



Easy Access Rules for European Technical Standard Orders (CS-ETSO) (Amendment 16)

EASA eRules: aviation rules for the 21st century

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EASA eRules will be a comprehensive, single system for the drafting, sharing and storing of rules. It will be the single source for all aviation safety rules applicable to European airspace users. It will offer easy (online) access to all rules and regulations as well as new and innovative applications such as rulemaking process automation, stakeholder consultation, cross-referencing, and comparison with ICAO and third countries' standards.

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The **EASA eRules** system is developed and implemented in close cooperation with Member States and aviation industry to ensure that all its capabilities are relevant and effective.

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NOTE FROM THE EDITOR

CS paragraph titles are colour-coded and can be identified according to the illustration below. The EASA Executive Director (ED) decision through which the paragraph was introduced or last amended is indicated below the paragraph title(s) *in italics*.

Certification specification

ED decision

The format of this document has been adjusted to make it user-friendly and for reference purposes. Any comments should be sent to erules@easa.europa.eu.

INCORPORATED AMENDMENTS

CS (ED DECISIONS)

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Note: To access the official versions, please click on the hyperlinks provided above.

¹ This is the main applicability date defined in the ED Decision. However, the decision allowed that this CS was not applied to applications received until 31 December 2012, if so requested by the applicant and providing that in such a case the applicant could demonstrate that the process of development of the relevant part or appliance started before the entry into force of the ED Decision (5 July 2012), in accordance with the specifications applicable at that time.

² This is the main applicability date defined in the ED Decision. However, the decision allowed that this CS was not applied to applications received until 31 December 2013, if so requested by the applicant and providing that in such a case the applicant could demonstrate that the process of development of the relevant part or appliance started before the entry into force of the ED Decision (15 July 2013), in accordance with the specifications applicable at that time.

³ This is the main applicability date defined in the ED Decision. However, the decision allowed that this CS was not applied to applications received before 1 July 2018, if so requested by the applicant and providing that in such a case the applicant could demonstrate that the process of development of the relevant part or appliance started before the entry into force of the ED Decision (20 February 2018), in accordance with the specifications applicable at that time.

⁴ This is the main applicability date defined in the ED Decision. However, this decision shall not apply to applications received by EASA 6 months after the date of entry into force of this Decision, if so requested by the applicant, and provided that in such a case the applicant can demonstrate that the process of development of the relevant part or appliance started before the date of entry into force of this decision and is in accordance with the specifications applicable at that time.

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PREAMBLE

ED Decision 2020/011/R

Amendment 16

The following is a list of paragraphs affected by this amendment:

Subpart A — Paragraphs 1, 2.1, 2.2, 2.3, 2.4, and 2.5	Amended
Subpart A — Paragraphs 2.7 and 2.8	Newly introduced
INDEX 1	
ETSO-C10c	Amended
ETSO-C13g	Amended
ETSO-C20a	Amended
ETSO-C27a	Amended
ETSO-C43d	Amended
ETSO-C113b	Amended
ETSO-C117b	Amended
ETSO-C126c	Amended
ETSO-C142b	Amended
ETSO-C145e A1	Amended
ETSO-C146e A1	Amended
ETSO-C151d	Amended
ETSO-C153a	Amended
ETSO-C159d	Amended
ETSO-C160a A1	Amended
ETSO-C165b	Amended
ETSO-C168	Newly introduced
ETSO-C179b	Amended
ETSO-C196b	Amended
ETSO-C199 A1	Amended
ETSO-C207a	Amended
ETSO-C214 A1	Amended
INDEX 2	
ETSO-2C19c A1	Amended
ETSO-2C123c	Amended
ETSO-2C124c	Amended
ETSO-2C176a	Amended
ETSO-2C177a	Amended
ETSO-2C197 A1	Amended
ETSO-2C204a	Amended
ETSO-2C205a	Amended
ETSO-2C206	Amended
ETSO-2C515 A1	Amended
ETSO-2C517	Newly introduced
ETSO-2C518	Newly introduced
ETSO-2C519	Newly introduced

ED Decision 2020/006/R

Amendment 15

The following is a list of paragraphs affected by this amendment:

Subpart A	Amended (NPA 2019/01)

ED Decision 2018/008/R

Amendment 14

The following is a list of paragraphs affected by this amendment:

Subpart A	Amended
INDEX 1	
ETSO-C214	Newly introduced

ED Decision 2018/002/R

Amendment 13

The following is a list of paragraphs affected by this amendment:

INDEX 1	
ETSO-C1e	Amended
ETSO-C16b	Amended
ETSO-C23f	Amended
ETSO-C30d	Amended
ETSO-C59b	Amended
ETSO-C63e	Amended
ETSO-C78a	Amended
ETSO-C96b	Amended
ETSO-C97	Deleted
ETSO-C115d	Amended
ETSO-C118a	Amended
ETSO-C123c	Amended
ETSO-C124c	Amended
ETSO-C145e	Amended
ETSO-C146e	Amended
ETSO-C155b	Amended
ETSO-C159c	Amended
ETSO-C166b A3	Amended
ETSO-C176a	Amended
ETSO-C199	Newly introduced
ETSO-C203 A1	Amended
ETSO-C209	Newly introduced
ETSO-C210	Newly introduced
INDEX 2	
ETSO-2C514a	Amended

Amendment 12

The following is a list of paragraphs affected by this amendment:

Subpart A	Amended
INDEX 1	
ETSO-C26d	Amended
ETSO-C64b	Amended
ETSO-C65a	Deleted
ETSO-C68a	Deleted
ETSO-C85b	Amended
ETSO-C132a	Amended
ETSO-C147a	Amended
ETSO-C157b	Amended
ETSO-C172a	Amended
ETSO-C177a	Amended
ETSO-C195b	Amended
ETSO-C200a	Amended
ETSO-C203	Newly introduced
ETSO-C207	Newly introduced
INDEX 2	
ETSO-2C19c	Amended

Amendment 11

The following is a list of paragraphs affected by this amendment:

INDEX 1	
ETSO-C3e	Amended
ETSO-C5f	Amended
ETSO-C70b	Newly introduced
ETSO-C76b	Amended
ETSO-C88b	Amended
ETSO-C89a	Amended
ETSO-C90d A1	Amended
ETSO-C99a	Amended
ETSO-C100c	Amended
ETSO-C112e	Amended
ETSO-C113a	Amended
ETSO-C116a	Amended
ETSO-C119d	Amended
ETSO-C126b	Amended
ETSO-C127b	Amended
ETSO-C139a	Amended
ETSO-C151c	Amended
ETSO-C159b	Amended
ETSO-C166b A2	Amended

ETSO-C173a	Amended
ETSO-C201	Newly introduced
ETSO-C202	Newly introduced
INDEX 2	
ETSO-2C70b	Deleted
ETSO-2C515	Newly introduced

ED Decision 2016/006/R

Amendment 10

The following is a list of paragraphs affected by this amendment:

INDEX 2	
ETSO-2C153	Newly introduced (NPA 2014-23)

ED Decision 2014/010/R

Amendment 9

The following is a list of paragraphs affected by this amendment:

INDEX 1	
ETSO-C165	Replaced by ETSO-C165a (NPA 2012-02)

ED Decision 2013/012/R

Amendment 8

The following is a list of paragraphs affected by this amendment:

Subpart A	Amended (NPA 2012-16)
INDEX 1	
ETSO-C9c	Deleted (NPA 2012-16)
ETSO-C44c	Replaced by ETSO-C44c A1 (NPA 2012-16)
ETSO-C45b	Replaced by ETSO-C45b A1 (NPA 2012-16)
ETSO-C47a	Replaced by ETSO-C47a A1 (NPA 2012-16)
ETSO-C52b	Deleted (NPA 2012-16)
ETSO-C56b	Replaced by ETSO-C56b A1 (NPA 2012-16)
ETSO-C60b	Deleted (NPA 2012-16)
ETSO-C74d	Deleted (NPA 2012-16)
ETSO-C87a	Newly introduced (NPA 2012-16) replacing 2C87
ETSO-C106	Replaced by ETSO-C106 A1 (NPA 2012-16)
ETSO-C112c	Replaced by ETSO-C112d (NPA 2012-16)
ETSO-C114	Replaced by ETSO-C114 A1 (NPA 2012-16)
ETSO-C115b	Replaced by ETSO-C115c (NPA 2012-16)
ETSO-C121a	Replaced by ETSO-C121b (NPA 2012-16)
ETSO-C155	Replaced by ETSO-C155a (NPA 2012-16)
ETSO-C160a	Newly introduced (NPA 2012-16)
ETSO-C164	Newly introduced (NPA 2012-16)
ETSO-C166b	Replaced by ETSO-C166b A1 (NPA 2012-16)
ETSO-C174	Replaced by ETSO-C174 A1 (NPA 2012-16)

ETSO-C178	Newly introduced (NPA 2012-16)
ETSO-C198	Newly introduced (NPA 2012-16)
ETSO-C200	Newly introduced (NPA 2012-16)
INDEX 2	
ETSO-2C87	Deleted (NPA 2012-16)
ETSO-2C91a	Deleted (NPA 2012-16)

ED Decision 2012/009/R

Amendment 7

The following is a list of paragraphs affected by this amendment:

Subpart A	Amended (NPA 2011-12)
INDEX 1	
ETSO-C31d	Deleted (NPA 2011-12)
ETSO-C32d	Deleted (NPA 2011-12)
ETSO-C55	Replaced by ETSO-C55a (NPA 2011-12)
ETSO-C62d	Replaced by ETSO-C62e (NPA 2011-12)
ETSO-C90c	Replaced by ETSO-C90d (NPA 2011-12)
ETSO-C95	Replaced by ETSO-C95a (NPA 2011-12)
ETSO-C126a	Newly introduced (NPA 2011-12)
ETSO-C129a	Deleted (NPA 2011-12)
ETSO-C154c	Newly introduced (NPA 2011-12)
ETSO-C157a	Newly introduced (NPA 2011-12)
ETSO-C158	Newly introduced (NPA 2011-12)
ETSO-C159a	Newly introduced (NPA 2011-12)
ETSO-C161	Replaced by ETSO-C161a (NPA 2011-12)
ETSO-C162a	Newly introduced (NPA 2011-12)
ETSO-C166a	Replaced by ETSO-C166b (NPA 2011-12)
ETSO-C170	Newly introduced (NPA 2011-12)
ETSO-C172	Newly introduced (NPA 2011-12)
ETSO-C179a	Newly introduced (NPA 2011-12)
ETSO-C184	Newly introduced (NPA 2011-12)
ETSO-C194	Newly introduced (NPA 2011-12)
ETSO-C195a	Newly introduced (NPA 2011-12)
ETSO-C196a	Newly introduced (NPA 2011-12)
INDEX 2	
ETSO-2C70a	Replaced by ETSO-2C70b (NPA 2011-12)
ETSO-2C126	Deleted (NPA 2011-12)
ETSO-2C197	Newly introduced (NPA 2011-12)

Amendment 6

The following is a list of paragraphs affected by this amendment:

Subpart A	Amended (NPA 2009-11)
INDEX 1	
ETSO-C6d	Replaced by ETSO-C6e (NPA 2009-11)
ETSO-C8d	Replaced by ETSO-C8e (NPA 2009-11)
ETSO-C39b	Replaced by ETSO-C39c (NPA 2009-11)
ETSO-C48	Deleted (NPA 2009-11)
ETSO-C50c	Deleted (NPA 2009-11)
ETSO-57a	Deleted (NPA 2009-11)
ETSO-C58a	Deleted (NPA 2009-11)
ETSO-C112c	Newly introduced (NPA 2009-11)
ETSO-C123a	Replaced by ETSO-C123b (NPA 2009-11)
ETSO-C124a	Replaced by ETSO-C124b (NPA 2009-11)
ETSO-C135	Replaced by ETSO-C135a (NPA 2009-11)
ETSO-C139	Newly introduced (NPA 2009-11)
ETSO-C144	Replaced by ETSO-C144a (NPA 2009-11)
ETSO-C145	Replaced by ETSO-C145c (NPA 2009-11)
ETSO-C146	Replaced by ETSO-C146c (NPA 2009-11)
ETSO-C155	Newly introduced (NPA 2009-11)
ETSO-C165	Newly introduced (NPA 2009-11)
ETSO-C176	Newly introduced (NPA 2009-11)
ETSO-C177	Newly introduced (NPA 2009-11)
ETSO-C190	Newly introduced (NPA 2009-11)
INDEX 2	
ETSO-2C37e	Deleted (NPA 2009-11)
ETSO-2C38e	Deleted (NPA 2009-11)
ETSO-2C48a	Newly introduced (NPA 2009-11)
ETSO-2C112b	Replaced by ETSO-C112b (NPA 2009-11)
ETSO-2C169a	Newly introduced (NPA 2009-11)

Amendment 5

The following is a list of paragraphs affected by this amendment:

INDEX 1	
ETSO-C119b	Replaced by ETSO-C119c (NPA 2009-03)

Amendment 4

The following is a list of paragraphs affected by this amendment:

INDEX 1	
ETSO-C16	Replaced by ETSO-C16a (NPA 2009-08)

ED Decision 2008/012/R

Amendment 3

The following is a list of paragraphs affected by this amendment:

Subpart A	Amended (NPA 2007-14)
INDEX 1	
ETSO-C44b	Replaced by ETSO-C44c (NPA 2007-14)
ETSO-C45a	Replaced by ETSO-C45b (NPA 2007-14)
ETSO-C47	Replaced by ETSO-C47a (NPA 2007-14)
ETSO-C56a	Replaced by ETSO-C56b (NPA 2007-14)
ETSO-C78	Deleted (NPA 2007-10)
ETSO-C100b	Newly introduced (NPA 2007-10)
ETSO-C121	Replaced by ETSO-C121a (NPA 2007-14)
ETSO-C132	Newly introduced (NPA 2007-10)
ETSO-C142a	Newly introduced (NPA 2007-14)
ETSO-C161	Newly introduced (NPA 2007-14)
ETSO-C166a	Newly introduced (NPA 2007-14)
ETSO-173	Newly introduced (NPA 2007-14)
ETSO-174	Newly introduced (NPA 2007-14)
ETSO-175	Newly introduced (NPA 2007-14)
INDEX 2	
ETSO-2C78	Newly introduced (NPA 2007-10)
ETSO-2C512	Newly introduced (NPA 2007-10)
ETSO-2C513	Newly introduced (NPA 2007-10)
ETSO-2C514	Newly introduced (NPA 2007-10)

ED Decision 2007/017/R

Amendment 2

The following is a list of paragraphs affected by this amendment:

INDEX 1	
ETSO-C151a	Replaced by ETSO-C151b (NPA 14-2005)
INDEX 2	
ETSO-2C509	Newly introduced (NPA 14-2005)

ED Decision 2006/004/R

Amendment 1

The following is a list of paragraphs affected by this amendment:

Subpart B - List of ETSOs	Amended
INDEX 1	
ETSO-C13f	Newly introduced
INDEX 2	
ETSO-2C70a	Newly introduced
ETSO-2C112a	Replaced by ETSO-2C112b
ETSO-2C502	Newly introduced
ETSO-2C503	Newly introduced

ETSO-2C504	Newly introduced
ETSO-2C505	Newly introduced

SUBPART A – GENERAL

ED Decision 2020/011/R

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 (ETSO) authorisations are found in Part 21, Section A, Subpart Q.

2. STANDARDS TO MEET TECHNICAL CONDITIONS

2.1 Environmental standards

Unless otherwise stated in paragraph 3.1.2 of the specific ETSO, the applicable environmental standards are contained in EUROCAE/RTCA document ED-14D, Change 3/DO 160D 'Environmental Conditions and Test Procedures for Airborne Equipment', Change 3, dated December 2002, ED 14E/DO-160E dated March 2005, ED-14F/DO-160F dated March 2008, ED 14G/DO-160G dated December 2010, or ED-14G Change 1/DO-160G Change 1 dated January 2015.

Compliance shall be demonstrated entirely with one of the above versions of the applicable environmental standards.

