 2.1.a and b; 2.2b; 2.10; and 2.11 must be met.

3.12 *Explosion (when required)*. When the equipment is subjected to this test the equipment must cause no detonation of the explosive mixture within the test chamber.

3.13 *Waterproofness (drip proof) Test (when required)*. After subjection to this test, the standards of paragraphs 2.1; 2.2; 2.10; 2.11; and 2.13a must be met.

3.14 *Hydraulic Fluid Test (when required)*. After subjection to this test, the standards of paragraphs 2.1; 2.2; 2.10; 2.11; and 2.13a must be met.

3.15 *Sand and Dust Test (when required)*. After subjection to this test, the standards of paragraphs 2.1; 2.2; 2.10; 2.11; and 2.13a must be met.

3.16 *Fungus Resistance Test (when required)*. After subjection to this test, the standards of paragraphs 2.1; 2.2; 2.10; 2.11; and 2.13a must be met.

3.17 *Salt Spray Test (when required)*. After subjection to this test, the standards of paragraphs 2.1; 2.2; 2.10; 2.11; and 2.13a must be met.

## APPENDIX A

### 1.0 Test Conditions.

The following definitions of terms and conditions of test are applicable to the ATC transponder equipment.

a. *Power Input Voltage-Direct Current*. Unless otherwise specified, when the equipment is designed for operation from a direct current power source, all measurements must be conducted with the power input voltage adjusted to 13.75 volts,  $\pm 2$  percent for 12-14 volt equipment, or to 27.5 volts,  $\pm 2$  percent for 24-28 volt equipment. The input voltage must be measured at the equipment power input terminals.

b. *Power Input Voltage-Alternating Current*. Unless otherwise specified, when the equipment is designed for operation from an alternating current power source, all tests must be conducted with the power input voltage adjusted to design voltage  $\pm 2$  percent. In the case of equipment designed for operation from a power source of essentially constant frequency (e.g., 400 Hz, the input frequency must be adjusted to design  $\pm 2$  percent. In the case of

equipment designed for operation from a power source of variable frequency (e.g., 350 to 1000 Hz, tests must be conducted with the input frequency adjusted to within 5 percent of a selected frequency within the range for which the equipment is designed.

c. *Adjustment of Equipment*. The circuits of the equipment under test must be properly aligned and otherwise adjusted in accordance with the manufacturer's recommended practices prior to the application of the specified tests.

d. *Test Instrument Precautions*. Due precautions must be taken during the conduct of the tests to prevent the introduction of errors resulting from the improper connection of headphones, voltmeters, oscilloscopes, and other test instruments across the input and output impedances of the equipment under test.

e. *Ambient Conditions*. Unless otherwise specified, all tests must be conducted under conditions of ambient room temperature, pressure and humidity. However, the room temperature must not be lower than 10° C.

f. *Warm-up Period*. Unless otherwise specified, all tests must be conducted after a warm-up period of not less than fifteen (15) minutes.

g. *Connected Load*. Unless otherwise specified, all tests must be performed with the equipment connected to loads having the impedance value for which it is designed.

h. *Interrogation Test Signal*. The characteristics of the interrogation test signal are:

*Radio frequency*: The frequency of the signal generator oscillator must be 1030 MHz  $\pm 0.01$  percent.

*CW output*: CW output between pulses must be at least 60 db below the peak level of the pulses.

*Interrogation*: The interrogation must consist of two transmitted pulse designated P<sub>1</sub> and P<sub>3</sub>. When providing side-lobe suppression the basic interrogation is supplemented by pulse P<sub>2</sub> transmitted after P<sub>1</sub>. The amplitude of P<sub>3</sub> must not be more than 1 db below the radiated amplitude of P<sub>2</sub>.

*Pulse coding*: The interval, measured leading edge to leading-edge at half voltage points, between P<sub>1</sub> and P<sub>3</sub> is as follows:

Mode 3/A	8 $\pm 0.2$ microseconds.
Mode B	17 $\pm 0.2$ microseconds.
Mode C	21 $\pm 0.2$ microseconds.
Mode D	25 $\pm 0.2$ microseconds.

The interval between P<sub>1</sub> and P<sub>2</sub> when P<sub>2</sub> is used, must be 2.0  $\pm 0.15$  microseconds.

*Pulse shape*: The pulse envelope as detected by a linear detector must have a shape falling within the following limits:

(1) *Pulse rise time*: The time required for the leading edge of pulses P<sub>1</sub> and P<sub>2</sub>, and P<sub>3</sub> to rise from 10 to 90 percent of its maximum voltage amplitude must be between 0.05 and 0.1 microsecond.

(2) *Pulse fall time*: The time required for the trailing edge of pulses P<sub>1</sub>, P<sub>2</sub>, and P<sub>3</sub> to fall from 90 to 10 percent of its maximum voltage amplitude must be between 0.05 and 0.2 microseconds.

(3) *Pulse duration*: The duration of pulses  $P_1$ ,  $P_2$ , and  $P_3$ , must be  $0.8 \pm 0.1$  microsecond measured at the half voltage points.

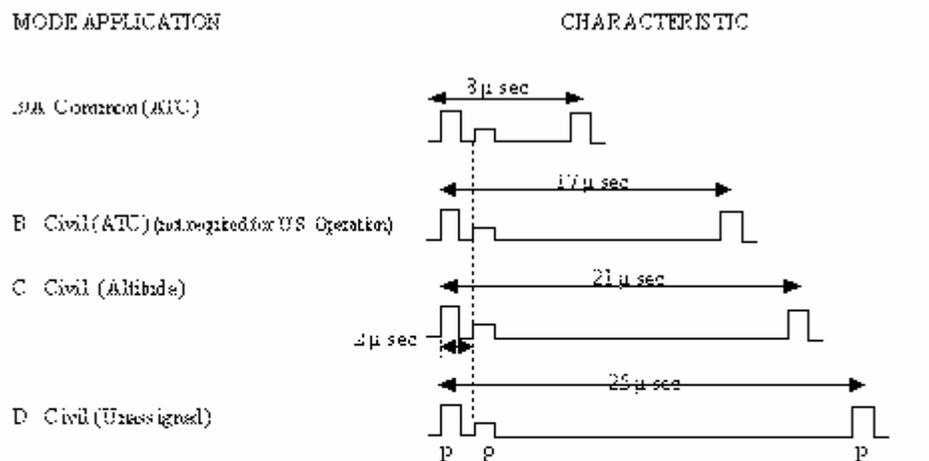
i. *Code Nomenclature*. The code designations consist of four digits each of which lies between 0 and 7, inclusive, and consist of the sum of the numerical subscripts of the pulse employed as follows:

<i>Digit</i>	<i>Pulse group</i>
First	A
Second	B
Third	C
Fourth	D

Examples:

1. Code 3600 consists of information pulses  $A_1$ ,  $A_2$ ,  $B_2$ ,  $B_4$
  2. Code 2057 Consists of  $A_2$ ,  $C_1$ ,  $C_4$ ,  $D_1$ ,  $D_2$ ,  $D_4$ .
- j. *Minimum Triggering Level (MTL)*. Means the lowest level of signal to which the transponder will reply to 90 percent of the received interrogations.

ATCRBS INTERROGATION MODES



TRANSponder REPLY CODES

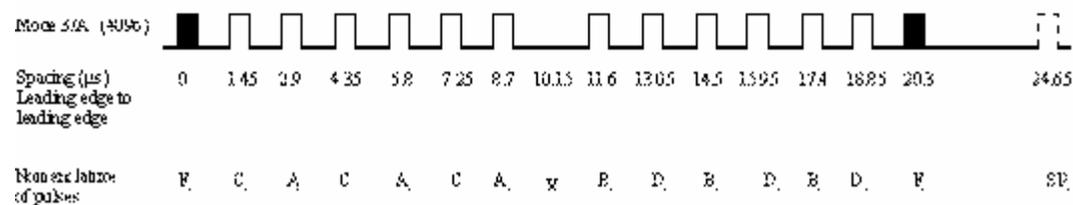


Figure 1 – ATCRBS, Interrogation modes and reply codes



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** FUEL DRAIN VALVES

### **1 - Applicability**

This ETSO gives the requirements which fuel drain valves that are manufactured on or after the date of this ETSO, must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the attached „Federal Aviation Administration Standard, Fuel Drain Valves“ dated October 1, 1962.

##### 3.1.2 - Environmental Standard

As stated in the Federal Aviation Administration Standard.

##### 3.1.3 – Computer Software

None

#### 3.2 - Specific

None.