2.2 Software

If the ETSO article includes the software shall be developed with development assurance. The accepted means of compliance for the development assurance of airborne software is contained in the revision of AMC 20-115, entitled 'Airborne Software Development Assurance using EUROCAE ED-12 and RTCA document DO-178', that is current at the time of the application, or in any later revision. The use of any other means of compliance shall be subject to a deviation request.

The software level, also known as the 'item development assurance level (IDAL)', should be determined by using the guidance proposed in Section 2.4. The applicant must declare the software level(s) to which the software has been developed and verified.

2.3 Airborne electronic hardware (AEH)

If the ETSO article includes airborne electronic hardware, the airborne electronic hardware shall be developed with development assurance. The accepted means of compliance for the development of airborne electronic hardware is contained in the revision of AMC 20 152¹, entitled 'Development Assurance for Airborne Electronic Hardware' that is current at the time of the application, or in any later revision. The use of any other means of compliance shall be subject to a deviation request.

The hardware development assurance level (DAL), also known as the 'item development assurance level (IDAL)', should be determined by using the guidance proposed in Section 2.4. The applicant must declare the hardware DAL(s) to which it has been developed and verified.

¹ Refer to ED Decision 2020/010/R (<https://www.easa.europa.eu/document-library/agency-decisions>).

2.4 Failure conditions classification and development assurance

During the development of an ETSO article, consideration should be given to failure conditions, and the ETSO article should then be developed in accordance with the possible effects of those failure conditions at the system and aircraft levels (see, for instance, AMC CS xx.1309 or AMC CS 23.2500/2510 for further guidance).

The ETSO article shall be developed according to at least the development assurance level that is appropriate to the failure condition classifications that are expected for the intended installation.

If the effects at the system or aircraft level are not known, due to the non-availability of aircraft or system design data, the applicant should make and declare an assumption for the failure classification. The assumed failure classification should be at least as high as the minimum hazard classification level required in the ETSO.

The classification of failure conditions at the level of the ETSO article may change as a result of particular aircraft installation architectures and characteristics.

EUROCAE/SAE document ED-79A/ARP 4754A, 'Guidelines for Development of Civil Aircraft and Systems', dated December 2010, should be used to assign the development assurance levels of the ETSO article, software and AEH. The document should also be used as guidance to ensure that a proper development, validation and verification process is followed for the ETSO article and its functional requirements.

2.5 ETSO article using an [ETSO-C153\(\)](#)-authorised IMA platform or module

If the ETSO article implements one (or several) ETSO-C153()-authorised integrated modular avionics (IMA) platforms/modules and the applicant seeks compliance credit from this (these) ETSOA authorisation(s) to demonstrate compliance with one or several functional ETSO standard(s), the applicant shall apply for authorisation to the ETSO-C214 standard, together with the intended functional ETSO standard(s).

Note: A functional ETSO standard is any ETSO standard of CS-ETSO that describes an 'aircraft' function, i.e. typically any ETSO standard, except ETSO-C153() and [ETSO-C214](#).

2.6 Information security protection

An ETSO article may be designed with a security assurance level (SAL) that is appropriate for specified security measures, according to the procedure provided in AMC 20-42.

2.7 Open problem reports (OPRs)

Problem reports that are related to ETSO articles that contain software or airborne electronic hardware shall be identified and managed. The accepted means of compliance for the management of OPRs is contained in the revision of AMC 20-189¹ 'Management of Open Problem Reports' that is current at the time of application, or in any later revision. The use of any other means of compliance shall be subject to a deviation request.

¹ Refer to ED Decision 2020/010/R (<https://www.easa.europa.eu/document-library/agency-decisions>).

2.8 Embedded batteries

If an ETSO article embeds a lithium battery whose energy is equal to or greater than 2 Wh, the battery shall be approved in accordance with the applicable battery ETSO. Additionally, when the battery ETSO covers the article embedding the battery, the article shall also be approved in accordance with the applicable battery ETSO.

For rechargeable lithium batteries whose energy is less than 2 Wh, the battery shall comply with the UN Recommendations on the Transport of Dangerous Goods - Model Regulations and shall be certified to UL 1642, UL 2054 or IEC 62133, unless it is shown to meet the requirements of RTCA document DO-311A Energy Category 2.

For non-rechargeable lithium batteries whose energy is less than 2 Wh, the battery shall be certified to UL 1642 and shall comply with the UN Recommendations on the Transport of Dangerous Goods - Model Regulations.

If there is no ETSO that is applicable to a particular battery that an applicant intends to use in an ETSO article, the applicant should contact EASA.

3. ADDITIONAL INFORMATION

3.1 In some ETSOs, reference is made to an associated FAA standard. In these cases, the corresponding FAA technical standard order (TSO) can be consulted on http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgTSO.nsf/Frameset?OpenPage.

3.2 Standards documents referred to in this CS-ETSO may be purchased or obtained from the following organisations:

— ASD-STAN documents:

AeroSpace and Defence Industries Association of Europe – Standardization
Rue Montoyer 10 - 1000 Brussels
(Email: sales@asd-stan.org, website: www.asd-stan.org)

— ASTM documents:

American Society for Testing and Materials, ASTM International,
100 Barr Harbor Drive, PO Box C700, West Conshohocken, Pennsylvania
19428-2959, USA
(Website: www.astm.org)

— ETSI European Telecommunications Standards Institute

650, Route des Lucioles
06560 Valbonne - Sophia Antipolis
FRANCE
Telephone: +33 4 92 94 42 00
(<https://www.etsi.org/standards>#Pre-defined Collections)

— EUROCAE documents:

European Organisation for Civil Aviation Equipment
9-23 rue Paul Lafargue, “Le Triangle” building, 93200 Saint-Denis, France
Telephone: +33 1 49 46 19 65

(Email: eurocae@eurocae.net, website: www.eurocae.net)

- EUROCONTROL Surveillance Document Library:
<https://www.eurocontrol.int/articles/surveillance-library>
- FAA standards:
Superintendent of Documents, Government Printing Office
732N Capitol Street NW, Washington DC 20401, USA
(Website: www.gpoaccess.gov)
- FCC Documents:
<http://www.fcc.gov>
- Global System, Inc., documents:
Global Systems, Inc., 2144 Michelson Drive, Irvine, California 92715, USA
Telephone: (714) 851-0119
- International Electrotechnical Commission
<https://webstore.iec.ch>
- MIL specifications:
DODSSP, Standardization Documents Order Desk
Building 4D, 700 Robbins Avenue, PHILADELPHIA, PA 19111-5094, USA
or from the ASSIST Customer Service Desk, telephone (215) 697-6396
(Website: <http://quicksearch.dla.mil/>)
- NAS specifications:
Aerospace Industries Association (AIA)
1327 Jones Drive, Ann Arbor, MI 48105, USA
(Website: www.techstreet.com)
- RTCA documents:
Radio Technical Commission for Aeronautics, Inc.
1828 L Street NW, Suite 805, Washington DC 20036, USA
(Website: www.rtca.org)
- SAE documents:
Society of Automotive Engineers, Inc.
400 Commonwealth Drive, WARRENDALE, PA 15096-001, USA
(Website: www.sae.org)
- UN United Nations Economic Commission for Europe transport regulations:
United Nations Bookshop
GA-1B-103
New York, NY 10017

USA

Tel: +1-212-963-7680

Email: bookshop@un.org

(Website:

https://www.unece.org/trans/danger/publi/unrec/rev13/13nature_e.html)

— UL Underwriters Laboratory standards:

(website: <https://standardscatalog.ul.com>)

[Amdt ETSO/3]

[Amdt ETSO/6]

[Amdt ETSO/7]

[Amdt ETSO/8]

[Amdt ETSO/12]

[Amdt ETSO/14]

[Amdt ETSO/15]

[Amdt ETSO/16]

SUBPART B – LIST OF ETSOs

ED Decision 2020/011/R

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 an 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 aircraft must record this ETSO number. The 'E' Symbol signifies that the article has been certified to the relevant ETSO by the Agency.
- 1.3 Index 1 lists all those ETSOs whose functional requirements are equivalent to those of the corresponding FAA TSOs that have the same identification numbers.
- 1.4 Reserved
- 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 the FAA-TSOs. Index 2 ETSOs are identified by '2C' prefixes, and numbered as follows:
 - (a) An ETSO with significant differences in the MOPS in comparison with the corresponding FAA TSO is identified by the same number as the corresponding FAA TSO (related to the same type of equipment) with a number in the range from ETSO-2C1 to ETSO-2C499; or
 - (b) An ETSO for which there is no corresponding FAA TSO (related to the same type of equipment) is identified by a number in sequence from ETSO-2C500 upwards.

EASA ETSO ref.	Title	Last amended by
ETSO-C1e	Cargo Compartment Fire Detection Instruments	CS-ETSO/13
ETSO-C2d	Airspeed Instruments	CS-ETSO/Initial Issue
ETSO-C3e	Turn and Slip Instruments	CS-ETSO/11
ETSO-C4c	Bank and Pitch Instruments	CS-ETSO/Initial Issue
ETSO-C5f	Direction Instrument, Non-Magnetic (Gyroscopically Stabilized)	CS-ETSO/11
ETSO-C6e	Direction Instrument, Magnetic (Gyroscopically Stabilized)	CS-ETSO/6
ETSO-C7d	Direction Instrument, Magnetic Non-Stabilized Type (Magnetic Compass)	CS-ETSO/Initial Issue
ETSO-C8e	Vertical Velocity Instrument (Rate-of-Climb)	CS-ETSO/6
ETSO-C10c	Pressure Altimeter System	CS-ETSO/16

ETSO-C13g	Life preservers	CS-ETSO/16
ETSO-C14b	Aircraft Fabric, Intermediate Grade; External Covering Material	CS-ETSO/Initial Issue
ETSO-C15d	Aircraft Fabric, Grade A; External Covering Material	CS-ETSO/Initial Issue
ETSO-C16b	Electrically Heated Pitot and Pitot-Static Tubes	CS-ETSO/13
ETSO-C20a	Combustion Heaters and Accessories	CS-ETSO/16
ETSO-C21b	Aircraft Turnbuckle Assemblies and/or Turnbuckle Safelying Devices	CS-ETSO/Initial Issue
ETSO-C22g	Safety Belts	CS-ETSO/Initial Issue
ETSO-C23f	Personal Parachute Assemblies and Components	CS-ETSO/13
ETSO-C25a	Aircraft Seats and Berths (Type I Transport 6g Forward Load)	CS-ETSO/Initial Issue
ETSO-C26d	Aircraft Wheels and Wheel-Brake Assemblies (CS-23, 27 and 29 aircraft)	CS-ETSO/12
ETSO-C27a	Twin Seaplane Floats	CS-ETSO/16
ETSO-C28	Aircraft Skis	CS-ETSO/Initial Issue
ETSO-C30d	Aircraft Position Lights	CS-ETSO/13
ETSO-C39c	Aircraft Seats and Berths Certified by Static Testing only	CS-ETSO/6
ETSO-C42	Propeller Feathering Hose Assemblies	CS-ETSO/Initial Issue
ETSO-C43d	Temperature Instruments	CS-ETSO/16
ETSO-C44c A1	Fuel Flowmeters	CS-ETSO/8
ETSO-C45b A1	Manifold Pressure Instruments	CS-ETSO/8
ETSO-C46a	Maximum Allowable Airspeed Indicator System	CS-ETSO/Initial Issue
ETSO-C47a A1	Pressure Instruments — Fuel, Oil, and Hydraulic (Reciprocating Engine-Powered Aircraft)	CS-ETSO/8
ETSO-C49b	Electric Tachometer: Magnetic Drag (Indicator and Generator)	CS-ETSO/Initial Issue
ETSO-C53a	Fuel and Engine Oil System Hose Assemblies	CS-ETSO/Initial Issue
ETSO-C54	Stall Warning Instruments	CS-ETSO/Initial Issue
ETSO-C55a	Fuel and Oil Quantity Instruments	CS-ETSO/7
ETSO-C56b A1	Engine-Driven Direct Current Generators/Starter Generators	CS-ETSO/8
ETSO-C59b	Airborne Selective Calling Equipment	CS-ETSO/13
ETSO-C62e	Aircraft Tyres	CS-ETSO/7
ETSO-C63e	Airborne Weather Radar Equipment	CS-ETSO/13
ETSO-C64b	Oxygen Mask Assembly, Continuous Flow, Passenger	CS-ETSO/12
ETSO-C69c	Emergency Evacuation Slides, Ramps and Slide/Rafts Combinations	CS-ETSO/Initial Issue
ETSO-C70b	Life Rafts	CS-ETSO/11
ETSO-C71	Airborne Static ('DC to DC') Electrical Power Converter (for Air Carrier Aircraft)	CS-ETSO/Initial Issue
ETSO-C72c	Individual Flotation Devices	CS-ETSO/Initial Issue
ETSO-C73	Static Electrical Power Inverter	CS-ETSO/Initial Issue
ETSO-C76b	Fuel Drain Valves	CS-ETSO/11

ETSO-C78a	Crewmember Demand Oxygen Mask	CS-ETSO/13
ETSO-C79	Fire Detectors (Radiation Sensing Types)	CS-ETSO/Initial Issue
ETSO-C80	Flexible Fuel and Oil Cell Material	CS-ETSO/Initial Issue
ETSO-C85b	Survivor Locator Lights	CS-ETSO/12
ETSO-C87a	Airborne Low-Range Radio Altimeter	CS-ETSO/8
ETSO-C88b	Automatic Pressure Altitude Reporting Code Generating Equipment	CS-ETSO/11
ETSO-C89a	Crew Member Oxygen Regulators, Demand	CS-ETSO/11
ETSO-C90d A1	Cargo Pallets, Nets and Containers	CS-ETSO/11
ETSO-C92c	Ground Proximity Warning, Glide Slope Deviation Alerting Equipment	CS-ETSO/Initial Issue
ETSO-C95a	Mach Meters	CS-ETSO/7
ETSO-C96b	Anticollision Light Systems	CS-ETSO/13
ETSO-C99a	Flight Deck (Sedentary) Crew Member Protective Breathing Equipment	CS-ETSO/11
ETSO-C100c	Aviation Child Safety Device (ACDS)	CS-ETSO/11
ETSO-C101	Overspeed Warning Instruments	CS-ETSO/Initial Issue
ETSO-C102	Airborne Radar Approach and Beacon Systems for Helicopters	CS-ETSO/Initial Issue
ETSO-C103	Continuous Flow Oxygen Mask Assembly (for Non-Transport Category Aircraft)	CS-ETSO/Initial Issue
ETSO-C105	Optional Display Equipment for Weather and Ground Mapping Radar Indicators	CS-ETSO/Initial Issue
ETSO-C106 A1	Air Data Computer	CS-ETSO/8
ETSO-C109	Airborne Navigation Data Storage System	CS-ETSO/Initial Issue
ETSO-C110a	Airborne Passive Thunderstorm Detection Systems	CS-ETSO/Initial Issue
ETSO-C112e	Secondary Surveillance Radar Mode S Transponder	CS-ETSO/11
ETSO-C113b	Airborne Multipurpose Electronic Displays	CS-ETSO/16
ETSO-C114 A1	Torso Restraint Systems	CS-ETSO/8
ETSO-C115d	Required Navigation Performance (RNP) Equipment using Multi-Sensor Inputs	CS-ETSO/13
ETSO-C116a	Crew Member Portable Protective Breathing Equipment	CS-ETSO/11
ETSO-C117b	Airborne Wind Shear Warning and Escape Guidance Systems (Reactive Type) for Transport Aeroplanes	CS-ETSO/16
ETSO-C118a	Traffic Alert and Collision Avoidance System I (TCAS I)	CS-ETSO/13
ETSO-C119d	Airborne Collision Avoidance System II (ACAS II) Version 7.1 with Hybrid Surveillance	CS-ETSO/11
ETSO-C121b	Underwater Locating Device	CS-ETSO/8
ETSO-C126c	Emergency Locator Transmitter	CS-ETSO/16
ETSO-C127b	Rotorcraft, Transport Aeroplane, and Small Aeroplane Seating Systems	CS-ETSO/11
ETSO-C132a	Geosynchronous Orbit Aeronautical Mobile Satellite Services Aircraft Earth Station Equipment	CS-ETSO/12
ETSO-C135a	Large Aeroplane Wheels, and Wheels and Brake Assemblies	CS-ETSO/6

ETSO-C139a	Aircraft Audio Systems and Equipment	CS-ETSO/11
ETSO-C141	Aircraft Fluorescent Lighting Ballast/Fixture Equipment	CS-ETSO/Initial Issue
ETSO-C142b	Non-Rechargeable Lithium Cells and Batteries	CS-ETSO/16
ETSO-C144a	Passive Airborne Global Navigation Satellite System (GNSS) Antenna	CS-ETSO/6
ETSO-C145e A1	Airborne Navigation Sensors Using the Global Positioning System Augmented by the Satellite-Based Augmentation System	CS-ETSO/16
ETSO-C146e A1	Stand-Alone Airborne Navigation Equipment Using the Global Positioning System Augmented by the Satellite-Based Augmentation System	CS-ETSO/16
ETSO-C147a	Traffic Advisory System (TAS) Airborne Equipment	CS-ETSO/12
ETSO-C151d	Terrain Awareness and Warning System (TAWS)	CS-ETSO/16
ETSO-C153a	Integrated Modular Avionics (IMA) Platform and Modules	CS-ETSO/16
ETSO-C154c	Universal Access Transceiver (UAT) Automatic Dependent Surveillance-Broadcast (ADS-B) Equipment	CS-ETSO/7
ETSO-C155b	Recorder Independent Power Supply	CS-ETSO/13
ETSO-C157b	Flight Information Services-Broadcast (FIS-B) Equipment	CS-ETSO/12
ETSO-C158	Aeronautical Mobile High Frequency Data Link (HF DL) Equipment	CS-ETSO/7
ETSO-C159d	Next Generation Satellite Systems (NGSS) Equipment	CS-ETSO/16
ETSO-C160a A1	VDL Mode 2 Communications Equipment	CS-ETSO/16
ETSO-C161a	Ground-Based Augmentation System Positioning and Navigation Equipment	CS-ETSO/7
ETSO-C162a	Ground-Based Augmentation System Very High Frequency Data Broadcast Equipment	CS-ETSO/7
ETSO-C165b	Electronic Map Systems for Graphical Depiction of Aircraft Position	CS-ETSO/16
ETSO-C166b A3	Extended Squitter Automatic Dependent Surveillance-Broadcast (ADS-B) and Traffic Information Service-Broadcast (TIS-B) Equipment Operating on the Radio Frequency of 1090 Megahertz (MHz)	CS-ETSO/13
ETSO-C168	Aviation Visual Distress Signals	CS-ETSO/16
ETSO-C170	High-Frequency (HF) Radio Communication Transceiver Equipment Operating Within the Radio Frequency 1.5 to 30 Megahertz	CS-ETSO/7
ETSO-C172a	Cargo Restraint Strap Assemblies	CS-ETSO/12
ETSO-C173a	Nickel-Cadmium, Nickel Metal-Hydride, and Lead-Acid Batteries	CS-ETSO/11
ETSO-C174 A1	Battery-Based Emergency Power Unit (BEPU)	CS-ETSO/8
ETSO-C175	Galley Cart, Containers and Associated Components	CS-ETSO/3
ETSO-C178	Single Phase 115 VAC, 400 Hz Arc Fault Circuit Breakers	CS-ETSO/8
ETSO-C179b	Rechargeable Lithium Cells, Batteries, and Battery Systems	CS-ETSO/16
ETSO-C184	Galley Equipment	CS-ETSO/7
ETSO-C190	Active Airborne Global Navigation Satellite System (GNSS) Antenna	CS-ETSO/6
ETSO-C194	Helicopter Terrain Awareness and Warning System (HTAWS)	CS-ETSO/7
ETSO-C195b	Avionics Supporting Automatic Dependent Surveillance-Broadcast (ADS-B) Aircraft Surveillance	CS-ETSO/12

ETSO-C196b	Airborne Supplemental Navigation Sensors for Global Positioning System Equipment Using Aircraft-Based Augmentation	CS-ETSO/16
ETSO-C198	Automatic Flight Guidance and Control System (AFGCS) Equipment	CS-ETSO/8
ETSO-C199 A1	Traffic Awareness Beacon System (TABS)	CS-ETSO/16
ETSO-C200a	Low-Frequency Underwater Locating Device (ULD)	CS-ETSO/12
ETSO-C201	Attitude and Heading Reference Systems (AHRS)	CS-ETSO/11
ETSO-C202	Cargo Stopper Devices	CS-ETSO/11
ETSO-C203 A1	Fire containment covers (FCC)	CS-ETSO/13
ETSO-C207a	Aeronautical Mobile Airport Communication System (AeroMACS)	CS-ETSO/16
ETSO-C209	Electronic Flight Instrument System (EFIS) Display	CS-ETSO/13
ETSO-C210	Airborne Head-Up Display	CS-ETSO/13
ETSO-C214 A1	Functional ETSO equipment using an ETSO-C153a-authorized IMA platform or module	CS-ETSO/16

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EASA ETSO ref.	Title	Last amended by
ETSO-2C11e	Power Plant Fire Detection Instruments (Thermal and Flame Contact Types)	CS-ETSO/Initial Issue
ETSO-2C19c A1	Portable Water-Solution Type Hand Fire Extinguishers	CS-ETSO/16
ETSO-2C34f	ILS Glide Slope Receiving Equipment Operating within the Radio Frequency Range of 328.6–335.4 Megahertz (MHz)	CS-ETSO/Initial Issue
ETSO-2C35d	Radar Marker Receiving Equipment	CS-ETSO/Initial Issue
ETSO-2C36f	Airborne ILS Localizer Receiving Equipment Operating within the Radio Frequency Range 108–112 Megahertz	CS-ETSO/Initial Issue
ETSO-2C40c	VOR Receiving Equipment Operating within the Radio Frequency Range of 108–117.95 Megahertz	CS-ETSO/Initial Issue
ETSO-2C41d	Airborne Automatic Direction Finding (ADF) Equipment	CS-ETSO/Initial Issue
ETSO-2C48a	Carbon Monoxide Detector Instruments	CS-ETSO/6
ETSO-2C66b	Distance Measuring Equipment (DME) Operating within the Radio Frequency Range 960–1215 Megahertz	CS-ETSO/Initial Issue
ETSO-2C75	Hydraulic Hose Assembly	CS-ETSO/Initial Issue
ETSO-2C93b	Airborne Interim Standard Microwave Landing System Converter Equipment	CS-ETSO/Initial Issue
ETSO-2C104a	Microwave Landing System (MLS) Airborne Receiving Equipment	CS-ETSO/Initial Issue
ETSO-2C122	Devices That Prevent Blocked Channels Used in Two-Way Radio Communications Due to Simultaneous Transmissions	CS-ETSO/Initial Issue
ETSO-2C123c	Cockpit Voice Recorder Systems	CS-ETSO/16
ETSO-2C124c	Flight Data Recorder Systems	CS-ETSO/16
ETSO-2C128	Devices That Prevent Blocked Channels Used in Two-Way Radio Communications Due to Unintentional Transmissions	CS-ETSO/Initial Issue
ETSO-2C169a	VHF Radio Communications Transceiver Equipment Operating within the Radio Frequency Range 117.975 to 137 Megahertz	CS-ETSO/6
ETSO-2C176a	Aircraft Cockpit Image Recorder Systems	CS-ETSO/16

ETSO-2C177a	Data Link Recorder Equipment	CS-ETSO/16
ETSO-2C197 A1	Information Collection and Monitoring Systems	CS-ETSO/16
ETSO-2C204a	Circuit Card Assembly (CCA) Functional Sensors Using the Satellite-Based Augmentation System (SBAS) for Navigation and Non-Navigation Position/Velocity/Time (PVT) Output	CS-ETSO/16
ETSO-2C205a	Circuit Card Assembly (CCA) Functional Class Delta Equipment Using the Satellite-Based Augmentation System (SBAS) for Navigation Applications	CS-ETSO/16
ETSO-2C206	Circuit Card Assembly (CCA) Functional Sensors Using Aircraft-Based Augmentation for Navigation and Non-Navigation Position/Velocity/Time (PVT) Output	CS-ETSO/16
ETSO-2C500a	Combined ILS/MLS Airborne Receiving Equipment	CS-ETSO/Initial Issue
ETSO-2C501	Mode S Aircraft Data Link Processor	CS-ETSO/Initial Issue
ETSO-2C502	Helicopter Crew and Passenger Integrated Immersion Suits	CS-ETSO/1
ETSO-2C503	Helicopter Crew and Passenger Immersion Suits for Operations to or from Helidecks Located in a Hostile Sea Area	CS-ETSO/1
ETSO-2C504	Helicopter Constant-Wear Life Jackets for Operations to or from Helidecks Located in a Hostile Sea Area	CS-ETSO/1
ETSO-2C505	Helicopter Life Rafts for Operations to or from Helidecks Located in a Hostile Sea Area	CS-ETSO/1
ETSO-2C509	Light Aviation Secondary Surveillance Transponders (LAST)	CS-ETSO/2
ETSO-2C512	Portable Gaseous Oxygen Supply (PGOS)	CS-ETSO/3
ETSO-2C513	Tow Release	CS-ETSO/3
ETSO-2C514a	Airborne Systems for Non-Required Telecommunication Services (in Non-Aeronautical Frequency Bands) (ASNRT)	CS-ETSO/13
ETSO-2C515 A1	Aircraft Halocarbon Clean Agent Hand-Held Fire Extinguishers	CS-ETSO/16
ETSO-2C516	Reserved	N/A
ETSO-2C517	Automatic Deployable Flight Recorder (ADFR) Systems for Large Aeroplanes	CS-ETSO/16
ETSO-2C518	Runway Overrun Awareness and Alerting Systems	CS-ETSO/16
ETSO-2C519	Emergency Breathing Systems (EBSs)	CS-ETSO/16

[Amdt ETSO/1]

[Amdt ETSO/2]

[Amdt ETSO/3]

[Amdt ETSO/4]

[Amdt ETSO/5]

[Amdt ETSO/6]

[Amdt ETSO/7]

[Amdt ETSO/8]

[Amdt ETSO/9]

[Amdt ETSO/10]

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[Amdt ETSO/14]

[Amdt ETSO/16]

INDEX 1 EUROPEAN TECHNICAL STANDARD ORDERS

ETSO-C1e

ED Decision 2018/002/R

CARGO COMPARTMENT FIRE DETECTION INSTRUMENTS**1 Applicability**

This ETSO provides the requirements which cargo compartment fire detection instruments that are designed and 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 SAE Aerospace Standard (AS) 8036 'Cargo Compartment Fire Detection Instruments', Revision A, dated December 17, 2013, except for paragraphs 4.9, 4.10 and 4.11.

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.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 Specific

Demonstrate the required functional performance under the test conditions specified in Section 4 of AS8036, Revision A.

Demonstrate the required performance under the test conditions specified in Section 5 of AS8036, Revision A, using standard environmental conditions in accordance with 3.1.2.

3.2.1 Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

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.

[Amdt ETSO/13]

ETSO-C2d

ED Decision 2003/10/RM

AIRSPPEED 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.

ETSO-C3e

ED Decision 2016/013/R

TURN AND SLIP INSTRUMENT**1 Applicability**

This ETSO provides the requirements which Turn And Slip Instruments that are designed and 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 [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 AS8004, '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.

3.1.4 Electronic Hardware Qualification

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific

None

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

Failures of the function defined in paragraph 3.1.1 of this ETSO resulting in misleading or loss of information are minor failure conditions.

4 Marking**4.1 General**

Marking as 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.](#)

[Amdt ETSO/11]

ETSO-C4c

ED Decision 2003/10/RM

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.

ETSO-C5f

ED Decision 2016/013/R

DIRECTION INSTRUMENT, NON-MAGNETIC (GYROSCOPICALLY STABILIZED)**1 Applicability**

This ETSO provides the requirements which Direction Instruments, Non-Magnetic (Gyroscopically Stabilized) that are designed and 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 [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 AS8021, 'Direction Instrument, Non-Magnetic (Gyroscopically Stabilized)', dated March 16, 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.

3.1.4 Electronic Hardware Qualification

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific

None.

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 of this ETSO resulting in misleading information is a major failure condition. Failure of the function defined in paragraph 3.1.1 of this ETSO resulting in loss of information is a minor failure condition.

4 Marking**4.1 General**

Marking as 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.

[Amdt ETSO/11]

ETSO-C6e

ED Decision 2010/010/R

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 General****3.1.1 Minimum Performance Standard**

Standards set forth in the SAE Aerospace Standard (AS) document: AS-8013A, “Direction Instrument, Magnetic (Gyroscopically Stabilized)”, dated September 1996, as modified by [Appendix 1](#) of this ETSO.

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

3.1.4 Electronic Hardware Qualification

See CS-ETSO Subpart A paragraph 2.3

3.2 Specific**3.2.1 Failure Condition Classification**

See CS-ETSO Subpart A paragraph 2.4

Failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a major failure condition.

4 Marking**4.1 General**

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

4.2 Specific

None. Clarification: SAE AS 8013A paragraph 3.15 is not applicable.

5 Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.

[Amdt ETSO/6]

APPENDIX 1 TO ETSO-C6E – MODIFICATION TO MPS FOR DIRECTION INSTRUMENT, MAGNETIC (GYROSCOPICALLY STABILIZED)

ED Decision 2010/010/R

Modify AS8013A as follows:

SAE AS8013A reference:	Replace with:
Section 3.4: Except for small parts (such as knobs, fasteners, seals, grommets, and small electrical parts) that would not contribute significantly to the propagation of a fire, all materials must be self-extinguishing when tested in accordance with the requirements of Federal Aviation Regulation 25.1359(d) and Appendix F thereto, with paragraph (b) of Appendix F or may be configured as used.	Except for small parts (knobs, fasteners, seals, grommets, and small electrical parts) that do not contribute significantly to the propagation of a fire, all materials must be self-extinguishing when tested according to EASA CS 25.869(a). See further to Appendix F, Part I (b)(2), Specimen configuration, for current requirements.

[Amdt ETSO/6]

ETSO-C7d

ED Decision 2003/10/RM

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.

ETSO-C8e

ED Decision 2010/010/R

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 8016A “Vertical Velocity Instrument (Rate-of-climb)”, dated September 1996.

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

3.1.4 Electronic Hardware Qualification

See CS-ETSO Subpart A paragraph 2.3

3.2 Specific**3.2.1 Failure Condition Classification**

See CS-ETSO Subpart A paragraph 2.4

Failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a minor failure condition.

4 Marking**4.1 General**

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

4.2 Specific

See SAE AS 8016 paragraph 1.2

5 Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3

[Amdt ETSO/6]

ETSO-C10c

ED Decision 2020/011/R

PRESSURE ALTIMETER SYSTEM**1 Applicability**

This ETSO provides the requirements which pressure altimeter systems that are designed and 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**

The 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**

The applicable standards are those provided in SAE International's Aerospace Standard AS8009C, Pressure Altimeter Systems, dated 24 May 2016, as amended by [Appendix 1](#) to this ETSO.

3.1.2 Environmental Standard

See CS-ETSO, [Subpart A](#), paragraph 2.1.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific

The declaration of design and performance (DDP) and the installation manual shall state the maximum calibrated altitude.

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

4 Marking**4.1 General**

See CS-ETSO, [Subpart A](#), Paragraph 1.2.

4.2 Specific

None.

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/Initial issue]

[Amdt ETSO/16]

APPENDIX 1 TO ETSO-C10c – MINIMUM PERFORMANCE STANDARD (MPS) FOR PRESSURE ALTIMETER SYSTEMS

ED Decision 2020/011/R

This Appendix defines the modifications and additions to the MPS for pressure altimeter equipment specified in SAE AS8009C, Pressure Altimeter Systems, dated 24 May 2016.