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

FAA Standard associated with ETSO-C76

October 1, 1962

FAA STANDARD – FUEL DRAIN VALVES

1. PURPOSE: To specify minimum requirements for fuel drain valves that are intended to drain fuel or water from low points in aircraft fuel systems. Fluid discharge from the valve is intended to be drained to a container for inspection.
2. SCOPE: This standard covers the requirements for acceptance of fuel drain valves used as a quick means of draining fuel or water from aircraft fuel systems. These valves are intended to be used in fuel tank sumps, strainers and gascolators.
3. GENERAL REQUIREMENTS:
  - 3.1 Materials. Materials shall be of a high quality which experience and/or tests have demonstrated to be suitable for use with aviation fuels having an aromatic content from 0 to 30 percent. Synthetic rubber parts shall be age dated in accordance with ANA Bulletin No. 438. All metals used in the construction of fuel drain valves shall be of corrosion resisting type or shall be suitably protected to resist corrosion during the normal service life of the valve.
  - 3.2 Design and Construction.
    - 3.2.1 Fuel Spillage. The drain valve shall be designed to permit operation without spillage or leakage of fuel on operating personnel.
    - 3.2.2 Position Indication. Indication shall be provided for the open and closed position of valves. The valve shall utilize detents or other suitable means to retain the valve in the full-closed position. When manually released from the open position, the valve shall automatically return to the closed position.
    - 3.2.3 Self-locking. The valve shall be provided with a means to prevent accidental opening or opening due to vibration or air loads.
    - 3.2.4 Seals. The valve shall be designed so that the inlet pressure does not tend to open the valve, and so that the inlet pressure keeps the valve in the closed and sealed condition.
    - 3.2.5 Loss of Parts. Fuel drain valves shall be designed to preclude the loss of parts. Design consideration shall be given so that the main seal will remain in place and prevent fuel leakage in the event of possible damage to or loss of the valve stem from operational loads to be anticipated in service. If threaded fittings are employed to support the valve, positive design provisions shall be included to prevent operational loads from rotating the valve body out of its boss.
    - 3.2.6 Screens. The design of the valve shall include no features, such as screens or baffles, which could impair the valves effectiveness in draining fuel containing water and other contaminants.
4. TEST CONDITIONS:
  - 4.1 Atmospheric Conditions. Unless otherwise specified, all tests required by this standard shall be conducted at an atmospheric pressure of approximately 29.92 inches of mercury and at an ambient temperature of approximately 25° C.
  - 4.2 Fluids. Unless otherwise specified, commercial grade aviation fuels shall be used for all tests.
5. TEST METHODS AND PERFORMANCE REQUIREMENTS:
  - 5.1 Functional. This test shall demonstrate the ability of the valve to meet the design requirements specified in Sections 3.2.1, 3.2.2, 3.2.3, 3.2.4, and 3.2.5.

- 5.2 Flow Test. The drain valve shall be connected to a suitable container and the time required to pass a 1 quart quantity of fuel shall be determined when conducted with a maximum head of six inches of fuel. The time to flow 1 quart shall not take longer than 1 minute.
- 5.3 Leakage Tests.
- 5.3.1 Fuel Leakage. The fuel leakage test shall be conducted at pressures of four inches of fuel, one p.s.i., 20 p.s.i., and 60 p.s.i. The pressure shall be applied to the drain valve inlet with the valve in the closed position; there shall be no leakage.
- 5.3.2 Air Leakage. The air leakage test shall be conducted with the valve installed in a suitable test setup so that the valve inlet port is covered by fuel. Air pressure varying from 0 to five p.s.i. shall be applied to the valve outlet port with the valve in the closed position. There shall be no air leakage evident.
- 5.4 Fuel Resistance and Extreme Temperature. The fuel resistance and extreme temperature tests shall be conducted in accordance with the following table:

Fuel Resistance and Extreme Temperature  
Test Schedule

Test	Fuel Resistance		
	Phase I Soak	Phase I Dry	Low Temperature
Component configuration	2/	Drained and blown dry, normal condition as would be expected under service conditions, ports open.	Mounted as would be expected under normal service conditions 2/
Test Fluid	MIL-S-3136, type III	None	MIL-S-3136, type I
Period duration	96 hours (4 days)	24 hours	18 hours
Ambient and test fluid temperature.	158° ±2° F. or the normal operating temperature of the system in which the component is used, whichever is higher.	Circulating air at 158° ±2° F. or the normal operating temperature of the system in which the component is used, whichever is higher.	Lower the fluid temperature to maintain -67° ±2° F., then maintain the fluid temperature at -67° ±2° F. for a minimum of 18 hours.
Operation or tests during period	Actuate component at least 4 cycles per day in a normal manner.	None	None

Operation or tests immediately after period	Conduct leakage test, using MIL-S-3136, type III fluid.	(a) Actuate components for 5 cycles.  (b) Conduct functional and leakage tests, using MIL-S-3136, type I fluid.	With temperature not higher than -65° F., conduct functional and leakage tests, using MIL-S-3136, type I fluid.
	3/	3/	3/

- 1/ Each period shall follow immediately after the preceding one in the order noted.
- 2/ The component shall be maintained in such a manner as to insure complete contact of all nonmetallic parts with the test fluid as would be expected under normal service conditions
- 3/ No leakage is allowed at any time during the test except for the first 15 minutes of the leakage test of the dry cycle.

5.5 Vibration.

5.5.1 Resonance. The valve shall be subjected to a resonant frequency survey of the range specified in the following table in order to determine if there exists any resonant frequencies of the parts. If resonance is encountered, the valve shall be successively vibrated along the three axes for four hours at the critical frequency.

5.5.2 Cycling. The valve, in the closed positions shall be mounted on a vibration device, fluid pressure shall be applied to the inlet port. The valve shall be subjected to the three vibration scanning cycle tests contained in the following table:

Vibration Test			
Scanning cycle	1	2	3
Axis of vibration	X	Y	Z
Fluid pressure	60 p.s.i.	60 p.s.i.	60 p.s.i.
Scanning cycle	15 min.	15 min	15 min.
Number of scanning cycles per test	2	2	2
Procedure	The vibration test shall be conducted on the valve along three mutually perpendicular axes herein referred to as the X, Y, and Z axes; the X axis being defined as lying along center lines of the valve. The frequency shall be uniformly increased with respect to time through a frequency range from 10 to 500 c.p.s. with an applied double amplitude of 0.036 inch up to 75 c.p.s. and from there an applied vibration acceleration not less than ±10g. The frequency shall be similarly decreased such that the complete cycle is accomplished in the specified cycle time.		

The test shall also be conducted at pressures of 1/2 p.s.i. and five p.s.i. There shall be no fluid leakage during the test.

The test shall also be conducted with air pressure varying from 0-5 p.s.i. gage at the outlet port. Air leakage shall not exceed 10 cc. per minute of free air during the five p.s.i. air suction test.

There shall be no evidence of damage to the valve or loosening of parts as a result of the test.

- 5.6 Proof Pressure. The valve shall be in the closed position and shall be subjected to a fuel pressure of  $100 \pm 2$  p.s.i. for a period of one minute at the inlet port, with the outlet port open to atmospheric pressure. There shall be no evidence of permanent distortion or other damage to the valve. There shall be no external leakage when the pressure is reduced to 60 p.s.i.
- 5.7 Reliability Tests. (Cycling Operations)
- 5.7.1 Dry. The valve shall be dried in an oven at  $158^{\circ} \pm 2^{\circ}$  F. for four hours and then, in the dry condition, be subjected to 2,000 complete cycles of operation.
- 5.7.2 Wet. The valve shall be moistened with fuel, supplied with a six inch head of fuel and then be subjected to 6,000 complete cycles of operation.
- 5.7.3 Post Reliability Test. Upon completion of the cycling operations, the valve shall be subjected to the Leakage Test. There shall be no leakage from any portion of the valve as the result of the Reliability Test.



# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** CREWMEMBER DEMAND OXYGEN MASKS

### **1 - Applicability**

This ETSO gives the requirements which crewmember demand oxygen masks that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the attached „Federal Aviation Administration Standard, Crewmember Demand Oxygen Masks“.

##### 3.1.2 - Environmental Standard

As stated in the Federal Aviation Administration Standard.

##### 3.1.3 - Computer Software

None

#### 3.2 - Specific

None

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2; in addition each mask shall be marked to indicate:

- (i) whether it is a „non pressure demand“ or a „pressure demand“ mask
- (ii) the maximum environmental (cabin) altitude for which it is qualified.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

# FAA Standard associated with ETSO-C78

## FEDERAL AVIATION ADMINISTRATION STANDARD Crewmember Demand Oxygen Masks

### 1.0 Purpose.

This Standard contains minimum performance standards for the manufacture of demand type oxygen masks for use with non-pressure demand (straight-demand and diluter-demand) and pressure-demand oxygen systems.

### 2.0 Design and Construction of Mask.

To be eligible for approval under a Technical Standard Order authorization, the oxygen mask must possess the following design and construction characteristics.

2.1 Masks designed for use with a remotely located oxygen flow regulator must include a flexible oxygen supply tube fixed or detachable at the mask or at the regulator or at both. Oxygen supply tubes used in conjunction with mask-mounted oxygen flow regulators are not subject to this paragraph.

2.2 The mask must be designed for respiration through the nose and mouth (oronasal). The mask may also include integral goggles designed to protect the eyes from smoke and harmful gases (fullface).

2.3 The mask must be constructed of materials that –

- (a) do not contaminate air or oxygen;
- (b) are not adversely affected by continuous contact with oxygen; and
- (c) are at least flame resistant.

2.4 The mask must be designed to prevent the accumulation of hazardous quantities of expiratory gases within the facepiece chamber.

2.5 The mask must be designed to prevent the formation of accumulation of frost which would interfere with the function of the exhalation valve, unless it can be shown that the frost can be removed by external manipulation without removing the mask from the face of the user.

2.6 The fullface mask must be designed to include means for the prevention or the removal of condensation from the inside surfaces of the goggle lenses.