SAE AS8009C Section(s)	Change
3.4	Add a note following the paragraph to read: Note: Markings for the altitude range may be omitted for instruments that use a tape-type display.
3.10	Delete current Section 3.10 and Table 9. Replace with the following: 3.10 Temperature Corrections Altimeters covered by this standard shall not incorporate automatic temperature corrections.
3.11	Add a new third paragraph to read: Instruments that use a tape-type display or present altitude with a digital readout are permitted to use tic marks every 100 feet with a more prominent mark every 500 feet in agreement with SAE ARP4102/7, Appendix A, Symbols 39 and/or 40.
3.12	Change the third sentence to read: The word ALTITUDE or ALT may be marked on the dial in capital letters and may be in the same finish as the numerals.
3.12	Add a note following the paragraph to read: Note: Markings for the altitude range may be omitted for instruments that use a tape-type display.
5.	Add a new paragraph: Some of these tests may be performed only once provided that it is demonstrated that this test will demonstrate performance for each article.
5.10	Add a new paragraph: For altimeters with an electronic display, this test may be replaced by showing compliance with SAE AS8034C, Section 3.8, Malfunctions/Failure Indications and Section 4.6, Operating Time.
5.11	Add a requirement for performance testing of Electronic Display Altimeters: Electronic displays shall demonstrate their compliance with the SAE AS8034C requirements specified in Table 10 using the test procedures specified in SAE AS8034C, Section 6, as applicable.
6.29	Add a requirement for environmental testing of Electronic Display Altimeters: Electronic displays shall demonstrate the compliance of their equipment with the requirements of SAE AS8034B specified in Table 10 using the environmental performance requirements specified in SAE AS8034B, Section 5.

[Amdt ETSO/16]

ETSO-C13g

ED Decision 2020/011/R

LIFE PRESERVERS**1 Applicability**

This ETSO provides the requirements which life preservers that are designed and 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**

The applicable procedures are detailed in CS-ETSO, [Subpart A](#).

2.2 Specific

None.

3 Technical Conditions**3.1 Basic**

The standards of this ETSO apply to items of equipment that are intended to function as life preservers.

3.1.1 Minimum Performance Standard

The applicable standards are those provided in SAE International's Aerospace Standard AS1354, Individual Inflatable Life Preserver, dated 24 February 2016, as amended by [Appendix 1](#).

3.1.1.1 Functional Qualification

The required functional performance under the test conditions specified in AS1354, Individual Inflatable Life Preserver, dated 24 February 2016, as amended by [Appendix 1](#) and [Appendix 2](#), shall be demonstrated.

3.1.2 Environmental Standard

The required performance under the test conditions specified in AS1354, Individual Inflatable Life Preserver, dated 24 February 2016, as amended by Appendix 1, shall be demonstrated.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific**3.2.1 Failure Condition Classification**

Not applicable.

4 Marking**4.1 General**

See CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

See [Appendix 1](#).

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/1]

[Amdt ETSO/16]

APPENDIX 1 TO ETSO-C13G – FUNCTIONAL AND ENVIRONMENTAL QUALIFICATION REQUIREMENTS

ED Decision 2020/011/R

Appendix 1 modifies the text in SAE International's Aerospace Standard AS1354, Individual Inflatable Life Preserver, dated 24 February 2016. Compliance with the modified text is required in order to comply with the requirements of this ETSO.

When reading AS1354	Do the following:
Section 1	Disregard
Section 2	Apply all the subsections unless they are disregarded or modified below:
	Page 4, replace Subsection 2.1 with the following text: 2.1 Applicable Documents The following publications form a part of this document to the extent specified herein. The applicable issue of cited publications shall be the issue that was in effect on the date of the publication of this document, unless otherwise specified. In the event of conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes the applicable laws and regulations unless a specific exemption has been obtained.
	Page 6, Subsection 2.3 applies as written, except replace the definitions of the following terms with the ones below: APPROVED: The status of equipment that meets EASA standards. CHILLED HANDS TEST METHOD: A technique to simulate the reduced dexterity of chilled, wet hands that may occur during an emergency in a cold and wet environment. A naïve test subject simultaneously submerges their left and right forearms and hands in 50 °F (10 °C) water for 2 minutes and immediately upon removal attempts to open/operate the designated packaging/equipment. The test subject <i>shall</i> be healthy and wear a loose-fitting, sleeveless upper garment that will not inhibit blood flow to the arms and hands. (Alternate: GLOVED HANDS TEST METHOD) SEAT PITCH: The distance from any point on one seat to exactly the same point on the seat in front or behind it. TEST SUBJECTS: Individuals who participate in life preserver tests (e.g. donning, retention, flotation). All such individuals shall be naïve, i.e. they shall have had no experience in using a life preserver or the specific equipment to be tested, and they shall not have viewed or talked with other persons performing the same or similar activities. Note that individuals who have experience in using marine or boating life preservers are considered to be acceptable test subjects.
Section 3	Apply all the subsections unless they are disregarded or modified below:
	Page 7, Section 3, replace the introductory text with the following: 3. DESIGN AND PERFORMANCE REQUIREMENTS Tests and measurements performed to demonstrate compliance with this standard shall be conducted with equipment that is calibrated according to the original equipment manufacturer (OEM) specifications, using standards and references that are traceable to a recognised national authority (e.g. the National Institute of Standards and Technology (NIST)). The description of the test results shall include the accuracy and precision of the measurement(s), e.g. measured in 5-pound increments with an accuracy of ± 0.10 pounds. All tests that require timing shall use time-encoded video. In addition, tests that require human subjects or a child test dummy shall use time-encoded video. Demonstration life preservers are not addressed by this ETSO. They are not intended to be functional and should be marked accordingly.

Page 10, replace Subsection 3.9 with the following text:

3.9 Donning

Donning tests shall be performed to show compliance with the design requirements and the comprehensibility of markings. The procedure for donning the life preserver shall be simple and obvious such that it can be rapidly donned by an untrained person without any assistance. This shall be demonstrated in accordance with the test criteria and procedures in Subsection 5.3.

For the adult and adult-child category, it shall be demonstrated that at least 75 % of the total number of test subjects, and at least 60 % of the test subjects in each age group specified in Subsection 5.3.1, can don the life preserver within 25 seconds, unassisted, starting with the packaged life preserver on the test participant's lap. It must also be demonstrated that an unassisted adult can install an appropriate life preserver on another adult or child within 30 seconds.

For the child and infant-small child category, it shall be demonstrated that at least 60 % of five adult test subjects of both sexes between the ages of 20 and 40, unassisted, can install a child life preserver on a child who weighs between 35 and 90 pounds (15.88 and 40.82 kg) and an infant-small child life preserver on a child dummy within 90 seconds, unassisted, starting with the packaged life preserver.

The donning-time test does not apply to constant wear life preservers that are intended to be fully donned by the wearer while on board the aircraft. The donning-time test does apply to constant wear life preservers that are intended to be partially donned by the wearer while on board the aircraft and require an additional donning procedure prior to inflating the life preserver or entering the water. For these partially donned life preserver designs, the test shall begin with the life preserver in the partially donned condition.

Page 10, replace Subsection 3.10 with the following text:

3.10 Retention

The means of retaining the life preserver on the wearer for an adult, adult-child, and child life preserver shall require the wearer to secure no more than one attachment and make only one adjustment for fit. This requirement does not apply to constant wear life preservers. The retention means shall not make use of knots. The means of retaining the life preserver shall not require any action to secure it other than fastening and fit adjustment (e.g. removal of rubber bands, unfastening of attachment points). Partially donned life preservers shall not require the wearer to secure more than one attachment or make more than one adjustment for fit after the life preserver is partially donned.

The means of retaining the life preserver shall be shown to be operable within 5 seconds with chilled or gloved hands (e.g. fastening/unfastening buckles, snapping/unsnapping, etc.). This will be demonstrated in accordance with the Chilled Hands or Gloved Hands Test Methods in Subsection 5.4.2. This requirement does not apply to constant wear life preservers that are intended to be fully donned by the wearer while on board the aircraft. The adult, adult-child, and child category life preserver shall remain inflated, secured, and not cause injury to a wearer when it is tested in accordance with 5.4. There shall be no damage to the life preserver as a result of the jump. Chafing of the wearer's skin shall not be considered to be an injury.

The infant-small child category life preserver shall remain inflated and undamaged, and the infant-small child dummy, specified in 5.3.2, shall remain properly secured in the donned life preserver, while being held by an adult and tested in accordance with 5.4.3.

Page 11, replace Subsection 3.11.2 with the following text:

3.11.2 Infant-Small Child

The life preserver *shall* provide insulation for the wearer's head and upper torso (i.e. from the waist up) with a minimum R-value of 0.25 (equivalent to approximately 2 mm of wetsuit fabric). There shall be a means, other than knots, to restrict the position of the life preserver relative to the wearer, so as to provide proper function and prevent the wearer from releasing the means of restriction. Means shall be provided to prevent the introduction

	and/or entrapment of water. This shall be demonstrated in accordance with the Flotation Attitude Test procedure in 5.5.2.
	Page 11, replace Subsection 3.13 with the following text: 3.13 Tether, Infant-Small Child Category A tether of PIA-C-5040, Type 3 cord or equivalent, at least 72 inches (182.88 mm) long, shall be attached to the infant-small child life preserver. The attachment shall be located such that the flotation attitude specified in 3.11.2 is maintained when the line is held taut in the water. The attachment shall be shown to withstand a 70-pound (31.75 kg) pull for at least 3 seconds without a failure of the line or the attachment. A positive-buoyancy attachment means shall be provided at the free end of the tether. The attachment means shall be shown to be operable with cold, wet hands, using either the Chilled Hands or Gloved Hands Test Method. <i>This must be demonstrated in accordance with Subsection 5.9.</i> There shall be a provision for stowing or securing the tether during use so that it remains readily accessible and does not dangle loosely.
	Page 11, replace Subsection 3.14 with the following text: 3.14 Survivor Locator Light The life preserver shall be equipped with a survivor locator light that meets the requirements of ETSO-C85b or TSO-C85b, Survivor Locator Lights. The light shall automatically activate upon initial immersion in the water or by other means that do not require additional action by the wearer once the life preserver is fully donned. The light shall be located so to enhance visibility from a surface vessel or from an aircraft.
	Page 12, replace Subsection 3.17.2 with the following text: 3.17.2 Package Opening Opening of the package shall be demonstrated in accordance with the Package Opening test procedures in 5.7.
	Page 12, replace Subsection 3.18.1 with the following text: 3.18.1 Instructions The proper donning procedure and other operational instructions shall be simple, obvious, and <i>shall</i> be presented pictorially with a minimum use of words. Instructions that pertain to operations normally accomplished after the life preserver has been donned shall be oriented so that the wearer, or the person assisting a child or an infant-small child wearer, can see them while in the water. Instructions shall be sized, positioned and contrasted with the background to make them easily readable and comprehensible at a viewing distance of 24 inches (60.96 cm) with illumination no greater than 0.05 ft-c (0.54 lux) by a person who has 20/20 vision. Written instructions shall use bold lettering at least 0.22 inches (5.6 mm) high with a stroke width of at least 0.047 inches (1.2 mm). Comprehensibility shall be demonstrated in accordance with the Comprehensibility test procedure in Subsection 5.8.
Section 4	Apply all the subsections unless they are disregarded or modified below:
	Page 13, replace Subsection 4.2.1 with the following text: 4.2.1 Permeability The materials used in the construction of the air holding cell shall have a maximum permeability to helium of 5 L/m² in 24 hours at 77 °F (25 °C) when tested in accordance with 5.6.3.
Section 5	Apply all the subsections unless they are disregarded or modified below:
	Page 15, replace Subsection 5.1.2 with the following text: 5.1.2 Overpressure The life preserver shall meet the minimum buoyancy requirements defined in 3.4 when it is subjected to overpressure. Inflate each flotation chamber via the oral inflation tube to 1 psig (6.89 kPa), then manually actuate the discharge of the gas reservoir for each chamber. Submerge the life preserver in fresh water at a temperature of 70 °F ± 5 °F (21.1 °C ± 2.8 °C), so that no part of it is less than 24 inches (60.96 cm) below the surface of the water.

	Measure the buoyancy to show compliance with the applicable requirement in Table 1. Keep the life preserver submerged for at least 8 hours, after which time it shall be shown to meet or exceed the requirement in Table 1. Alternatively, the test may be discontinued in less than 8 hours if buoyancy measurements taken at 4 successive 30-minute intervals show that the buoyant force of the life preserver has stabilised at or above the value specified in Table 1.
	Pages 15-16, replace Subsection 5.3.1 with the following text: 5.3.1 Test Subjects At least 25 test subjects shall be employed in tests of an adult or adult-child preserver. At least 5 of those test subjects shall be from each of the following age groups: 20 to 29 years; 30 to 39 years; 40 to 49 years; 50 to 59 years; and 60 to 69 years. No more than 60 % of the test subjects in any age group may be of the same sex. The number of test subjects in any age group may not exceed 30 % of the total number of test subjects. Child-donning tests shall be performed by a minimum of 5 adult test subjects of both sexes between the ages of 20 and 40. Tests shall be performed using a child that weighs between 35 and 90 pounds (15.88 and 40.91 kg). Infant-small child donning tests shall be performed by a minimum of 5 adult test subjects of both sexes between the ages of 20 and 40. Tests shall be performed using an articulating infant-small child dummy per Subsection 5.3.2. Adult test subjects shall have no experience with inflatable life preservers or donning tests. Test subjects shall not be familiar with the manufacture, production, or maintenance of inflatable life preservers. Test subjects shall receive no donning instructions other than the general introduction briefing and preflight video briefing on the use of the life preserver per Appendix D — Donning Test Briefings. Instructions for the child and infant-small child category life preserver shall be the typical briefing given by a flight attendant to a parent/guardian that accompanies a child or infant on a flight. Test subjects may be informed (during the pre-test introduction briefing) that this is a timed test, and that their task is to don the life preserver within the applicable time frame specified in Subsection 3.9. Furthermore, the installation, operating and maintenance instructions shall also reflect the requirements of this section. The operating instructions must report the detailed content of the simulated preflight briefing and any special instructions for the unique aspects of operating the design of the life preserver that should be considered for its operational use and continued performance.
	Page 16, replace Subsection 5.3.3 with the following text: 5.3.3 Arrangement Subjects in tests of an adult, adult-child, or child life preserver shall be seated in previously approved air carrier coach class seating, with a seat row in front of the test subjects, creating a seat pitch not exceeding 31 inches (78.74 cm). Subjects shall be seated one per row. All subjects shall have their seat belts fastened. Infant-small child life preserver donning tests shall be performed with the adult test subject holding the infant on their lap, seated between two other adult subjects who shall not assist or hamper the test subject who performs the donning test. The adult test subject shall be wearing their own life preserver.
	Page 16, replace Subsection 5.3.4 with the following text: 5.3.4 Procedure The donning test shall start on signal with the packaged life preserver held on the test subject's lap, or for a constant wear life preserver, the test shall start in the partially donned configuration. The timing of the test shall end when the life preserver is properly donned, secured, and adjusted for fit (the means of adjustment shall be adjusted for a snug fit on the test subject). Donning tests shall be captured on video; the timing for each individual subject shall be recorded separately.

	Page 16, add two new subsections to 5.4 as follows: 5.4.2 Retention Mechanism Test Demonstrate the operability of the life preserver retention mechanism using either the Chilled Hands or Gloved Hands Test Method (see 2.3 Definitions). At least 4 out of 5 test subjects shall secure the life preserver retention mechanism (e.g. fasten and then unfasten it) within 5 seconds. In cases for which additional participants are required, 75 % of the total number of test participants for each demonstration must complete the retention mechanism task within the allowed time. 5.4.3 Infant-Small Child Life Preserver The infant-small child category life preserver shall remain inflated and undamaged, and the infant-small child dummy, specified in 5.3.2, shall remain properly secured in the donned life preserver, while being held by an adult who jumps into the water from a height of 5 feet (1.52 m) above the water. The adult shall wear an inflated life preserver for this test.
	Page 17, replace Subsection 5.6.2 with the following text: 5.6.2 Flammability The life preserver and package shall be constructed of material that meets the requirements of the latest amendment of CS-25, Appendix F, Part I. The definition and use of parts that are considered to be small parts (e.g. oral inflation tubes, clips, etc.) that would not contribute significantly to the propagation of a fire must be coordinated in advance with EASA.
	Page 17, replace Subsection 5.6.3 with the following text: 5.6.3 Permeability The permeability shall be tested in accordance with the permeability test procedure in FTMS 191, Method 5460; or alternatively, ASTM D1434-82, Procedure V may be used. The permeameter shall be calibrated for the gas that is used.
	Page 18, replace Subsection 5.7.1 with the following text: 5.7.1 Pull Force The pull force necessary to operate the opening mechanism shall be mechanically demonstrated not to exceed 9 pounds (40 N), or the opening of the mechanism shall be demonstrated in less than 7 seconds by at least 8 of 10 females over the age of 60, without any preview of the instructions. The timing shall start when the test participant has both hands on the package and is ready to open it, and shall end when the package is fully opened (e.g. the pull tab/strip is completely removed). A nick or cut shall not be introduced in the edge of the material at the tear line unless it is normally a part of the package design. In cases for which additional participants are required, 75 % of the total number of test participants for each demonstration must complete the opening of the package within the allowed time.
	Page 18, replace Subsection 5.7.2 with the following text: 5.7.2 Operation of the Opening Mechanism Operation of the opening mechanism shall be demonstrated within 10 seconds by 8 of 10 females with reduced dexterity simulated by the Chilled Hands or Gloved Hands Test Method, and without a preview of the instructions. The timing shall start when the test participant has both hands on the package and is ready to open it, and end when the life preserver is fully removed from the package. In cases for which additional participants are required, 75 % of the total number of test participants for each demonstration must complete the opening of the package within the allowed time.
	Page 18, replace Subsection 5.8 with the following text: 5.8 Comprehensibility Comprehensibility shall be demonstrated by 5 out of 6 test subjects, tested independently, using an open-ended answer format (see examples in ANSI Z535 or ISO 9186:2001) and/or a successful empirical demonstration of the equipment or feature.
	Page 18, add new Subsection 5.9 as follows: 5.9 Tether Attachment Test

	Demonstrate that the means of attachment, on the tether of the infant-small child life preserver, is operable using either the Chilled Hands or Gloved Hands Test Method (see 2.3 Definitions). At least 4 out of 5 test subjects shall secure the means of attachment of the life preserver. In cases for which additional participants are required, 75 % of the total number of test participants for each demonstration must complete the attachment task. This test may be performed on dry land. NOTE: The attachment should be demonstrated in the manner in which it is designed to be used; it should be attached to something as designed.
Appendix A	No change
Appendix B	No change
Appendix C	Page 24, replace Appendix C with Appendix 2 Tests Involving Subjects. See Appendix 2 on the final page.
	Page 25, add a new Appendix D as follows: Appendix D — Donning Test Briefings You must use the following scripts for the donning-test briefing. For the assisted donning tests, substitute the appropriate donning time requirement as specified in Subsection 3.9. The scripts may be modified as applicable for constant wear life preservers that are designed to be partially donned during flight. <u>General introduction briefing script:</u> You are participating in a passenger safety study to determine how long it takes to put on an aircraft life preserver. You are seated in a seat that is similar to those found on passenger aeroplanes; please fasten your seatbelt [pause until all seatbelts are fastened]. The test will simulate an actual airline emergency; your goal is to put on the life preserver as quickly as possible within 25 seconds or less. Video cameras will record your actions. To start the test, your instructor will say: ‘3, 2, 1, go!’ This is your signal to open the package and put on the life preserver. Following this introduction, a video of a simulated passenger information briefing will be presented. After the video, you will be handed your life preserver package. [Optional: Before the video, please review the safety information card for additional instructions on putting on the life preserver.] <u>Preflight video briefing script:</u> This test will simulate an actual airline emergency; your goal is to put on the life preserver as quickly as possible within 25 seconds or less. To start the test, your instructor will say: ‘3, 2, 1, go!’ This is your signal to open the package and put on the life preserver. To put on your life preserver: Pull the tab and tear open the package. Remove the life preserver from the package. Pull the life preserver over your head. Grab the waist strap and wrap it around your waist. Insert the clip into the buckle and pull the end of the waist strap to tighten the belt. Raise your arms when you have finished.

[Amdt ETSO/1]

[Amdt ETSO/16]

APPENDIX 2 TO ETSO-C13G – TESTS INVOLVING SUBJECTS¹

ED Decision 2020/011/R

Test name	Paragraph	Number of subjects
Donning Test	5.3	
Adult or Adult-Child	5.3.1	— 25 adults minimum — Age groups: 20-29, 30-39, 40-49, 50-59, 60-69 yrs (see 5.3.1 for more details)
Child	5.3.1	— 5 adults: ages: 20-40 years, male and female — 5 children: each child: 35-90 lbs (15.88-40.91 kg)
Infant-Small Child	5.3.1 5.3.2	— 5 adults: ages: 20-40 years, male and female — 1 anthropometric, infant-small child test dummy or child
Retention Test	5.4	
Adult, Adult-Child, and Child	5.4.1	— 3 adults minimum, including at least one 5th percentile female and one 95th percentile male (measured by weight and head circumference)
Chilled Hands or Gloved Hands Test Method	5.4.2	— 5 adults minimum (see 2.3)
Infant-Small Child	5.4.3	— 1 adult holding child test dummy or child (see 5.3.2)
Flotation Attitude Test	5.5	
Adult, Adult-Child, or Child	5.5.1	— 3 minimum, including at least one 5th percentile female and one 95th percentile male (measured by weight and head circumference)
Packaging Opening	5.7	
Pull Force (2 methods)	5.7.1	— Mechanical: not to exceed 9 lbs (40 N) OR — 10 minimum, female, older than 60 yrs
Operation of the Opening Mechanism	5.7.2	— 10 minimum, female with reduced dexterity simulated by chilled or gloved hands (see 2.3)
Comprehensibility	5.8	— 6 adults

¹ NOTE: Tests that require human subjects or a child test dummy shall use time-encoded video

Tether Attachment**5.9****— 5 adults minimum**

[Amdt ETSO/16]

ETSO-C14b

ED Decision 2003/10/RM

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 65lb (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.

ETSO-C15d

ED Decision 2003/10/RM

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.

ETSO-C16b

ED Decision 2018/002/R

ELECTRICALLY HEATED PITOT AND PITOT-STATIC TUBES**1 Applicability**

This ETSO provides the requirements which electrically heated pitot and pitot-static tubes, heated by aircraft electrical power, that are designed and 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**2.2.1 Test Report**

The test report identified in Section 2.4.2 and data identified in Chapter 4 of EUROCAE ED-225, Ice and Rain Minimum Qualification Standards for Pitot and Pitot-Static Probes, shall be provided to the installer to support installation approval.

2.2.2 Rated Performance Documentation

The rated performance to be declared in the declaration of design and performance (DDP) shall at least contain:

- the probe type and class;
- the passed test conditions;
- the concentration factors used for icing tests; and
- the probe test voltage

3 Technical Conditions**3.1 Basic****3.1.1 Minimum Performance Standard**

Standards set forth in SAE International's Aerospace Standard AS8006A, Minimum Performance Standard for Pitot and Pitot-Static Tubes, revised August 2015, as Modified in [Appendix 1](#) of this ETSO, and EUROCAE ED-225, Ice and Rain Minimum Qualification Standards for Pitot and Pitot-Static Probes, issued February 2016, as modified in [Appendix 2](#) of this ETSO.

Note: The electric heater function is defined as starting with the aircraft interface (connector). The pneumatic pressure function is defined as starting with the pressure transducer interface if it is integrated with the probe or starting with the aircraft interface if the pressure transducer is separated from the probe.

3.1.2 Environmental Standard

EUROCAE ED-14G / RTCA DO-160G, Environmental Conditions and Test Procedures for Airborne Equipment, or later revision as permitted by CS-ETSO, Subpart A, paragraph 2.1 and complemented by the minimum performance standards specified in Section 3.1.1 of this ETSO.

3.1.3 Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

4 Marking

4.1 General

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

4.2 Specific

In addition, the following identification information must be permanently and legibly marked:

- (1) The TYPE and CLASS designation in accordance with EUROCAE ED-225, paragraph 1)
- (2) All the information in SAE AS8006A, paragraphs 3.5.4 and 3.6.

5 Availability of Referenced Document

See CS-ETSO, Subpart A, paragraph 3.

[Amdt ETSO/4]

[Amdt ETSO/13]

APPENDIX 1 TO ETSO-C16B – MINIMUM PERFORMANCE STANDARD FOR ELECTRICALLY HEATED PITOT AND PITOT-STATIC TUBES

ED Decision 2018/002/R

This ETSO modifies SAE AS8006, as follows:

AS8006A Section	EASA Modification
2.1	Page 1, Replace Subsection 2.1, with the following text: 2.1 Applicable Documents The following publications form a part of this document to the extent specified herein. The applicable issue of cited publications shall be the issue in effect on the date of the publication of this document, unless otherwise specified. In the event of conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific deviation or exemption has been obtained.
3.4.2	Page 3, replace Subsection 3.4.2 with the following text: 3.4.2 Particle Separation Features The probe shall be designed with baffling or a pitot settling chamber, or both, to minimise the entry of liquid or solid particles into the tubing connecting the probe to the aircraft instruments. There shall be at least one drain hole to discharge or scavenge entrained liquid, such as rain or melted ice water. The probe design shall consider the effects of ingested solid particles such as ice, sand and dust.
3.4.3	Page 3, replace Subsection 3.4.3 with the following text: 3.4.3 Mis-installation The probe shall incorporate design features to minimise the potential for mis-installation on the aircraft. For example, in the case where the probe contains multiple pneumatic or electrical connections these features may include the incorporation of different pneumatic fitting sizes or types, or different electrical connector keying.
3.4.11	Page 4, amend 3.4.11 as follows: Protective coatings and finishes utilised in the construction of the probe shall not crack, chip, or scale to the extent that the probe no longer meets the aerodynamic accuracy requirements when exposed to the qualification test requirements of this standard. Other FAA modification not retained.
4.6	Page 7, amend 4.6 as follows: Other means can be used to demonstrate compliance with this requirement provided there is evidence they are equivalent or better than the specified test. Such alternate means is considered a deviation.

5.26

Page 12, replace Subsection 5.26 with the following text:

5.26 Fire, flammability

Non-metallic probes shall be tested for compliance with the fire and flammability test standards specified in EUROCAE ED-14G / RTCA DO-160G, Section 26, Category C. If ignition occurs inside or outside of the equipment, the probe shall not propagate the flame. Tests are not required for metallic probes.

[Amdt ETSO/4]

[Amdt. ETSO/13]

APPENDIX 2 TO ETSO-C16B – ICE AND RAIN MINIMUM QUALIFICATION STANDARDS FOR PITOT AND PITOT-STATIC PROBES

ED Decision 2018/002/R

ED-225 introduces the possibility to use alternate methods. EASA considers the following alternate means as deviations from this ETSO:

ED-225 Section	Alternate method
1.2	Modified test conditions
2.2	Modified test conditions
2.3	Scaling method not listed in section 2.3
Table 5	MMD value outside the specified range
Table 6	MVD value outside the specified range

In addition, this ETSO modifies EUROCAE ED-225, as follows:

ED-225 Section	EASA Modification
1.2	Page 1: Replace the first 'NOTE' with the following: NOTE: Class 2 is divided into two subgroups identified as either Class 2a or Class 2b. Class 2a probe applications typically include aircraft that operate within the mid to lower end of the Class 2 altitude range and that only use probe outputs to display basic airspeed and/or altitude. As such, Class 2a probes do not have to be tested against ice crystals at an altitude-capable icing tunnel. Class 2b applications are for probe installations intended to serve a critical function and shall be tested at an altitude-capable icing tunnel. Probes qualified to Class 2 of this standard shall be identified as either Class 2a or Class 2b.
1.2	Replace the second 'NOTE' with the following: NOTE: This specification, when used in conjunction with AS8006A, provides a comprehensive design and test standard for the devices that fall within the scope of this document.
1.6	Page 3: Add subsection 1.6 1.6 General Definitions SHALL: The word 'shall' is used in this document to express an essential requirement where compliance is mandatory. MUST: The word 'must' is used in this document to express an essential requirement where compliance is mandatory.
3.5	Page 8, Paragraph 3.5 add the following note: NOTE: The probe test voltage reported to the installer shall not include any voltage adjustments made per paragraph 3.9 to simulate worst-case heater performance.

[Amdt ETSO/13]

ETSO-C20a

ED Decision 2020/011/R

COMBUSTION HEATERS AND ACCESSORIES**1 Applicability**

This ETSO provides the requirements which combustion heaters and accessories that are designed and 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**

The 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**

The applicable standards are those provided in SAE International's Aerospace Standard AS8040B, Heater, Aircraft, Internal Combustion Heat Exchanger Type, dated 14 February 2013, as amended by Appendices [1](#) and [2](#) to this ETSO.

3.1.1.1 Functionality

This standard in this ETSO applies to equipment that is intended to provide heated air for civil aircraft.

Note: For combustion heaters and accessories, the maintenance and inspection items contained in the instructions for continued airworthiness play an important role in preventing failures that result in combustion by-products entering the cabin/flight deck.

3.1.2 Environmental Standard

The required performance under the test procedures in SAE AS8040B, Heater, Aircraft, Internal Combustion Heat Exchanger Type, dated 14 February 2013, as amended by Appendix 1 to this ETSO, using standard environmental conditions and test procedures that are appropriate for airborne equipment, shall be demonstrated.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific

3.2.1 Failure Condition Classification

- (1) A failure of the function defined in paragraph 3.1.1.1 of this ETSO is a major failure condition.
- (2) A loss of the function defined in paragraph 3.1.1.1 of this ETSO is a minor failure condition.
- (3) Design the system to at least fulfil these failure conditions above.

4 Marking

4.1 General

See CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

If the article includes software and/or airborne electronic hardware, then the part numbering scheme for the article must identify the configuration of both the software and the airborne electronic hardware. The part numbering scheme can use separate, unique part numbers for the software, the hardware, and the airborne electronic hardware.

If the combustion heater includes a deviation from this ETSO, the marking must include a means to indicate that a deviation was granted.

5 Availability of Referenced Document

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/16]

APPENDIX 1 TO ETSO-C20A – MPS FOR COMBUSTION HEATER BASED ON SAE AS8040B

ED Decision 2020/011/R

This Appendix prescribes the MPS for combustion heaters. The applicable standard is SAE International's Aerospace Standard AS8040B, Heater, Aircraft, Internal Combustion Heat Exchanger Type, dated 14 February 2013. EASA has modified it as follows:

Section: 3. Accessories

- 3.2.a. Includes the fuel/air ratio controller, fuel lines and preheater.
- 3.2.b. Rewritten to read 'Ignition System: The ignition system uses an aircraft-supplied energy source to enable the proper functioning of the igniter. Examples of accessory devices that may be utilised in a heater ignition system include but are not limited to:'
 - 3.2.b.2. Replaces the term 'spark plug' with 'igniter'.
 - 3.2.b.3. Removes the statement 'Heaters with output ratings of 11,700 W (40,000 Btu/hour) or less may use an electrically heated resistance wire as an ignition source.'
- 3.2.c. Includes the requirement 'Any component whose failure could lead to an unsafe condition, such as ducting, that is in a fire zone, must be fireproof.'
- 3.2.c. Includes ducting/tubing, the combustion air blower, combustion air flow sensor, ventilation air flow sensor, and air flow/pressure regulator.
- 3.2.d.1. Revised to read 'Cabin temperature controls'.
- 3.2.e. Includes a device to sense differential pressure across the combustion chamber, a device to sense combustion, a device that senses excessive combustion by-products in the ventilation air, a device to shut off the fuel flow when required, and a device to alert the crew that a safety system has engaged.
- 3.3.2. Includes the phrase 'having the capacity to withstand at least as well as .015-inch-thick stainless steel, the heat produced when there is a severe fire of extended duration.'
- 3.5. Includes the service ceiling.
- 3.6. Includes the statement 'It is best practice to set inspection, maintenance and/or replacement intervals based on individual component performance during design qualification testing (such as endurance testing).'