2.7 Masks equipped with oxygen supply tubes designed for quick disconnection at the mask or at the regulator must incorporate means to alert the user when his oxygen supply tube has become disconnected. Such means must not restrict the flow of ambient air through the oxygen supply tube by an amount exceeding 25 percent. This section does not apply if the quick disconnect device incorporates means to prevent inadvertent separation.

### 3.0 Performance.

Five masks of each kind for which approval is sought must be shown to comply with the minimum performance standards set forth in paragraphs 3.1 through 3.12, except that only one mask of each kind is required to comply with the provisions of paragraphs 3.6, 3.8, 3.9, and 3.11. Tests must be

conducted at ambient atmospheric conditions of approximately 30" hg. and 70° F., except as otherwise specified. Gas flow rates and pressures must be corrected to STPD.

3.1 *Quick-disconnect Coupling.* The force required to separate quick disconnect couplings not designed to prevent inadvertent separation must not be less than 10 pounds exerted along the axis of symmetry of the oxygen supply tube.

#### 3.2 *Strength.*

(a) The mask must be capable of sustaining a pull force on the suspension device attachment fittings of not less than 35 pounds in any direction for a period of not less than 3 seconds.

(b) The oxygen supply tube assembly must be capable of sustaining a pull force of not less than 30 pounds exerted along the axis of symmetry of the tube for a period of not less than 3 seconds.

(c) The oxygen supply tube assembly must be capable of sustaining an internal pressure of 1.5 p.s.i.g.

#### 3.3 *Leakage.*

(a) The total inward leakage rate, with the complete mask positioned on the face or on a suitable test stand in a manner which simulates normal use, must not exceed 0.10 LPM STPD at any negative differential pressure within the range of from zero to 6.0 inches of water.

(b) Inhalation valves installed in pressure-demand masks must not backleak more than 0.015 LPM, STPD, when subjected to a suction pressure differential of 0.1" H<sub>2</sub>O and not more than 0.15 LPM, STPD, when subjected to a suction pressure differential of 12.0" H<sub>2</sub>O.

(c) The oxygen supply tube assembly must not leak when subjected to an internal pressure of 1.5 p.s.i.g.

#### 3.4 *Flow Resistance.*

(a) The inspiratory resistance of the mask and oxygen supply tube including the oxygen supply connector when inserted in an appropriate mating fitting must not exceed the following negative differential pressures at the corresponding oxygen flow rates:

<i>Differential Pressure</i> <i>(inches H<sub>2</sub>O)</i>	<i>Flow Rate</i> <i>(LPM)</i>
0.6	20
1.5	70
2.5	100

(b) The expiratory resistance of the mask must not exceed the following positive differential pressures at the corresponding oxygen flow rates:

<i>Differential Pressure</i> <i>(inches H<sub>2</sub>O)</i>	<i>Flow Rate</i> <i>(LPM)</i>
1.0	20
2.0	70
3.0	100

3.5 *Pressure-Demand. Exhalation Valve Performance.* The exhalation valve installed in a pressure demand mask must open when the pressure within the facepiece is 20 mm Hg and the pressure in the supply tube is 15 to 19.9 mm Hg.

## FAA Standard associated with ETSO-C78

3.6 *Vibration.* The flow of gases during the respiratory process must not cause vibration, flutter, or chatter which would interfere with the satisfactory operation of the mask.

3.7 *Acceleration Load.* The exhalation valve must not inadvertently operate under a 3g load applied in any direction.

3.8 *Extreme Temperature.* The mask must comply with paragraphs 3.3 through 3.5 in an ambient temperature of 70° F. within 15 minutes after being stored at a temperature of 160° F. for 12 hours, and within 15 minutes after being stored at 0° F. for 2 hours. The relative humidity during storage must vary from 5 to 95 percent. The mask facepiece must not be gummy or sticky and must provide a normal seal after the high temperature exposure.

### 3.9 *Low Temperature Test Delay*

(a) The mask must function properly, without apparent delay, at a temperature of 70° F. after being stored at a temperature of 20° F. for not less than 2 hours.

(b) The mask must function properly, without apparent delay, and continue for a period of not less than 15 minutes when tested at a temperature of 20° F. after being stored at a temperature of 70° F. for not less than 12 hours.

### 3.10 *Decompression.*

(a) A mask not equipped with a pressure relief valve must not suffer damage and must comply with paragraphs 3.3 through 3.5 after being subjected to a decrease in ambient pressure from 12 p.s.i.a. to not less than 2.7 p.s.i.a. for a straight or diluter-demand kind, or to not less than 2.1 p.s.i.a. for a pressure demand kind, within a period of not more than 1 second. This decompression test must simulate the condition that could be imposed on a mask being worn by a crewmember during the specified decompression.

(b) A mask equipped with a pressure relief valve must be subjected to the decompression specified in subparagraph (a) of this section during which the pressure relief valve must open at a differential pressure of 17" H<sub>2</sub>O and must relieve the differential pressure to a value not exceeding 16" H<sub>2</sub>O within 5 seconds. During the 5-second interval, the pressure differential must not exceed a value of 20" H<sub>2</sub>O. The pressure relief valve must close at a differential pressure of 14" H<sub>2</sub>O.

3.11 *Cycling.* The mask must comply with paragraphs 3.3 through 3.5 after being subjected to

the following simulated breathing schedule for a total of 50,000 cycles:

<i>Respiratory Cycles</i>	<i>Minute Flow Rate LPM, STPD</i>	<i>Volume, Tidal Liters</i>
20,000	20	1.0
25,000	30	1.5
5,000	70	2.0

A constant time interval must be maintained between respiratory cycles.

3.12 *Microphone.* If the mask is designed to include a microphone, the installation of the microphone must not interfere with the operation of the mask.

## 4.0 **Quality Control.**

4.1 *Production Tests.* Each mask must be shown to comply with the provisions of paragraph 3.3(a), total leakage.

4.2 *Random Tests.* One mask must be selected at random from each lot and must be shown to comply with paragraph 3.1 through 3.12. The lot size must be selected by the applicant subject to the approval of the Federal Aviation Administration (see FAR § 37.5), on the basis of evaluation of the applicant's quality control systems (see § 37.5 (a) (3) ).

## 5.0 **Maximum Environmental (Cabin) Altitude.**

The minimum pressure to which the mask has been shown to decompress satisfactorily in accordance with paragraphs 3.10(a) or (b) of this standard determines the maximum environmental altitude of the mask, except that it shall not exceed the value shown in the following table:

MAXIMUM ENVIRONMENTAL (CABIN) ALTITUDE	KIND OF MASK
40,000 feet	STRAIGHT OR DILUTER-DEMAND
45,000 feet	PRESSURE-DEMAND

## 6.0 **Abbreviations and Definitions.**

LPM	Liters per minute.
STPD	Standard temperature and pressure, dry (0°C. 760 mm. Hg.)
p.s.i.g.	Pounds per square inch, gage.
p.s.i.a.	Pounds per square inch, absolute.
g	Acceleration or gravity, 32.2 feet/second <sup>2</sup> .
Tidal volume	Volume of air inspired per breath.

**FAA Standard associated with ETSO-C78**

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** FIRE DETECTORS (RADIATION SENSING TYPE)

### **1 - Applicability**

This ETSO gives the requirements which fire detectors (radiation sensing type) that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### **2 - Procedures**

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### **3 - Technical Conditions**

#### 3.1 - Basic

##### 3.1.1 - Minimum Performance Standard

Standards set forth in the attached Federal Aviation Administration Standard "Fire Detectors - Radiation Sensing Type", dated May 15, 1963.

##### 3.1.2 - Environmental Standard

As specified in Federal Aviation Administration Standard: "Fire Detectors - Radiation Sensing Type".

##### 3.1.3 - Computer Software

None

#### 3.2 - Specific

None.

### **4 - Marking**

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2; in addition, the operating voltage for the detector shall be shown and the compliance of the detector with the piston or turbine engine requirements or both shall be designated by -P, -T or -PT respectively, as a suffix following the ETSO designation as ETSO-C79-P.

#### 4.2 - Specific

None.

### **5 - Availability of Referenced Document**

- See CS-ETSO Subpart A paragraph 3.

# FAA Standard associated with JTSO-C79

## Federal Aviation Agency Standard For Fire Detectors-Radiation Sensing Type

**1.0 Purpose.** To specify minimum requirements for powerplant fire detection instruments for use in piston and turbine engine-powered aircraft, the operation of which subjects the instrument to environmental conditions specified in paragraph 3.3.

**2.0 Scope.** This standard covers the requirements for acceptance of radiation sensing "surveillance" type fire detectors, intended for use in protecting aircraft powerplant installations, auxiliary powerplants, combustion heaters, and other installations where fires may occur. For purposes of this document, the "instrument" shall be considered as the fire warning system and all components thereof.

**2.1 Definition.** Radiation sensing type fire detector is an instrument which will initiate an alarm signal when exposed to radiant energy emitted by a flame. The detector and associated circuitry may be designed to be selective with respect to such factors as spectral sensitivity, irradiance level at the detector, rate of rise of irradiance, or frequency characteristics of the fluctuations of irradiance (flicker) or other flame characteristics.

### 3.0 General Requirements.

#### 3.1 Materials and Workmanship.

**3.1.1 Materials.** Materials shall be of a quality which experience and/or tests have demonstrated to be suitable and dependable for use in aircraft instruments.