Section: 4. Detailed Requirements

- 4.3.1. Replaces 'gasoline or aviation grade kerosene, or both' with 'fuel'.
- 4.3.4. Adds 'fittings and controls' after 'All fuel lines'.
- 4.3.5. Replaces 'no lead or low lead type gasoline and kerosene' with the word 'applicable'. Adds 'Low starting temperature limits for other types of fuels need to be addressed on a case-by-case basis.' to the end of this paragraph.
- 4.5. Replaces '649 °C (1 200 °F)' with 'material capabilities in this section of the heater'. Adds the sentences 'Best practice is to ensure that the temperature at the point of discharge does not exceed 649 °C (1 200 °F). Consideration should also be given to the impact of heat impingement on the region of the aircraft that surrounds the combustion heater.' at the end of the paragraph.

4.6.3. Adds at the end of the paragraph the following: ‘or heated solid surface, though it is not considered to be a best practice to use resistance wires as ignition sources for power levels above 11 700 W.’

4.6.8. Adds the statement ‘Other types of fuels need to be addressed on a case-by-case basis.’ at the end of the paragraph.

4.6.9. Adds the statement ‘Other types of fuels need to be addressed on a case-by-case basis.’ at the end of the paragraph.

4.7.d. replaced with this paragraph: ‘These safety controls shall be independent of the controls that are normally used to control the operation of the heater. The shut-off of ignition and fuel shall occur at a point that is remote from the heater itself. The combustion heater shall have a means to warn the crew when any heater whose heat output is essential for safe operation has been shut off by the automatic means. The requirement to shut off ignition and fuel at a point that is remote from the heater until restarted by the crew, may require a safety interlock relay and an additional fuel shut-off device to be supplied in addition to the valve that is usually supplied with the heater as an accessory. The relay and valve are the responsibility of the installer. See 5.2.10.6 for the tests to be conducted on safety controls.’

4.9. Adds at the end of the first paragraph: ‘Use electrical load analysis to show that the heater is safe to operate in the worst-case situation.’

4.12. Adds a new paragraph:

Radio Interference

4.12.1 If the manufacturer elects to demonstrate compliance with the standard radio interference requirements, it is considered to be a best practice to test the combustion heat exchanger per:

- (a) EUROCAE/RTCA, ‘Environmental conditions and test procedures for airborne equipment’, ED 14D/DO-160D Change 3 (or later revisions), Section 21, Category M, for operation in the passenger compartment and the flight crew compartment; and
- (b) EUROCAE ED-14D/RTCA document DO-160D Change 3 (or later revisions), Section 21, Category H, for operation in areas not accessible during the flight, and report the result in the aircraft flight manual supplement.

4.12.2 If the manufacturer elects not to demonstrate compliance with the radio interference requirements, the manufacturer shall include the following statement in the aircraft flight manual supplement for the combustion heat exchanger:

‘This combustion heat exchanger assembly does not include protection against radio and/or avionics interference, and has not been tested against it.’

Section: 5 Required Testing

The initial paragraph includes the statement ‘Test plans and reports shall be generated and retained for the life of the design.’

5.2.2.2 Revised to include ‘A suitable instrument with a resolution of 5 ppm or better, calibrated against a known standard, will be used to determine CO concentration.’

5.2.2.3 Adds the statement ‘A pressure decay test may alternatively be used, provided that the decay rate can be determined to be equivalent to the requirements listed above.’ at the end of the paragraph.

5.2.3 Replaces:

‘The service ceiling determined by this test shall meet the requirement specified by the purchaser.’

with:

‘It is typical for the service ceiling of a combustion heater to be at least 6 100 m (20 000 ft), and in order to ensure that there is an adequate margin with this test being performed on only one heater, a safety margin of 5 % shall be applied. Therefore, in order to set a service ceiling of 6 100 m (20 000 ft), the peak of the ignition characteristics curve shall be no lower than 6 405 m (21 000 ft).’

5.2.4. The text is replaced by the following:

‘Install the test unit into the test set-up used in 5.2.2.1 and cold soak the combustion heater assembly to - 54 °C (- 65 °F) for gasoline type heaters, and - 29 °C (- 20 °F) for kerosene type heaters (for other fuel types, the applicable temperature will be determined on a case-by-case basis). The valve leakage in the closed position with either the rated fuel pressure or the minimum practical fuel pressure shall not exceed 0.068 fluid ounces (2 mL) of fuel in 10 minutes. Supply combustion air and ventilating air to the heater at sea-level pressure and a temperature of - 54 °C (- 65 °F). The temperature of the fuel supplied to the heater shall be - 54 °C (- 65 °F) for gasoline-type heaters and - 29 °C (- 20 °F) for kerosene-type heaters. The combustion and ventilating air pressure levels and the mass flow rates shall be the same as in 5.2.2.1. Glow plug ignited heaters shall ignite within 200 seconds. Spark ignited heaters shall ignite within 15 seconds when burning gasoline-type fuels, and within 60 seconds when burning kerosene-type fuels. Measure and record the parameters specified in 5.2.2.1.’

5.2.10.6.2.1. This includes the following statement after the first sentence in the second paragraph:

‘Leakage through the fuel valve shall then be measured, and shall not exceed 0.068 fluid ounces (2 mL) in 10 minutes.’

Section: 6 Desirable Features

6.1.2 This includes the statement ‘Other types of fuels need to be addressed on a case-by-case basis.’

[Amdt ETSO/16]

APPENDIX 2 TO ETSO-C20A – INSTRUCTIONS FOR CONTINUED AIRWORTHINESS OF THE AIRCRAFT COMBUSTION HEATER AND ACCESSORIES

ED Decision 2020/011/R

- 1.0 The following information contained in this Appendix must be included in the manual to ensure that the combustion heater and its accessories continue to comply with the ETSO once it is installed in a product:
- 1.1 Scheduling information for each part of the combustion heater, stating the inspection criteria and service limits. Necessary cross-references to the Airworthiness Limitations section must also be included.
- 1.2 Troubleshooting information that describes the probable malfunctions, and how to recognise and resolve those malfunctions.
- 1.3 Information that describes the order and method for removing and replacing parts, the order and method for disassembly and assembly, with any necessary precautions to be taken.
- 1.4 Cleaning and inspection instructions that cover the material and apparatus to be used and the methods and precautions to be taken. Methods of inspection must also be included.
- 1.5 Details of repair methods for worn or otherwise substandard parts and components, along with the information necessary to determine when a replacement is necessary.
- 1.6 Instructions for testing, including the use of the test equipment and instrumentation.
- 1.7 A list of the tools and equipment that are necessary for maintenance, and guidance for their use.
- 1.8 Instructions on how to ensure that the combustion heater assembly is fit to return to service after maintenance and prior to installation (for example, procedures for a pressure decay test).

[Amdt ETSO/16]

ETSO-C21b

ED Decision 2003/10/RM

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.

ETSO-C22g

ED Decision 2003/10/RM

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.

ETSO-C23f

ED Decision 2018/002/R

PERSONNEL PARACHUTE ASSEMBLIES AND COMPONENTS**1 Applicability**

This ETSO provides the requirements which emergency parachutes that are designed and 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 for emergency parachutes in Parachute Industry Association (PIA) Technical Standard 135 (TS-135) Revision 1.4, issued April 22, 2010, 'Performance Standards for Personnel Parachute Assemblies and Components', as modified by [Appendix 1](#) of this ETSO.

3.1.2 Environmental Standard

As set forth in Parachute Industry Association (PIA) Technical Standard 135 (TS-135) Revision 1.4, issued April 22, 2010, 'Performance Standards for Personnel Parachute Assemblies and Components'.

3.1.3 Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 Specific**3.2.1 Failure Condition Classification**

See CS-ETSO Subpart A paragraph 2.4

Equipment suitability for supporting the function defined in paragraph 3.1.1 of this ETSO is established by performing the tests as prescribed in Parachute Industry Association (PIA) Technical Standard 135 (TS-135) Revision 1.4, issued April 22, 2010, 'Performance Standards for Personnel Parachute Assemblies and Components', as modified by Appendix 1 of this ETSO, with no further analysis required.

4 Marking**4.1 General**

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

4.2 Specific

Also, mark the following permanently and legibly, with at least the manufacturer's name, subassembly part number, and the ETSO number:

- (1) Each component that is easily removable (without hand tools), and
- (2) Each subassembly of the article that you determined may be interchangeable.

5 Availability of Referenced Document

You can download a free copy of PIA TS-135 Revision 1.4 issued April 22, 2010, Performance Standards for Personnel Parachute Assemblies and Components, at:

<http://www.pia.com/piapubs/TSDocuments/TS-135v1.4.pdf>

[Amdt ETSO/13]

APPENDIX 1 TO ETSO-C23F – MINIMUM PERFORMANCE STANDARD FOR PERSONNEL PARACHUTE ASSEMBLIES AND COMPONENTS

ED Decision 2018/002/R

This Appendix prescribes the MPS for a personnel parachute assembly and its components. The applicable standard is PIA TS-135 Revision 1.4, issued April 22, 2010, Performance Standards for Personnel Parachute Assemblies and Components, as modified for this ETSO:

1. Page 2, replace paragraph 2.1.i. to read as follows:
'Cognisant Agency' — The European Aviation Safety Agency (EASA).
2. Page 2, replace paragraph 2.1.a. to read as follows:
'Administrator' — EASA.
3. Page 5, paragraph 4.1.2. delete: 'generally'.
Stitching should not ravel when it is broken. 'Generally' reduces the requirement for stitch choice, and adversely impacts the current standard.
4. Page 5, paragraph 4.1.3. delete: 'Ref: Table 2'.
Table 2 is not relevant to this requirement. Testing of a packed assembly will show if the main parachute will interfere with the proper function of the reserve parachute.
5. Page 8, paragraph 4.3.5.3 replace 'a 200 lbf (889.6 N)' with 'the greater of (200 lbf (889.6 N)) and the (maximum operating weight times 0.84)'.
To ensure that the compression load is at least the compression load of the body without legs and feet.
6. Page 9, paragraph 4.3.7. in first sentence delete: 'a weight not more than'.
The worst case is the maximum operating weight.
7. Page 11, paragraph 4.3.11. in the first sentence delete 'not more than'.
The worst case is the maximum operating weight.
8. Page 11, disregard paragraph 4.3.9.1., Rate of Descent Tests (Method 2).
9. Page 14, Table 1, under Marking Data Requirements, replace:
Statement of Authorisation under TSO-C-23e and/or (J) TSO-C-23e if applicable.
with:
Statement of Authorisation under ETSO-C23f.

[Amdt ETSO/13]

ETSO-C25a

ED Decision 2003/10/RM

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.

ETSO-C26d

ED Decision 2016/029/R

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 designed and 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.

The MPS is based, in part, on the Society of Automotive Engineers (SAE), Aerospace Recommended Practice (ARP) 5381, Minimum Performance Recommendations for Part 23, 27 and 29 Aircraft Wheels, Brakes, and Wheel-Brake Assemblies, dated October 2000.

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 and in lieu of the marking specified in 21.A.807(a), the following information shall be legibly and permanently marked on the major equipment components:

- (1) Name of the manufacturer responsible for compliance;
- (2) Serial number;
- (3) Part number;

- (4) Applicable ETSO number;
- (5) Rim size (this marking applies to wheels only);
- (6) Hydraulic fluid specification (this marking applies to hydraulic brakes only).

4.2 Specific

None.

5 Availability of Referenced Document

Copies of SAE ARP5381 may be purchased from the Society of Automotive Engineers Inc., Department 331, 400 Commonwealth Drive, Warrendale, PA 15096-0001. Copies also can be obtained through the SAE Internet website at: www.sae.org.

[Amdt ETSO/12]

APPENDIX 1 TO ETSO-C26D – MINIMUM PERFORMANCE STANDARD FOR AIRCRAFT WHEELS, BRAKES AND WHEEL/BRAKE ASSEMBLIES FOR SMALL AIRPLANES AND ROTORCRAFT

ED Decision 2016/029/R

This appendix prescribes the Minimum Performance Standard (MPS) of SAE ARP5381, 'Minimum Performance Recommendations for Part 23, 27, and 29 Aircraft Wheels, Brakes, and Wheel-Brake Assemblies', dated October 2000, as modified in this ETSO.

Additions to and one deletion from the standard, are shown in italics as follows:

Additions:

1. *Page 3, a new paragraph is added after 3.6:*

Suitable Tyre for Brake Tests, TT_{BT}

TT_{BT} is the rated tyre type and size.

TT_{BT} is the tyre type and size that has been determined as being the most critical for brake performance and/or energy absorption tests. The TT_{BT} must be a tyre type and size approved for installation on the wheel (TS_{WR}). The suitable tyre may be different for different tests.

2. *Page 7, a new paragraph is added after 4.3:*

Fire Protection: Except for small parts (such as fasteners, seals, grommets, and small electrical parts) that would not contribute significantly to the propagation of a fire, all solid materials used must meet the applicable flammability rules for the part and category of aircraft.

Deletion:

1. *Page 13, paragraph 5.3.3.2 is disregarded. Worn brake testing is not a requirement of Part 23, 27 or 29, so it cannot be included in this TSO.*

[Amdt ETSO/12]

ETSO-C27a

ED Decision 2020/011/R

TWIN SEAPLANE FLOATS**1 Applicability**

This ETSO provides the requirements which twin seaplanes floats that are designed and 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**

The 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**

The applicable standards are those provided in Aerospace Industries of America, Inc., National Aerospace Standard (NAS) 807, Revision 2, Twin Seaplane Floats, dated 30 June 2017.

3.1.2 Environmental Standard

See CS-ETSO, [Subpart A](#), paragraph 2.1.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific**3.2.1 Functionality**

The standards of this ETSO apply to twin seaplane floats that are suitable for use on aeroplanes.

3.2.2 Failure Condition Classification

A failure condition classification is not required.

3.2.3 Functional Qualification

The materials and workmanship must conform to the requirements specified in Section 3 of NAS 807, Revision 2. The functional performance must be demonstrated under the test conditions specified in Section 4 of NAS 807, Revision 2. The applicant must define the design parameters to which the article is qualified (e.g. maximum aeroplane weight, V_{so} , etc.).

4 Marking**4.1 General**

See CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

None.

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/16]

ETSO-C28

ED Decision 2003/10/RM

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.

ETSO-C30d

ED Decision 2018/002/R

AIRCRAFT POSITION LIGHTS**1 Applicability**

This ETSO provides the requirements which aircraft position lights that are designed and 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 8037C 'Minimum Performance Standard for Aircraft Position Lights' dated July 2013.

3.1.2 Environmental Standard

See CS-ETSO [Subpart A](#) paragraph 2.1

3.1.3 Software

See CS-ETSO [Subpart A](#) paragraph 2.2

3.1.3 Airborne Electronic Hardware

See CS-ETSO [Subpart A](#) paragraph 2.3

3.2 Specific**3.2.1 Failure Condition Classification**

See CS-ETSO [Subpart A](#) paragraph 2.4.

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.

[Amdt ETSO/13]

ETSO-C39c

ED Decision 2010/010/R

AIRCRAFT SEATS AND BERTHS CERTIFIED BY STATIC TESTING ONLY**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 A – Large Aeroplane (9g forward load seats only)

Type I – Large Aeroplane (berths only)

Type II – Normal, Utility and Commuter

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****3.1.1.2 Type A**

Standards set forth in sections 3.1.4, 3.1.8, 3.1.11, 3.1.14, 3.1.15, 3.1.17, 3.1.18, 3.1.19, 3.1.20, 3.2, 3.3, 3.4 (except 3.4.2), 3.5, 4 (except 4.2), 5 (except 5.3 and 5.4) of SAE Aerospace Standard (AS) document AS 8049 Rev. A, “Performance Standard for Seats in Civil Rotorcraft, Transport Aircraft, and General Aviation Aircraft” dated September 1997, as modified by [Appendix 1](#) of this ETSO.

Seat cushions, when included, for large aeroplane passenger, flight attendant, and observer seats shall meet the fire protection provisions of Appendix F, Part II of EASA CS 25, as required by CS 25.853(c).

3.1.1.3 Type I, II, III and IV

Standards set forth in the National Aerospace Standard (NAS) Specification 809, dated January 1, 1956 with the following exception:

- (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) Materials in Type I berths must comply with the fire protection provisions of CS 25.853(a).

3.1.2 Environmental Standard

None

3.1.3 Computer Software

None

3.1.4 Electronic Hardware Qualification

None

3.2 Specific

None.

4 Marking

4.1 General

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

4.2 Specific

4.2.1 The marking must also include the applicable seat type: “Type A-”, “Type I-”, “Type II-”, “Type III-”, or “Type IV-” followed by the appropriate seat facing direction designation: “FF” – forward; “RF”- rearward; or “SF” – sideward

4.2.2 Each passenger, flight attendant and observer seat cushion required for qualification of the seating system must be marked with “Complies with CS 25.853(c)” when tested in accordance with the requirements of CS 25.853(c)

5 Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3

[Amdt ETSO/6]

APPENDIX 1 TO ETSO-C39c – MODIFICATION TO AS 8049 REV. A

ED Decision 2010/010/R

Modify SAE AS8049 Rev. A as follows:

- (1) Disregard first paragraph in section 3.2 Requirements.
- (2) Revise Section 3.2.1 as follows:

Seat systems shall be designed to provide protection for the occupant at seat adjustment positions, orientations, and locations allowed to be occupied during takeoff and landing.
- (3) Revise Section 3.2.2 as follows:

Seat elements shall be designed so that, when evaluated under the static test conditions of this document, they do not leave hazardous projections that could significantly contribute to occupant injury or impede rapid evacuation.
- (4) Revise Section 3.2.6 as follows:

Adjustable features (seat swivel, back recline, and stowage of movable tables, armrests, footrests, etc.) shall be designed to permit the seat occupant access to those features to adjust to the positions required for takeoff and landing without releasing the occupant's restraints.
- (5) Revise Section 3.2.7 as follows:

When an under-seat baggage restraint is incorporated in a passenger seat, it shall be designed to restrain at least 9.1 kg (20 lb) or the placard weight of stowed items per passenger place, under the static test conditions of this document in a manner that will not significantly impede rapid egress from the seat.
- (6) Revise Section 3.5 as follows:

Allowable permanent deformations sustained by a seat subjected to the ultimate static tests of this document are specified below. Permanent seat deformations shall be measured on the critically loaded seat after static tests. Significant measuring points shall be identified and marked on the test seat, and their positions measured in the lateral, vertical, and longitudinal directions relative to fixed points on the test fixture. Measurement of the selected points shall be recorded before and after the tests. Post test deformations shall be recorded and reported.
- (7) Revise Section 4 as follows:

STRENGTH: All seats qualified for occupancy during takeoff and landing shall be capable of withstanding, within the criteria defined below, statically applied loading.
- (8) Revise Section 5 as follows:

QUALIFICATION TESTS: Initial qualification of a seat shall be performed by static tests. Subsequent qualifications related to design changes to seats of a similar type may be performed by rational analysis based on existing qualification test data.
- (9) Revise Section 3.1.11 as follows:

Restraint system anchorages should provide self-aligning features. If self-aligning features are not provided, the static tests in this document should be conducted with the restraints and anchorages positioned in the most adverse configuration allowed by the design. The anchorage system should minimise the possibility of incorrect installation or inadvertent disconnection of the restraints.

[Amdt ETSO/6]

ETSO-C42

ED Decision 2003/10/RM

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: 1.23dm³ (1.3quart)/minute (maximum).
Duration: 4 minutes, 30 seconds.
 - (b) Part II (which shall immediately follow Part I) Pressure: 11378kPa (1650 psi) (minimum).
Oil flow rate: 13.2dm³ (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: 13.2dm³ (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: 13.2dm³/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.

ETSO-C43d

ED Decision 2020/011/R

TEMPERATURE INSTRUMENTS**1 Applicability**

This ETSO provides the requirements which new models of temperature instruments that are designed and 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**

The 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**

The applicable standards are those provided in SAE International's Aerospace Standard AS8005 'Minimum Performance Standard for Temperature Instruments' Revision A, September 1996, as amended by Appendix 1.

Exceptions:

- (i) In the friction error test SAE AS8005A, paragraph 4.8, the vibration (to minimise friction) provisions of paragraph 4.3 do not apply.
- (ii) For clarification, the vibration test of SAE AS8005A, paragraph 5.8, shall be conducted in accordance with the test procedure required by paragraph 3.1.2 below.

3.1.2 Environmental Standard

See CS-ETSO, [Subpart A](#), paragraph 2.1.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific**3.2.1 Failure Condition Classification**

See CS-ETSO, [Subpart A](#), paragraph 2.4.

4 Marking**4.1 General**

See CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

None.

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/16]

APPENDIX 1 TO ETSO-C43D – MODIFICATIONS TO SAE AS8005A

ED Decision 2020/011/R

- Change Section 4.1 of SAE AS8005A to read:
‘Unless otherwise specified herein, all the tests required shall be made at the atmospheric conditions specified in Section 3.5 of the document required by Section 3.1.2 of ETSO-C43d.’
- Remove Section 4.3 of SAE AS8005A, as vibration as a means to reduce friction is no longer acceptable.
- In Section 5 of SAE AS8005A, remove the sentence ‘The order of tests shall be in accordance with paragraph 3.2, page 5, DO-138.’
- In Section 5 of SAE AS8005A, the text ‘RTCA Document Number DO-138 entitled “Environmental Conditions and Test Proc. for Airborne Electronic/Electrical Equipment and Instruments”, dated 27 June 1968’ shall be replaced with the document required by Section 3.1.2 of ETSO-C43d.’
- In Section 5 of SAE AS8005A, any reference to ‘DO-138’ shall be replaced by a reference to the document required by Section 3.1.2 of ETSO-C43d’.

[Amdt ETSO/16]

ETSO-C44c A1

ED Decision 2013/012/R

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 [Appendix 1](#).

3.1.2 Environmental standard

The Fuel Flowmeter must be tested in accordance with SAE AS407C “Fuel Flowmeters” from July 1, 2001, unless otherwise specified by Appendix 1 to this ETSO, SAE AS1055D “Fire Testing of Flexible Hose, Tube Assemblies, Coils, Fittings, and Similar System Components” (sections 4 and 5) from June 1997, and the applicable environmental test procedure as specified by paragraph 2.1 of CS-ETSO, Subpart A, unless otherwise specified by Appendix 1 to this ETSO.

3.1.3 Software

If the equipment design includes a digital computer, see CS-ETSO, Subpart A, paragraph 2.2, for software development.

3.1.4 Airborne Electronic hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 Specific**3.2.1 Failure condition classification**

See CS-ETSO, Subpart A, paragraph 2.4.

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.

[Amdt ETSO/3]

[Amdt ETSO/7]

[Amdt ETSO/8]

APPENDIX 1 TO ETSO-C44c A1 – MINIMUM PERFORMANCE STANDARD FOR FUEL FLOWMETERS

ED Decision 2013/012/R

1. General Requirements.

The applicable standard is SAE AS407C, Fuel Flowmeters, dated July 1, 2001.

Paragraphs 3.1, 3.1.1, 3.1.2, 3.2.b, and 4.2.1 of the SAE AS407C do not apply to this ETSO.

SAE AS407C must be applied as follows (changed text shown framed):

- a. Temperature. On Page 2 of SAE AS407C, replace Table 1 with the following table.

TABLE 1		
INSTRUMENT LOCATION	A	B
Heated Areas (Temp. Controlled)	-30 to 50 °C	-65 to 70 °C
Unheated Areas (Temp. Controlled)	-55 to 70 °C	-65 to 100 °C
Power Plant Compartment	-55 to 70 °C	-65 to 100 °C
Power Plant Accessory Compartment	-55 to 70 °C	-65 to 100 °C

- b. Altitude. In the first sentence of paragraph 3.3.4, Altitude, (page 3), replace '40.000 feet (12.192 m) standard altitude' with '51.000 ft (15.545 m) standard altitude'.
- c. Leak Test. In the second sentence of paragraph 6.3, Leak Test, (page 6), replace 'to an air pressure of 40 psi (275.8 kPa)' with 'to an air pressure in accordance with the manufacturer's recommendations'.

2. Testing Your Fuel Flowmeter.

In addition to the qualification test requirements described in SAE AS407C, perform the following tests:

- a. Thermal Shock Test. This test applies to any hermetically sealed components. Subject the components to four cycles of exposure to water 85 °C ± 2 °C and 5 °C ± 2 °C. There should be no evidence of moisture damage to coating or enclosure. During each cycle of the test, immerse the component in water at 85 °C ± 2 °C for 30 minutes. Within 5 seconds of removal from the bath, immerse the component for 30 minutes in the other bath maintained at 5 °C ± 2 °C. Repeat this cycle continuously, one cycle following the other until four cycles are completed. After this test, subject the component to the sealing test in paragraph 2b (2) of this appendix. The component must have no leakage resulting from the test.
- b. Sealing Test. Apply this performance test to any hermetically sealed components. Immerse the component in a suitable liquid such as water. Then reduce the absolute pressure of the air above the liquid to about 1 inch of mercury (Hg) (3.4 kPa) Maintain this absolute pressure for 1 minute, or until the liquid stops giving off air bubbles, whichever is longer. Increase the absolute pressure by 2½ inches Hg (8.5 kPa). If any bubbles come from the component case, consider it Leakage and reject the component. Do not consider bubbles, resulting from entrapped air in the exterior parts of the case, as leakage. If other test methods provide evidence equal to the immersion test, they can be used to test the integrity of the instrument's seals. If the component includes non-hermetically sealed appurtenances such as a case extension, these appurtenances can be removed before the sealing test.

- c. Other Tests. The following table lists where other tests and conditions can be found:

For:	Use the test conditions in:
Fire-resistant or fireproof test	SAE AS 1055, Rev. D, dated June 1997, Sections 4 and 5
	The following sections of the environmental standards mentioned in paragraph 3.1.2 above.
Explosion proofness test	Section 9
Power input test	Section 16
Voltage spike test	Section 17
Audio frequency conducted susceptibility test	Section 18
Induced signal susceptibility test	Section 19
Radio frequency susceptibility test	Section 20

[Amdt ETSO/3]

[Amdt ETSO/8]

ETSO-C45b A1

ED Decision 2013/012/R

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**

Standard set forth in the SAE Aerospace Standard (AS) document: SAE AS 8042 from December 1, 1985, unless otherwise specified by [Appendix 1](#) to this ETSO.

3.1.2 Environmental standard

The Manifold Pressure Instruments must be tested according to Section 7 of SAE AS 8042 and the environmental test procedures as defined in CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 Software

If the Manifold Pressure Instruments includes a digital computer, see CS-ETSO, Subpart A, paragraph 2.2, for software development.

3.1.4 Airborne electronic hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 Specific**3.2.1 Failure condition classification**

See CS-ETSO, Subpart A, paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a major failure condition. The applicant must develop the system to at least the design assurance level commensurate with this failure condition.

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.

[Amdt ETSO/3]

[Amdt ETSO/8]

APPENDIX 1 TO ETSO-C45b A1 – MINIMUM PERFORMANCE STANDARD FOR MANIFOLD PRESSURE INSTRUMENTS

ED Decision 2013/012/R

This appendix lists EASA modifications to the MPS for Manifold Pressure Instruments.

The applicable standard is SAE AS 8042, Manifold Pressure Instruments, dated December 1, 1985.

1. Manifold Pressure Instruments are not required to meet the requirements in SAE AS 8042 paragraphs 3.1, 3.2, and 3.3.
2. Replacement of SAE AS 8042 paragraph 3.24.2 (Fire Hazards) by:
“Except for small parts (such as fasteners, grommets, knobs, seals, and small electrical parts) that would not contribute significantly to the propagation of a fire, all material used must be self-extinguishing when tested in accordance with the requirements of CS 25.869(a)(4) and the applicable portions of Part I, Appendix F.”

[Amdt ETSO/3]

[Amdt ETSO/8]

ETSO-C46a

ED Decision 2003/10/RM

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 V_{mo} and M_{mo} 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.

APPENDIX 1 TO ETSO-C46A – FEDERAL AVIATION ADMINISTRATION STANDARD, MAXIMUM ALLOWABLE AIRSPEED INDICATOR SYSTEMS

ED Decision 2003/10/RM

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_{mo} and M_{mo} 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 Mach 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	0.020	-----
	55-1000	-----	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 proto- type 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

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

- (2) For altitudes where MMO is limited factor:

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

Where:

V_{mo} = Maximum allowable indicated airspeed in knots.

M_{mo} = Maximum allowable mach.

K = Ratio of specific heats=1.40 for air.

P_o = 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

ETSO-C47a A1

ED Decision 2013/012/R

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: SAE AS 408C “Pressure Instruments - Fuel, Oil and Hydraulic” from July 1, 2001 unless otherwise specified by [Appendix 1](#) to this ETSO.

3.1.2 Environmental standard

Testing fuel, oil, and hydraulic pressure instruments must be in accordance with SAE AS408C section 7 and see CS-ETSO, [Subpart A](#), paragraph 2.1, for environmental test procedures.

3.1.3 Software

If fuel, oil, and hydraulic pressure instrument includes a digital computer, see CS-ETSO, [Subpart A](#), paragraph 2.2, for software development.

3.1.4 Airborne electronic hardware

See CS-ETSO, [Subpart A](#), paragraph 2.4.

3.2 Specific**3.2.1 Failure condition classification**

See CS-ETSO, [Subpart A](#), paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a major failure condition. The applicant must develop the system to at least the design assurance level commensurate with this failure condition.

4 Marking**4.1 General**

Marking is detailed in CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

- a) At least one major component of the fuel, oil, and hydraulic pressure instrument shall be marked permanently and legibly with all the information as provided for in SAE AS408C, Section 3.2 (except paragraph 3.2.b).
- b) Mark “Fire resistant” or “Fireproof” information legibly and permanently

5 Availability of referenced document

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/3]

[Amdt ETSO/8]

APPENDIX 1 TO ETSO-C47A A1 – MINIMUM PERFORMANCE STANDARDS (MPSS) FOR PRESSURE INSTRUMENTS - FUEL, OIL AND HYDRAULIC

ED Decision 2013/012/R

1. The MPSS applying to this ETSO are provided in SAE AS408C, Pressure Instruments - Fuel, Oil, and Hydraulic, dated July 1, 2001, except for paragraphs 3.1, 3.1.1, 3.1.2, and 3.2.b.

Here are provided the modifications to be applied to the referenced SAE document:

AS408C**modification:**

Title Replace “Pressure Instruments – Fuel, Oil, and Hydraulic (Reciprocating Engine Powered Aircraft)” Substitute: “Pressure Instruments – Fuel, Oil, and Hydraulic”

Section 1.1 Replace “...primarily for use with reciprocating engine powered transport aircraft, ...” Substitute: “...for use with civil aircraft,...”

AS408C section 7**modification:**

Para 7.13 Use test conditions in SAE AS1055 Rev D, “Fire Testing of Flexible Hose, Tube Assemblies, Coils, Fittings, and Similar System Components”, dated June 1, 1997, Sections 4 and 5.

The following test conditions from the environmental standards mentioned in paragraph 3.1.2 above are added.

Para 7.14 Section 16, Power Input.

Para 7.15 Section 17, Voltage Spike.

Para 7.16 Section 18, Audio Frequency Conducted Susceptibility – Power Inputs.

Para 7.17 Section 19, Induced Signal Susceptibility

Para 7.18 Section 20, Radio Frequency Susceptibility.

2. The performance of fuel, oil and hydraulic pressure instruments can be enhanced or made superior to this specification, depending on intended application and configuration.

[Amdt ETSO/3]

[Amdt ETSO/8]

ETSO-C49b

ED Decision 2003/10/RM

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.

ETSO-C53a

ED Decision 2003/10/RM

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 sub-paragraph (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.

ETSO-C54

ED Decision 2003/10/RM

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.

ETSO-C55a

ED Decision 2012/009/R

FUEL AND OIL QUANTITY INSTRUMENTS**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) 405C Fuel and oil quantity Instruments, dated July 2001, as amended and supplemented by this ETSO:

- (i) Conformance with the following paragraphs of AS 405C 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

See CS-ETSO Subpart A paragraph 2.1.

As specified in the SAE Aerospace Standard AS 405C.

3.1.3 Computer Software

See CS-ETSO Subpart A paragraph 2.2.

3.1.4 Electronic Hardware Qualification

See CS-ETSO Subpart A paragraph 2.3.