**3.1.2 Workmanship.** Workmanship shall be consistent with high-grade aircraft instrument manufacturing practice.

#### 3.2 Blank.

**3.3 Environmental Conditions.** The following conditions have been established as design minimum requirements. Tests shall be conducted as specified in paragraphs 5, 6 and 7.

**3.3.1 Temperature.** When installed in accordance with the manufacturer's recommendations, the instrument shall function over the range of ambient temperatures shown in column A.

Instrument Location	A
Powerplant Compartment (Piston)	-30 to 130 C.
Powerplant Compartment (Turbine)	-30 to 150 C.
Pressurized Areas (Both types)	-30 to 50 C.
Nonpressurized or of engine)	-55 to 70 C.
External Areas	

If the instrument is intended for use in compartments where the maximum ambient temperature is higher than 130° C for piston engines and 150° C. for turbine engines or if ambient temperatures lower than those specified in column A are anticipated, appropriate special limits shall be selected and specified by the manufacturer.

**3.3.2 Humidity.** The instrument shall function without adverse effect and shall not be adversely

affected when exposed to an atmosphere having any relative humidity in the range from 0 to 95 percent at a temperature of approximately 70° C.

**3.3.3 Altitude.** When installed in accordance with the instrument manufacturer's instructions, the instrument shall function and shall not be adversely affected by pressure conditions equivalent to those experienced over an altitude range of -1,000 feet to 50,000 feet. Altitude pressures are to be per NACA Report 1235.

**3.3.4 Vibration.** When installed in accordance with the instrument manufacturer's instructions, the instrument shall function without adverse effect and shall not be adversely affected when subjected to vibrations having the following characteristics:

	Frequency Cycles Per Sec	Max. Double Amplitude in Inches	Maximum Acceleration
<i>Piston Engines</i>			
Airframe Structure			
Mounted	5-500	0.050	10 g.
Shock-Mounted Panel	5-50	0.020	1.5 g.
Powerplant Mounted	5-500	0.100	20 g.
<i>Turbine Engines</i>			
Nacelle and Nacelle Mounts, Wings, Empenage and Wheel Wells			
	5-1000	0.036	10 g.
Fuselage-			
Forward of Spar Area	5-500	0.036	2 g.
Center of Spar Area	5-1000	0.036	4 g.
Aft of Spar Area	5-500	0.036	7 g.
	500-1000	-----	5 g.
Vibration Isolated	5-50	0.020	1.5 g
Racks	50-500	-----	0.5 g
Instrument Panel	5-500	0.030	1.0 g

**3.3.5 Fluids and Sand.** The instrument shall not be adversely affected by exposure to rain, fuel, salt spray, oil, or sand.

**3.4 Radio Interference.** The installation limitations imposed as a result of radio frequency emissions shall be determined and specified.

**3.5 Magnetic Effect.** The installation limitations imposed as the result of a magnetic field shall be determined and specified.

### 4.0 Detail Requirements.

**4.1 Indication Means.** The instrument shall be capable of actuating visual and/or aural alarm indicators.

**4.2 Reliability.** The instrument shall be designed to withstand the mechanical and thermal shocks, and stresses incident to its use in aircraft. False alarm signals shall not result from variations in voltage encountered during operation of the aircraft, abnormal altitudes, contaminants in the atmosphere, ambient light conditions, acceleration forces

encountered during flight, landing and take-off. The fire detector shall not false alarm and the detector sensitivity shall not be appreciably affected by the ambient light in the aircraft compartment in which the sensor is installed, under any combination of normal aircraft operating conditions and atmospheric conditions. Tests aimed at determining the effects of the foregoing factors on detector reliability are described in paragraph 7.3.

4.3 *Integrity Test Means.* The instrument shall be designed to provide a means for testing the continuity and functioning of the electrical circuits inflight.

4.4 *Calibration Means.* The instrument shall be designed so that all calibration means are provided with tamper-proof seals.

4.4.1 *Adjustable Detector Systems.* Instruments which incorporate an adjustment means shall be tested to prove compliance with this standard, particularly paragraphs 7.1, 7.1.1 and 7.3 throughout the range of adjustability.

## 5.0 *Test Conditions.*

5.1 *Atmospheric Conditions.* Unless otherwise specified, all tests required by this standard, shall be conducted at an atmospheric pressure of approximately 29.92 inches of mercury and at an ambient temperature of approximately 25 C. and at a relative humidity of not greater than 85 percent.

5.2 *Vibration* (To minimize friction): Unless otherwise specified, all tests for performance may be conducted with the instrument subjected to a vibration of 0.002 to 0.005 inch double amplitude at a frequency of 1,500 to 2,000 cycles per minute. The term double amplitude as used herein indicates the total displacement from positive maximum to negative maximum.

5.3 *Vibration Equipment.* Vibration equipment shall be such as to allow vibration to be applied along each of three mutually perpendicular axis of the instrument at frequencies and amplitudes consistent with the requirements of paragraph 3.3.4.

5.4 *Power Conditions.* Unless otherwise specified, all tests shall be conducted at a power rating recommended by the manufacturer, and the instrument shall be in actual operation.

5.5 *Test Position.* Unless otherwise specified, the instrument shall be mounted and tested in its normal operating position.

6.0 *Individual Performance Requirements.* All instruments or components of such shall be subjected to tests by the manufacturer to demonstrate specific compliance with this standard including the following requirements where applicable.

6.1 *Sensitivity and Calibration.* The sensor shall be tested as specified in paragraph 7.1, to determine the response sensitivity and calibration.

6.2 *Dielectric.* Each instrument shall be tested by the methods of inspection listed in paragraphs 6.2.1 and 6.2.2.

6.2.1 *Insulation Resistance.* The insulation resistance between all electrical circuits connected together and the metallic case shall not be less than 5

megohms when 200 volts d.c. is applied for five seconds. Insulation resistance measurements shall not be made to circuits where the potential will appear across elements such as windings, resistors, capacitors, etc., since this measurement is intended only to determine adequacy of insulation.

6.2.2 *Overpotential Tests.* Equipment shall not be damaged by the application of a test potential between electrical circuits, and between electrical circuits and the metallic case. The test potential shall be a sinusoidal voltage, of a commercial frequency, with an r.m.s. value of five times the maximum circuit voltage or per paragraphs 6.2.2.1 or 6.2.2.2, which ever applies. The potential shall start from zero and be increased at a uniform rate to its test value. It shall be maintained at this value for five seconds, and then reduced at a uniform rate to zero.

Since these tests are intended to insure proper electrical isolation of the circuit components in question, these tests shall not be applied to circuits when the potential will appear across elements such as windings, resistors, capacitors, etc.

6.2.2.1 Hermetically sealed instruments shall be tested at 200 volts r.m.s.

6.2.2.2 Circuits that operate at potentials below 15 volts are not to be subjected to overpotential tests.

## 7.0 *Qualification Performance Requirements.*

As many instruments as deemed necessary to demonstrate that all instruments will comply with the requirements of this section shall be tested in accordance with the manufacturer's recommendations. The tests on each instrument shall be conducted consecutively in the order listed, and after the tests have been initiated, further adjustments to the instrument shall not be permitted. A false alarm signal occurring during any of the tests shall disqualify the instrument. A response time test per paragraph 7.1 shall be conducted after each test, except paragraphs 7.2, 7.2.1, 7.2.3, and 7.14. In conducting the test of paragraph 7.14, the instrument(s) tested need not be the same instrument(s) being subjected to the entire series of qualification tests.

7.1 *Response Time.* The sensor of the instrument shall be exposed, at a distance of four feet to a test flame produced by burning gasoline in a flat pan five inches in diameter and with a flow of air of ten feet per second maximum. The temperature of the gasoline and the pan at the start of each test shall not exceed 85° F. A nonleaded white gasoline shall be used. The response time shall not exceed five seconds.

7.1.1 *Saturation Test.* The sensor shall be mounted facing downward approximately three inches above the center of a flat pan, two feet in diameter, containing gasoline to a level of 1/8-inch from the bottom. The gasoline shall be ignited by a source that cannot be detected by the sensor. The response time shall not exceed five seconds, and the system shall not clear the alarm while exposed to this test for a period of one minute.

**7.1.2 Repeat Response Time.** The sensor of the fire detector shall be exposed to the flame as described in 7.1 for a period of one minute. It shall then be prevented from sensing the flame. Within five seconds after the alarm has cleared, the sensor shall again be exposed to the flame. An alarm shall be signalled within five seconds.

**7.2 False Alarm Due to Rate of Temperature Rise.** The tests described in 7.2.1 and 7.2.2 shall be conducted in a temperature-controlled airflow moving at a velocity of 250 feet per minute plus or minus 25 feet per minute. The instrument for this test shall consist of a control unit complete with the maximum number of sensors to be used with a single control unit. An alarm signal shall occur.

**7.2.1 Local Temperature Rise.** One sensor shall be subjected to various combinations of rates of temperature rise and duration of those rates of rise shown in the shaded area of Figure 3(a). The other sensors in the system shall be maintained at ambient room temperature. This test shall be conducted simulating conditions due to local overheating. No alarm signal shall occur.

**7.2.2 General Temperature Rise.** The test described in 7.2.1 shall be repeated using Figure 3(b) except that all the sensors shall be subjected to the temperature variations simultaneously. The test shall be conducted simulating conditions due to a general temperature rise throughout the compartment where the sensors are located. No alarm signal shall occur.

**7.2.3 False Clearing of Alarm Due to Partial Extinguishment of Fire.** With the instrument arranged to test the response time, in accordance with 7.1, the test flame shall be applied for 30 seconds. The test flame shall then be masked so as to reduce its effective area by approximately 50 percent. The alarm signal shall not clear. After an additional 30 seconds, the flame shall be removed entirely, and the alarm signal shall clear within 10 seconds.

**7.3 Test Procedures to Establish Detector Reliability Under Special Environmental Conditions.** The following test procedures shall apply to establish detector system reliability under various adverse conditions. In conducting the tests, the system shall contain the critical number of sensors for specific test conditions.

**7.3.1 Blank.**

**7.3.2 Magnesium Flame.** Using the test apparatus and setup given in paragraph 7.1 place a 6 inch length of magnesium ribbon, approximately  $\frac{1}{8}$  inch wide and 0.005 inch thick, at a point midway between the sensor element and the fire and in line with the sensor. Ignite the gasoline and while the alarm light is on, ignite the magnesium. The alarm shall not clear while either the magnesium, the gasoline, or both are burning.

**7.3.3 Sunlight.** The test shall be made with sunlight shining directly on the detector (not through a closed window) and the sun shall be within 45° of the zenith so that the slant path through the atmosphere will not be too long. The illumination shall be 5,000 foot-candles or greater, with the light meter probe facing the sun. The detector shall be

exposed to sunlight for 30 seconds without actuating the alarm.

**7.3.4 Chopped Sunlight.** In this test, the sunlight (see 7.3.3) shall be modulated by a shutter blade system over a frequency range of 100 cycles per second to 0 cycles per second. This frequency range shall be swept out over a sufficient duration so that there will be a dwell time of a few seconds in any frequency band over the range. A satisfactory chopping arrangement would be a four-bladed shutter on the shaft of a small universal wound motor operating from a Variac or other source of adjustable voltage. The shutter blades must be large enough to obscure the sun completely from the detector when they are in front of the detector, and blades should be not more than 1 inch away from the detector so that the light from the sky itself will also be modulated. No alarms shall result from the above testing.

**7.3.5 Sunsets and Signal Lights.** An array of colored, incandescent light bulbs shall be used to simulate the colorimetric properties of sunsets at several stages. (This test would also take care of identification and marker lights, and red side of a beacon light, and the anticollision light that flicks past the powerplants). The bulbs shall be 40-watt yellow, orange, and red ones such as General Electric Nos. 40 A/Y, 40 A/O, and 40 A/R, or equivalent. The test is to be conducted in subdued room illumination of not more than one-foot candle on the detector (too dim to read fine print). The test shall comprise an exposure of the detector to each of the three lamps, at 3 feet, for 30 seconds each, without causing an alarm.

**7.3.6 Restricted Light.** The effect of sunlight and incandescent light on the instrument when viewed through apertures of varying sizes shall be determined. The aperture sizes may be chosen arbitrarily but should be representative of openings that might be encountered in an aircraft installation (e.g. vents, scoops, and drains in engine cowling, etc.)

NOTE. If the instrument false alarms during ambient light test requirements of paragraphs 7.3.3, 7.3.4, 7.3.5, and 7.3.5, but otherwise qualifies, installation limitations shall be determined and imposed. These limitations shall be clearly and explicitly stated as part of the required data.

**7.4 Vibration.**

**Resonance:** The instrument, while operating, shall be subjected to a resonant frequency survey of the appropriate range specified in paragraph 3.3.4 in order to determine if there exists any resonant frequencies of the parts. The amplitude used may be any convenient value that does not exceed the maximum double amplitude or the maximum acceleration specified in paragraph 3.3.4.

The instrument shall then be subjected to vibration at the appropriate maximum double amplitude or maximum acceleration specified in paragraph 3.3.4 at the resonant frequency for a period of one hour in each axis.

When more than one resonant frequency is encountered with vibration applied along any axis, a

test period may be accomplished at the most severe resonance or the period may be divided along the resonant frequencies, whichever shall be considered most likely to produce failure. The test period shall not be less than one-half hour at major resonant mode.

When resonant frequencies are not apparent within the specified frequency range, the instrument shall be vibrated for two hours in accordance with the vibration requirements schedule (paragraph 3.3.4) at the maximum double amplitude and the frequency to provide the maximum acceleration.

*Cycling:* The instrument, while operating, shall be tested with the frequency varied between limits specified in paragraph 3.3.4 in 15-minute cycles for a period of one hour in each axis at an applied double amplitude specified in paragraph 3.3.4 or an acceleration specified in 3.3.4 whichever is the limiting value.

*7.5 Water Spray.* The instrument components which are to be located outside the pressurized area of the aircraft shall be subjected to the following tests:

*7.5.1 Simulated Rain.* The component shall be subjected to a spray of water to simulate rain for a period of three hours. The component shall not be dried prior to testing, per paragraph 7.1.

*7.5.2 Salt Spray.* The instrument components which are to be installed in exposed portions of the aircraft shall be subjected to a finely atomized spray of 20 percent sodium chloride solution for 50 hours. At the end of this period, the component shall be allowed to dry and shall be tested per paragraph 7.1.

*7.6 Humidity.* The instrument shall be mounted in a chamber maintained at a temperature of  $70\pm 2$  C. and a relative humidity of  $95\pm 5\%$  for a period of six hours. After this period, the heat shall be shut off and the instrument shall be allowed to cool for a period of 18 hours in this atmosphere in which the humidity rises to 100% as the temperature decreases to not more than 38 C. This complete cycle shall be conducted five times.

Immediately after this cycling, there shall be no evidence of damage or corrosion which affects performance.

*7.7. Fuel and Oil Immersion.* The instrument components which are to be installed in engine compartments or other locations in the aircraft where they may be contaminated by fuel or oil shall be subjected to the following tests:

*7.7.1 Fuel Immersion.* The component shall be immersed in normally leaded grade 100/130 gasoline or turbine engine fuel as appropriate, at room temperature and then allocated to drain for one (1) minute before being tested, per paragraph 7.1. No cleaning shall be accomplished prior to conducting subsequent tests.

*7.7.2 Oil Immersion.* The test procedures outlined in paragraph 7.7.1 shall be conducted with MIL-O-7808 oil (turbine engine oil) or SAE #50 (piston engine oil) as appropriate.

*7.8 Sand.* The instrument components which are to be located in externally exposed portions of the aircraft (such as in nacelles, wheel wells, etc.) shall

be subjected to a sand-laden airstream flowing at a constant rate of  $2\frac{1}{2}$  pounds of sand per hour for four hours. The airstream shall contain sand that has been sifted through a 150-mesh screen and the particles shall come in contact with all external parts of the component being tested. The test chamber shall be equivalent to that shown in Figure 1.

*7.9 High Temperature Operation.* The instrument shall be subjected to the applicable higher ambient temperature listed in Column A of table in paragraph 3.3.1 Temperature, for a period of 48 hours (electrical equipment energized). Where the highest recommended operating temperature exceeds those of Column A, this higher temperature shall be used. The instrument shall meet, while at that temperature(s), the performance tests described in paragraphs 7.1 and 7.1.1.

*7.10 Low Temperature Operation.* Same as requirement 7.9, except substitute "lower" for "higher". The instrument shall then meet, at that temperature, the performance tests described in paragraphs 7.1 and 7.1.1.

*7.11 Altitude Effects.*

*7.11.1 High Altitude and Rate of Climb.* The instrument shall be subjected to a pressure that is varied from normal atmospheric pressure to an altitude pressure equivalent to 50,000 feet at a rate of not less than 3,000 feet per minute. The instrument shall be maintained at the altitude pressure equivalent to 50,000 feet for a period of 48 hours. The instrument shall then be tested per paragraphs 7.1 and 7.1.1 under the conditions specified in the first sentence. Sealed components shall not leak as a result of exposure to the pressures stated herein. This shall be demonstrated by immersion of sealed components in water or equivalent and by performing a leak test.

*7.11.2 Low Altitude.* The instrument shall be subjected to the same test as outlined in paragraph 7.11.1, except that the pressure shall be maintained at an altitude pressure equivalent to -1,000 feet and the rate or pressure variation need not be as specified therein.

*7.11.3 Depressurization Test.* The components which are to be located in a pressurized area shall be subjected to a pressure of 22 inches of mercury absolute for a period of 15 minutes. The pressure shall then be reduced to 3 inches of mercury. This reduction in pressure shall be effected in a time period not to exceed 10 seconds. The instrument shall not false alarm while being subjected to this test.

*7.12 Voltage Variation.* The instrument shall be operated with the voltage varied between 75 and 110 percent of the rated voltage. The instrument shall then be tested per paragraph 7.1 under these conditions. Compliance with the provisions of paragraph 4.2 shall also be demonstrated.

*7.13 Clearance Time.* The instrument shall be exposed to the flame as described in paragraph 7.1 and three determinations made of the time required for the signal to clear. This shall be accomplished by obtaining a response, and immediately turning the

instrument so that it ceases to sense (view) the fire, and the time required for the signal to disappear obtained. This time duration is the "clearance time". It shall not exceed 10 seconds. During this test, the sensor shall be subjected to the most critical vibration (frequency and amplitude conditions as determined in 7.4).

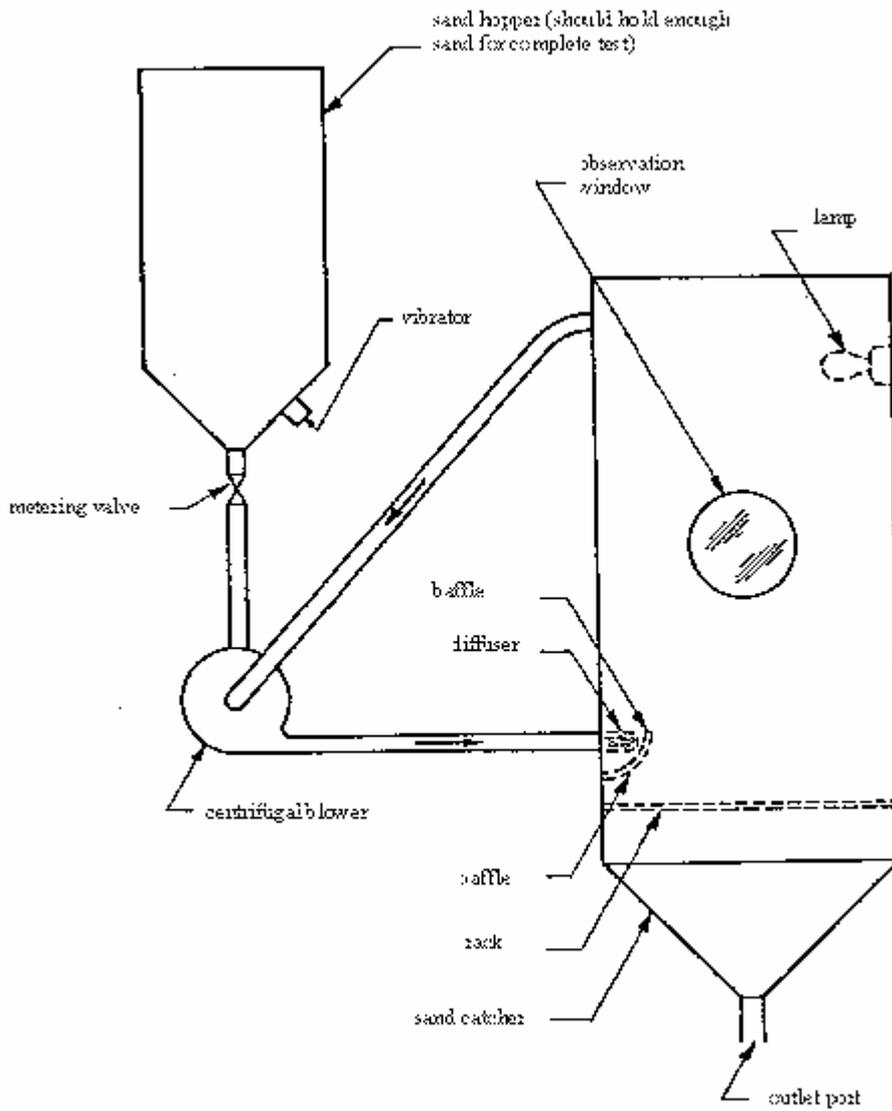
*7.14 Fire Resistance.* For instrument sensing components, including detectors and connecting electrical wire, which are to be installed in a fire zone, tests shall be conducted to show resistance to a completely enveloping flame of 1,100° C. minimum for two periods of one minute each. The flame shall be as specified in Figure 2. The sensor shall be cooled to room temperature after each exposure to flame. The instrument shall then be exposed to the same flame for a third time. An alarm shall be signalled in not more than five seconds after each of the exposures. The instrument shall produce alarm clearance in not more than 45 seconds after the flame has been removed in the first two cases. Artificial means of cooling the instrument shall not be used until after the alarm has cleared.

If the instrument does not comply with the fire resistance test requirements, but otherwise qualifies,

the instrument can be subjected for installation in locations where it would not be subjected to flame. In this case, however, the instrument would be restricted to this type of installation and any other limitations involved.

*7.15 Radio Interference.* Using Stoddard Models M-20B, NM-5A, NM-10A, NM-50A or equivalent noise and field strength meters, measure the RF voltage developed in the various circuitry, tuning the noise meter throughout the range of frequencies from 90 kc. to 1,500 mc. Peak readings in microvolts shall be recorded. When the peak reading is in excess of 200 microvolts, then all readings above 200 microvolts shall be tabulated and installation limits imposed accordingly.

*7.16 Magnetic Effect.* Using a Kueffel and Esser Type 5600 or equipment magnetic compass, determine the minimum distance between the instrument and compass without causing a compass deflection of more than 5 degrees. In substantiating the minimum distance, compact readings shall be taken in each of the four quadrants of a plane passing through the component's axis.



**Figure 1. Schematic Sand Test Arrangement (Ref. Section 7.8)**

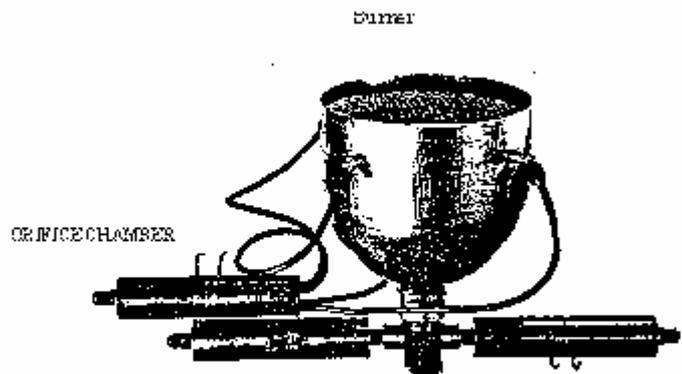


Figure 2-1. Standard Bumer Assembly

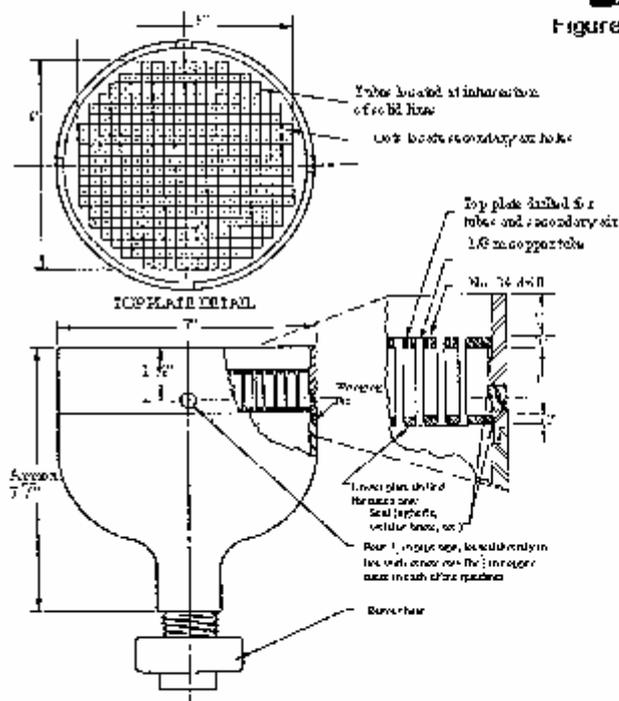
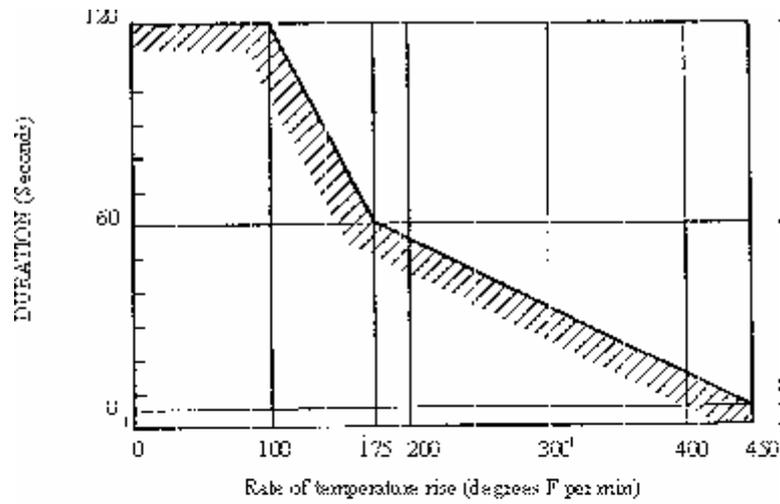
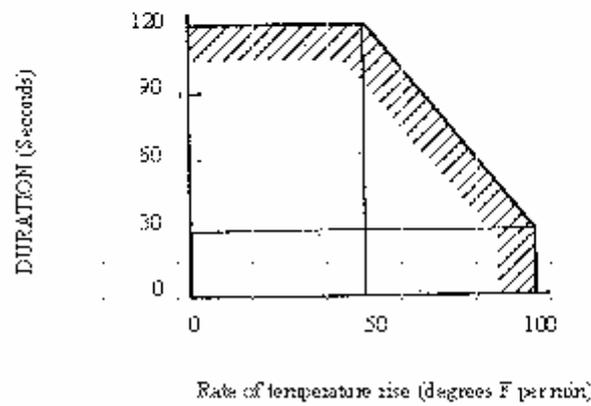


Figure 2-2. Standard Bumer





**Figure 3 (a). Local temperature rise condition**  
(Ref. Section 7.2.1)



**Figure 3 (b). General temperature rise condition**  
(Ref. Section 7.2.2)

# European Aviation Safety Agency

## European Technical Standard Order

Subject: FLEXIBLE FUEL AND OIL CELL MATERIAL

### 1 - Applicability

This ETSO gives the requirements that flexible fuel and oil cell material which are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

### 2 - Procedures

#### 2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

#### 2.2 - Specific

None.

### 3 - Technical Conditions

#### 3.1 - General

##### 3.1.1 - Minimum Performance Standard

Standards set forth in Federal Aviation Agency Standard, "Flexible Fuel and Oil Cell Material", dated August 1, 1963 (see Appendix 1).

##### 3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1

##### 3.1.3 - Computer Software

None

### 4 - Marking

#### 4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2; in addition, each flexible fuel and oil cell material shall be legibly and permanently marked with the following information:

- (i) Type of fluid for which approved, i.e. fuel, or MIL-L-6082 oil, or MIL-L-7808 oil,
- (ii) For oil cell material, the minimum and maximum temperature limit,
- (iii) For oil cell material, the oil-dilution suitability.

#### 4.2 - Specific

None.

### 5 - Availability of referenced documents

See CS-ETSO Subpart A paragraph 3.

**APPENDIX 1**  
FEDERAL AVIATION AGENCY STANDARD  
FOR  
FLEXIBLE FUEL AND OIL CELL MATERIAL

**1.0 Purpose.** To specify minimum requirements for flexible fuel and oil cell material intended for use in fuel and oil tanks of aircraft.

**2.0 Scope.** This standard covers the requirements of fuel and oil cell material in which hydrostatic loads are resisted by the structure of the cavity or tank and not by the cell material itself.

**3.0 General Requirements.**

**3.1 Materials.** Samples of flexible fuel and oil cell materials and construction techniques shall be subjected to and satisfy the following tests prescribed under paragraph 4.0

**4.0 Tests.** The applicable tests for substantiating flexible fuel and oil cell material and construction techniques are indexed below in Table I.

TABLE I

<i>Tests</i>	<i>Par. No.</i>	<i>Oil</i>	<i>Fuel</i>
Leakage <sup>1</sup>	5.0	X	X
Aging	6.0	X	-
Slosh	7.0	X	X
Stand	8.0	X	X
Humidity	9.0	X	X
Fluid Resistance of Exterior Surfaces	10.0	X	X
Permeability	11.0	-	X
Fuel Contamination <sup>2</sup>	12.0	-	X
Oil Dilution Resistance	13.0	X	-
Inner Liner Strength	14.0	X	X
Seam Adhesion	15.0	X	X
Puncture Resistance	16.0	X	X
Low Temperature Leakage	17.0	X	X

**4.1 Test Samples.** Test samples shall consist of the following :

a. Two cells with outside dimensions of 24x30x30 inches containing fittings representative of those used in tank construction for airframe installation. One cell to be used for stand test (par. 8.0), the other for all other cell tests.

b. Two 12x12 inch samples of composite cell construction. One for humidity test (par. 9.0), the other for puncture test (par. 16.0).

c. One sample of inner layer ply, without barrier, approximately 900 square inches in area including seam for inner liner strength test (par. 14.0) and seam adhesion test (par. 15.1).

d. One sample 6x6 inch inner layer ply, without barrier for all other inner layer tests.

e. Two permeability samples as specified in paragraph 11.0. None of these samples shall be preplasticized with fluid prior to testing.

**4.2 Test Fluids.** Unless otherwise specified, the following test fluids shall be used in testing the different tanks.

a. Fuel Tank: Test fluid conforming to MIL. Spec. MIL-S-3136, Type III.

b. Oil Tank: Oil conforming to MIL. Spec. MIL-L-6082, Grade 1100.

c. Oil Tank: Oil conforming to MIL. Spec. MIL-L-7808.

**5.0 Leakage.** Each cell, with all openings sealed and with the minimum of external support necessary to maintain the cell shape, shall be subjected to an internal air pressure of 2.0 p.s.i. The cell shall then be completely submerged in water or completely covered with soapy water. Leakage indicated by air bubbles in the water or soapy water solution shall be cause for rejection. Alternate methods of checking leakage may be used if approved by the Authority.

## 6.0 Aging.

**6.1 Test Conditions.** The maximum temperature capability of oil cell material shall be selected by the manufacturer and stated as a limitation under § 514.86(c) (2). During the tests, the test fluid temperature shall be uniformly maintained throughout the cell.

**6.1.1 Test Duration.** This test shall be conducted for period of 200 hours.

**6.1.2 Test Procedure.** The cell shall be filled with 80 gallons of either test fluid 4.2b. or c. as applicable. At the end of the test period, the cell shall show no signs of deterioration or other unsatisfactory conditions.

## 7.0 Slosh.

**7.1 Test Conditions.** The following test conditions shall prevail during slosh test.

**7.1.1 Rocking Angle.** The slosh rocking angle shall be 30 degrees total, approximately 15 degrees on either side of the horizontal position.

**7.1.2 Mounting Axis.** The cell shall be mounted in such a manner that the 24 inch dimension is vertical. This position shall be known as the horizontal position.

**7.1.3 Fluid Temperatures.** The temperature of the fluid during the slosh test shall be as shown in the table below:

### Test Fluid Temperatures

#### Test Fluid Temperatures

Fuel	135°±10° F.
Oil	Maximum temperature (±10° F.) selected by manufacturer and stated as a limitation

**7.14 Test Duration.** This test shall be run as follows:

- a. Slosh for 25 hours at 16 to 20 c.p.m., or
- b. Slosh for 40 hours at 10 to 16 c.p.m.

**7.15 Test Procedure.** The test cell complete with filler cap, vents, and typical outlet fittings shall be installed in a suitable mounting structure, then mounted on the support jig and rocker assembly. Sections of flexible hose shall be connected to the vent and outlet fittings. The other end of each of these sections shall be rigidly attached to the support jig. The hoses shall be installed and supported in a manner representative of an actual installation in an aircraft.

The tank mounting structure is to be representative of an actual aircraft fuel cell compartment. Recommendations of the cell manufacturer for supporting or mounting the fuel cell in the aircraft fuel cell compartment are to be incorporated. The interior of the support jig shall be completely lined with brown paper held in place by a suitable adhesive.

The test specimen shall be filled two-thirds full with the applicable test fluid containing a suitable dye. For fuel cells, one-half gallon of water shall also be added. For oil cells intended for use in aircraft using an oil dilution system, 30 percent by volume of fluid 4.2a. shall be added to the test fluid. At the conclusion of this test, the test specimen shall be completely filled with the applicable test fluid and thoroughly inspected for leakage or other evidence of failure.

**8.0 Stand Test.** This test shall be conducted on the second test cell as provided for in paragraph 4.1a. The test cell may be installed in the support structure used for the slosh test or a similar structure which is lined with brown paper. The cell shall be filled with the appropriate test fluid containing a satisfactory staining agent. There should be no leakage or evidence of other failure at the end of 90 days under these conditions.

**9.0 Humidity.** A 12x12 inch sample of the composite cell construction shall be subjected for a total period of 15 days to the following 24-hour test cycle.

- a. 8 hours at 130°±3° F. and 100 percent relative humidity
- b. 4 hours cooling to approximately 70°±3° F.
- c. 8 hours at 70°±3° F. and 100 percent relative humidity.

d. 4 hours heating to 130°±3° F. There shall be no corrosion, peeling, cracking, warping, blistering, delamination or discoloration of the cell after this period.

**10.0 Fluid Resistance of Exterior Surfaces.** The cell shall be placed in a container sufficiently large to permit immersion to one-half the depth of the cell in the applicable test fluid. The cell shall be immersed for 24 hours at ambient temperature, after which it will be removed and examined. The exterior surface of the cell construction shall show no unsatisfactory swelling, blistering, dissolution, or other deterioration.

**11.0 Permeability.**

**11.1 Test Apparatus.** The test apparatus shall consist of the following:

- a. Two permeability cups and rings constructed in accordance with Figure 1.
- b. A nylon solution shall be used for sealing the test disk to the permeability cup.

**11.1.1 Preparation of Test Specimens.** The uncured inner liner shall be applied to a 10x10 inch piece of corrugated fiberboard coated on one side with a suitable water soluble breakaway agent. The exposed surface of the inner liner shall be coated with prime cement and barrier resin (if required) in accordance with applicable manufacturing specifications. The assembly shall be wrapped with cellophane and covered with a suitable waterproof bag.

The assembly shall be vulcanized as in normal production. After vulcanizing, the waterproof bag and cellophane shall be removed and the inner liner shall be removed from the fiberboard using water as necessary. Free moisture shall be wiped from the assembly and it shall be conditioned 24 hours at a constant temperature of 77°±5° F. and a relative humidity of 40±5 percent. Two 2.5 inch diameter disks shall be cut from the vulcanized panel. One hundred ml. of test fluid specified in paragraph 4.2a. shall be placed in each of the permeability cups. Nylon solution shall be applied to the face of the cup flanges covering the area inside the bolt circle. The nylon solution shall be allowed to come almost to dryness, then the test disks shall be applied to the cups with the barrier, if any, facing outward. The assemblies shall be completed by attaching the bolting rings and tightening the bolts in accordance with the following schedule:

<i>Inner Liner Type</i>	<i>Bolt Torque</i>
Gum stock	5 to 10 in.-lb.
Coated fabrics	15 to 20 in.-lb.
Unsupported plastic films	20 to 25 in.-lb.

**11.1.2 Test Procedure.** Permeability cups prepared as specified above shall be placed in a suitable rack in a constant temperature of 77°±5° F. and a relative humidity of 40±5 percent.

After allowing 1 hour for equilibrium, the cups shall be weighed to the nearest 0.005 gram and placed in the rack with the faces of the cups facing upward (test disks up). The cups shall be kept at the above constant temperature for 24 hours, then weighed to check for seal integrity. The bolts shall be retorqued if necessary. The cups shall then be inverted (test disks down) in a rack that permits free access of air to the test disks.

Cups shall be weighed at the end of the third, fifth, and eighth day after inverting. Defective films or leaks caused by faulty assembly will usually be found when making the weighing on the third day. The diffusion rate calculation shall be made on the fifth day to eighth day period and expressed as fluid ounces per square foot per 24 hours. The permeability shall be less than 0.025 fluid ounces per square foot per 24 hours for each sample tested.

NOTE.—Diffusion expressed in fluid ounces per square foot per 24 hours equals the gram loss of the test specimen per 24 hours multiplied by a factor K which is defined as follows:

$$K = \frac{144}{(Sp. gr.)(29.573)(3.142)R^2}$$

Where

sp.gr. = Specific gravity of test fluid at 77° F.

R = Inside radius of test cup expressed in inches.

**12.0 Fuel Contamination.**

**12.1 Nonvolatile Gum Residue.** A five gram sample of the inner layers up to the barrier, shall be diced up into approximately 0.062 inch squares and placed in a flash containing 250 ml. of test fluid as specified in paragraph 4.2a. and allowed to stand for 48 hours at 77°±5° F.

The contaminated test fluid shall be decanted off, and the nonvolatile gum residue determined by Method 3302 of Federal Test Method Standard No. 791,<sup>4</sup> ASTM D381-54T, except that the total evaporation time shall be 45 minutes. The nonvolatile material shall not exceed 60 milligrams per 100 ml. of the contaminated fluid.

**12.1.1 Stoved Gum Residue.** The beakers containing the nonvolatile material shall be placed in an appropriate bath maintained constantly at a temperature of 572°±9° F. for 30 minutes. After cooling in a closed container, the beakers shall be weighed. The stoved gum residue shall not exceed 20 milligrams per 100 ml. of the contaminated fluid, after necessary corrections have been made for preformed gums originally present in the test fluid.

**13.0 Oil Dilution Resistance.** Tensile and elongation tests shall be made on the inner layer ply according to the methods described in Federal Test Method Standard No. 601,<sup>5</sup> Methods 4111 and 4121, respectively. Before and after the tests the test specimens shall be immersed for 48 hours at room temperature in the appropriate oil diluted 30 percent by volume with test fluid specified in paragraph 4.2a. The tensile properties shall not be reduced more than 40 percent from the original values, and the Shore A durometer hardness shall not vary more than 15 points from the original value.

**14.0 Inner Liner Strength.**

**14.1 Gum Inner Liner Strength.** The strength of the gum inner layer ply, without barrier, shall be determined in accordance with Federal Test Method Standard No. 601,<sup>5</sup> Method 4111 before and after immersion in the test fluid specified in paragraph 4.2a. for 72 hours at a temperature of  $135^{\circ}\pm 3^{\circ}$  F. The tensile strength shall also be determined before and after immersion in water for 72 hours at a temperature of  $135^{\circ}\pm 3^{\circ}$  F. The tensile strength shall not be reduced more than 50 percent for fuel immersion and 20 percent for water immersion calculated on the basis of the original cross-sectional area.

**14.2 Fabric Inner Liner Strength.** The tensile strength of the fabric inner layer ply, without barrier, shall be determined in accordance with Specification CCC-T-191,<sup>5</sup> Method 5100 before and after immersion in test fluid specified in paragraph 4.2a. for 72 hours at a temperature of  $135^{\circ}\pm 3^{\circ}$  F. The tensile strength shall also be determined before and after immersion in water for 72 hours at a temperature of  $135^{\circ}\pm 3^{\circ}$  F. The tensile strength shall not be reduced more than 20 percent for fuel immersion and 50 percent for water immersion calculated on the basis of the original cross-sectional area.

**15.0 Seam Adhesion.** The seam adhesion of the inner layer ply to itself before and after immersion in the test fluid specified in paragraph 4.2a for 72 hours at a temperature of  $135^{\circ}\pm 3^{\circ}$  F. shall be tested within 4 hours along the length of the seam by the strip back method using a jaw separation rate of 2 inches per minute in accordance with Federal Test Method Standard No. 601,<sup>5</sup> Method 8011. Where the adhesion of the seam is less than the strength of the material, the adhesion shall be a minimum of 6 pounds per inch.

**15.1 Seam Adhesion (Alternate Procedure).** As an alternate procedure to the above, the seam adhesions of the inner-layer ply to itself may be tested by cutting a strip of inner-layer material one inch wide having a seam made in the same manner as is used in the tanks submitted under paragraph 4.1a. This seam shall be perpendicular to and midway in the length of the strip. When a tensile load has been applied of sufficient magnitude to break the strip, there shall be no failure of the seam.

**16.0 Puncture Resistance.** A cell wall shall be fastened in a specimen holder in accordance with Figure 2. A piercing instrument with its end conforming to Figure 2 shall be forced against the cell wall at approximately the centre of the area enclosed by the specimen holder. The force required to puncture the cell shall not be less than 15 pounds.

**17.0 Low Temperature Leakage.** The cell supporting structure cavity shall be lined with brown paper and the cell installed in the structure. The cell shall be completely filled with the appropriate test fluid containing a staining agent and allowed to stand for seven days at  $135^{\circ}\pm 10^{\circ}$  F. The cell shall then be emptied and subjected to an air dry out at  $155^{\circ}\pm 5^{\circ}$  F for seven days. The cell shall then be completely refilled with the appropriate test fluid containing a straining agent, cooled to  $-65^{\circ}\pm 5^{\circ}$  F. and allowed to stand at this temperature a minimum of three days. The test fluid in contact with the cell inner liner shall have reached  $-65^{\circ}$  F. prior to the start of the three-day period. The cell shall be instrumented by placing thermo-couples against the inside surface of the cell liner, one with six inches of the top surface on one side panel and the other within six inches of the bottom surface on the opposite side panel. At the end of the three-day period, the cell shall be brought back to room temperature, drained and examined internally and externally for fluid leakage or other evidence of failure. Any indication of failure shall be cause for rejection.

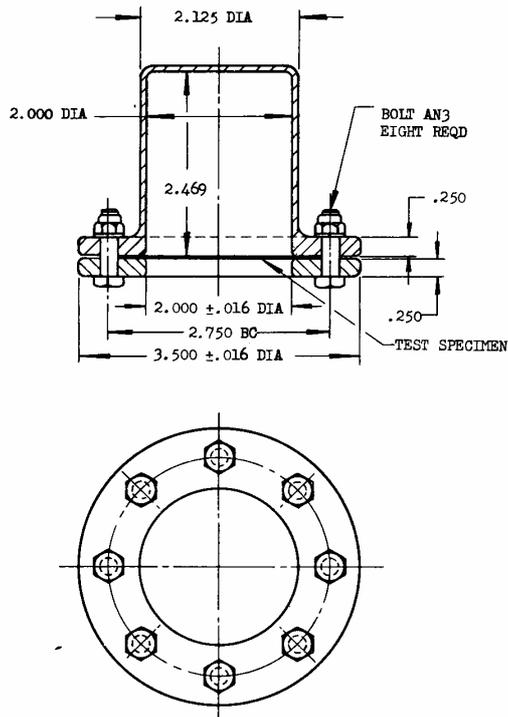


FIGURE 1. Permeability cup assembly

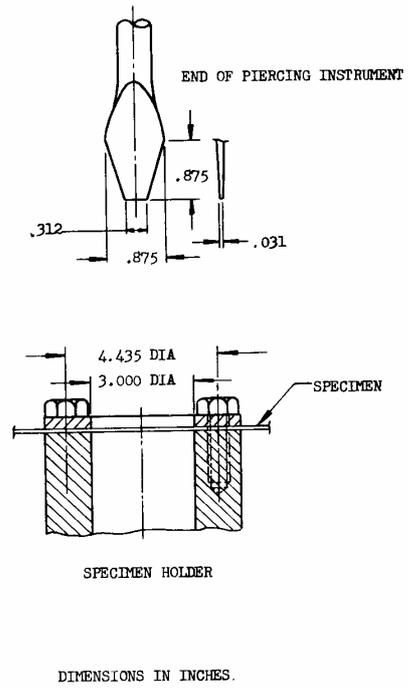


FIGURE 2. Piercing instrument and specimen holder