3.2 Specific**3.2.1 Failure Condition Classification**

See CS-ETSO Subpart A paragraph 2.4.

The failure condition classification will depend on the system on which the fuel and oil quantity instrument is installed. The classification must be determined by the safety assessment conducted as part of the installation approval. Develop each fuel and oil quantity instrument to at least the design assurance level assigned to the system on which the fuel and oil quantity instrument is installed.

4 Marking

4.1 General

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

4.2 Specific

- a. Mark at least one major component permanently and legibly with all the information in SAE AS405C, Section 3.2 (except paragraph 3.2.b). Also, mark the component with the following information:

- (1) The basic type and accuracy classification, and
- (2) The fluids for which the instrument is substantiated

- b. If the fuel and oil quantity instrument includes a digital computer, then the part number must include hardware and software identification. Or, you can use a separate part number for hardware and software. Either way, you must include a means to show the modification status.

NOTE: Similar software versions, approved for different software levels, must be differentiated by part number.

5 Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.

[Amdt ETSO/7]

ETSO-C56b A1

ED Decision 2013/012/R

ENGINE-DRIVEN DIRECT CURRENT GENERATORS/STARTER-GENERATORS**1 Applicability**

This ETSO gives the requirements which engine-driven direct current 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 SAE Aerospace Standard (AS) document: AS8020, "Engine Driven D.C. Generators/Starter-Generators and Associated Voltage Regulators", dated January 1980 (and reaffirmed by SAE in August 1991).

3.1.2 Environmental standard

See CS-ETSO, [Subpart A](#), paragraph 2.1.

3.1.3 Software

If the Engine Driven Direct Current Generator / Starter Generator and the associated voltage regulators include a digital computer, see CS-ETSO, [Subpart A](#), Paragraph 2.2, for software development.

3.1.4 Airborne electronic hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific

None.

4 Marking**4.1 General**

Marking is detailed in CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

In addition to the information specified in §4.1, the following information is required:

- (1) Means of indicating if the article is a D.C. generator or a D.C. starter-generator;
- (2) Nominal power output (electrical voltage and watts);
- (3) Mechanical power input requirements (pad requirements).

5 Availability of referenced document

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/3]

[Amdt ETSO/8]

ETSO-C59b

ED Decision 2018/002/R

AIRBORNE SELECTIVE CALLING EQUIPMENT**1 Applicability**

This ETSO provides the requirements which airborne selective calling equipment that are designed and 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 RTCA/DO-93A, Minimum Operational Performance Standards (MOPS) for Airborne Selective Calling (SELCAL) Equipment, dated March 17, 2016.

Demonstrate the required functional performance under the test conditions specified in RTCA/DO-93A, Minimum Operational Performance Standards for Airborne Selective Calling (SELCAL) Equipment, Section 2.4, dated March 17, 2016.

Demonstrate the required performance under the test conditions specified in RTCA/DO-93A, Section 2.3, using environmental conditions identified in paragraph 3.1.2 of this ETSO and test procedures appropriate for airborne equipment.

3.1.2 Environmental Standard

See CS-ETSO [Subpart A](#) paragraph 2.1.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific**3.2.1 Failure Condition Classification**

See CS-ETSO, [Subpart A](#), paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 of this ETSO is a minor failure condition.

Loss of the function defined in paragraph 3.1.1 of this ETSO is a minor failure condition.

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.

[Amdt ETSO/13]

ETSO-C62e

ED Decision 2012/009/R

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 29/09/2006.

3.1.2 Environmental Standard

As stated in the Federal Aviation Administration Standard.

3.1.3 Computer Software

None

3.1.4 Electronic Hardware Qualification

None

3.2 Specific

None.

3.2.1 Failure Condition Classification

N/A

4 Marking**4.1 General**

Marking as detailed in CS-ETSO [Subpart A](#) paragraph 1.2.

4.2 Specific

1. Balance marker, consisting of a red dot, on the sidewall of the tire immediately above the bead to indicate the lightweight point of the tire.
2. Production date code (may be included in the established serial number).

3. Ply rating must be established. Submit these ratings to the Tire and Rim Association, Inc. (TRA) or European Tyre and Rim Technical Organization (ETRTO). If the ply rating is marked on the tire, the load rating marked on the tire must be consistent with the ply rating established.

NOTE: for a new programme aircraft, define new tire dimensions and submit them to ETRTO for publication in the ETRTO Data Book. You do not have to wait until your submitted dimensions are incorporated into the Data Book before applying for the ETSO.

4. Serial number: the plant code and production date code may be included.
5. Size and load ratings, established and identified in a timely manner in the TRA Aircraft Year Book, latest edition or in the ETRTO *Aircraft Tyre and Rim Data Book*, latest revision. See the NOTE at paragraph g.
6. Skid depth, marked in inches to the nearest one-hundredth as defined in [appendix 1](#).
7. Speed rating, in MPH and as identified in [appendix 1](#), paragraph 4.b that is equal to or less than the speed at which the tire has been qualified.
8. Tire type. Mark tires requiring a tube with the words “Tube type.”
9. Non-re-treadable tires must be marked accordingly.

5 Availability of Referenced Document

See CS-ETSO [Subpart A](#) paragraph 3.

[Amdt ETSO/7]

APPENDIX 1 TO ETSO-C62E – FAA STANDARD FOR AIRCRAFT TIRES

ED Decision 2012/009/R

1. **PURPOSE.** Minimum performance standards for new and re-qualified radial and bias tires, excluding tailwheel tires, to be identified as meeting the standards of [ETSO-C62e](#).
2. **SCOPE.** Minimum performance standards apply to aircraft tires having speed and load ratings based on the speeds and loads to which the tires have been tested.
3. **DEFINITIONS.**

Bias tire: a pneumatic tire whose ply cords extend to the beads and are laid at alternate angles substantially less than 90° to the centerline of the tread. May also have a bias belted tire with a circumferential belt.

Radial tire: a pneumatic tire whose ply cords extend to the beads and are laid approximately at 90° to the centerline of the tread, the carcass being stabilised by an essentially inextensible circumferential belt.

Load rating: maximum permissible static load at a specific inflation pressure. Use the rated load combined with the rated inflation pressure when selecting tires for application to an aircraft, and for testing to the performance requirements of this ETSO.

Rated inflation pressure: specified unloaded inflation pressure which will result in the tire deflecting to the specified static loaded radius when loaded to its rated load against a flat surface.

Static loaded radius (SLR): perpendicular distance between the axle centerline and a flat surface for a tire initially inflated to the unloaded rated inflation pressure and then loaded to its rated load.

Ply rating: an index of tire strength from which a rated inflation pressure and its corresponding maximum load rating are determined for a specific tire size.

Speed rating: maximum ground speed at which the tire has been tested in accordance with this ETSO.

Skid depth: distance between the tread surface and the bottom of the deepest groove as measured in the mold.

4. **DESIGN AND CONSTRUCTION.**
 - a. General Standards. Tires selected for use on a specific aircraft must demonstrate suitability through appropriate laboratory simulations described in paragraphs 5.a or 5.b of this appendix, as appropriate. Determine material suitability by:
 - (1) Temperature: show by tests or analysis that the physical properties of the tire materials are not degraded by exposure to temperature extremes of -40°C (-40°F) and +71,1°C (+160°F) for a period of not less than 24 hours at each extreme.
 - (2) Wheel rim heat: substantiate by the applicable tests or show 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 148,9°C (300°F) for at least 1 hour, except that low-speed tires or nose-wheel tires may be tested or analysed at the highest wheel-bead seat temperatures expected to be encountered during normal operations.

- b. Speed Rating. See Table 1 below for applicable dynamometer test speeds for corresponding maximum takeoff ground speeds. For takeoff speeds over 245 mph, the tire must be tested to the maximum applicable load-speed-time requirements and identified with the proper speed rating.

TABLE 1. Applicable Dynamometer Test Speeds

Max Takeoff Speed Mph at liftoff over:	But not over:	Max takeoff Speed Of Aircraft Max Tire mph:	Min Dynamometer Speed (Figures 1, 2 or 3) Min Tire mph:
0	120	120	120
120	160	160	160
160	190	190	190
190	210	210	210
210	225	225	225
225	235	235	235
235	245	245	245

- c. Overpressure. The tire must successfully withstand a hydrostatic pressure of at least four times its rated inflation pressure for 3 seconds without bursting.
- d. Helicopter tires. You may use aircraft tires qualified according to this ETSO on helicopters. In such cases for standard tires, you may increase the maximum static load rating by a factor of 1.5 with a corresponding increase in rated inflation pressure without additional qualification testing (round loads to the nearest 10 lbs and inflation pressures to the nearest whole psi.). If significant taxi distance is expected, these guidelines may not apply. Consult tire and rim manufacturers for appropriate tire size selection. Maximum permissible inflation for aircraft tires used on helicopters is 1.8 times the rated inflation pressure.
- e. Dimensions. Maintain the tire size (outside diameter, shoulder diameter, section and shoulder width), within specified tolerances.

NOTE: for a new programme aircraft, define new tire dimensions and submit them to TRA for publication in the TRA Data Book. You do not have to wait until your submitted dimensions are incorporated into the Data Book before applying for the ETSO.

- (1) Outside diameter, shoulder diameter, section width and shoulder width: For the bias ply tire, outside diameter and section width are specified to a maximum and minimum value after a 12 hour growth period at rated inflation pressure. Shoulder diameter and width dimensions are specified to a maximum value after a 12-hour growth period at rated inflation pressure. Radial tire dimensions are limited by the grown tire envelope according to the static loaded radius (SLR) requirements in paragraph 4.e.(3) below.
- (2) Due to the increased inflation pressures permitted when using an aircraft tire in a helicopter application, we permit tire dimensions to be 4% larger.
- (3) Static loaded radius (SLR):
 - (a) Bias tires: provide the nominal SLR. The actual SLR is determined on a new tire stretched for a minimum of 12 hours at rated inflation pressure.
 - (b) Radial tires: provide the nominal SLR. The actual SLR of a radial tire is determined at rated inflation pressure after running 50 takeoffs, following paragraph 5.a.(2) requirements.

- (4) Helicopter tires: maximum dimensions for new tires used on helicopters are 4% larger than maximum aircraft tire dimensions. (In calculating maximum overall and shoulder diameters, rim diameter should be deducted before applying 4%.)
- f. Inflation retention. After an initial 12-hour minimum stabilisation period at rated inflation pressure, the tire must retain the inflation pressure with a loss of pressure not exceeding 5% of the initial pressure for 24 hours. Measure the ambient temperature at the start and finish of the test to ensure that any pressure change was not caused by an ambient temperature change.
- g. Balance. Test all tires for static unbalance. 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.
- (1) Auxiliary tires (not main or tailwheel tires): the moment of static unbalance (M) for auxiliary tires shall not be greater than the value determined using this equation:

$$M = 0.025D^2$$

Round the computed equation values to the next lower whole number where M is in inch-ounces and D is the standardised maximum new tire inflated outside diameter in inches. Your design must include requirements to measure the level of unbalance on each tire, and approved procedures to correct the unbalance within the above limits if necessary.

- (2) All main tires and all tires with 46-inch and larger outside diameter: the moment of static unbalance (M) for main tires shall not be greater than the value determined using this equation:

$$M = 0.035D^2$$

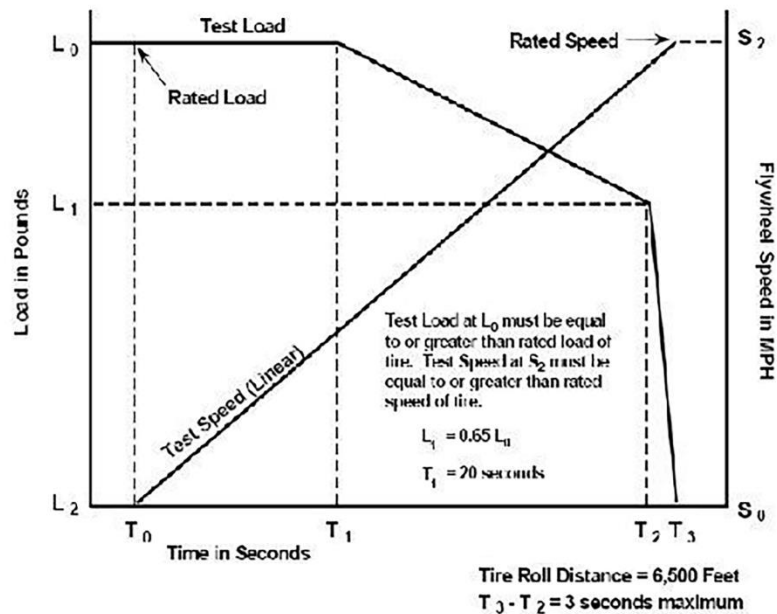
Round the computed equation values to the next lower whole number where M is in inch-ounces and D is the standardised maximum new tire inflated outside diameter in inches. Your design must include requirements to measure the level of unbalance on each tire, and approved procedures to correct the unbalance within the above limits if necessary.

5. TIRE TEST REQUIREMENTS.

- a. Use a single test specimen for a qualification test. The tire must withstand the following dynamometer cycles without detectable signs of deterioration, other than normal expected tread surface abrasion, except when the overload takeoff condition is run last (see paragraph 5.a.(8) below).
- (1) Dynamometer cycle requirements: all aircraft tires must satisfactorily withstand 58 dynamometer cycles as a demonstration of overall performance, plus 3 overload dynamometer cycles as a demonstration of the casing's capability under overload. The 58 dynamometer cycles consists of 50 takeoff cycles, per 5.a.(2), and 8 taxi cycles, per 5.a.(7). The overload cycles consist of 2 taxi cycles, per 5.a.(7) at 1.2 times rated load and 1 overload takeoff cycle per 5.a.(8) starting at 1.5 times rated load. Run the dynamometer cycles in any order. However, if the overload takeoff cycle is not run last, the tire must not show detectable signs of deterioration after the cycle completion, other than normal expected tread surface abrasion.

- (2) Takeoff cycles: the 50 takeoff cycles shall realistically simulate tire performance during runway operations for the most critical combination of takeoff weight and speed, and aircraft center-of-gravity position. When determining the most critical combination of the above, be sure to account for increased speeds resulting from high field elevation operations and high ambient temperatures, if applicable. Specify the appropriate load-speed-time data or parameters that correspond to the test envelope in which the tire is to be tested. Figures 1, 2, and 3 are graphic representations of the test. Starting at zero speed, load the tire against the dynamometer flywheel. The test cycles must simulate one of the curves illustrated in Figure 1 or 2 (as applicable to speed rating), or Figure 3.
- Figure 1 defines a test cycle that applies to any aircraft tire with a speed rating of 120 mph or 160 mph.
 - Figure 2 defines a test cycle that applies to any aircraft tire with a speed rating greater than 160 mph.
 - Figure 3 defines a test cycle that applies for any speed rating, is based on the most critical takeoff loads, speeds, and distances, and is aircraft specific.

Figure 1 – Graphic Representation of a Universal Load-Speed-Time Test Cycle (For 120 MPH and 160 MPH Tires)



Symbol Definitions (Figures 1, 2, and 3)

L_0 Tire load (lbs) at start of takeoff (not less than the load rating), Figures 1, 2, and 3.

L_0^1 Tire load (lbs) at start of takeoff for the operational load curve, Figure 3.

L_1 Tire load (lbs) at rotation, Figures 1 and 3.

L_1^1 Tire load (lbs), Figure 3.

L_2 Tire load at liftoff, 0 lbs, Figures 1, 2, and 3.

S_0 Zero (0) mph, Figures 1, 2, and 3.

S_1 Speed at rotation in mph, Figure 3.

S_2 Tire speed at liftoff in mph (not less than the speed rating), Figures 1, 2, and 3.

T_0 Time at start of takeoff, 0 s, Figures 1, 2, and 3.

T_1 20 seconds, Figure 1.

T_2 Time to rotation in seconds, Figures 1, 2, and 3.

T_3 Time to liftoff in seconds, Figures 1, 2, and 3.

Figure 2 – Graphic Representation of a Typical Universal Load-Speed-Time Test Cycle (For Tires Rated above 160 MPH)

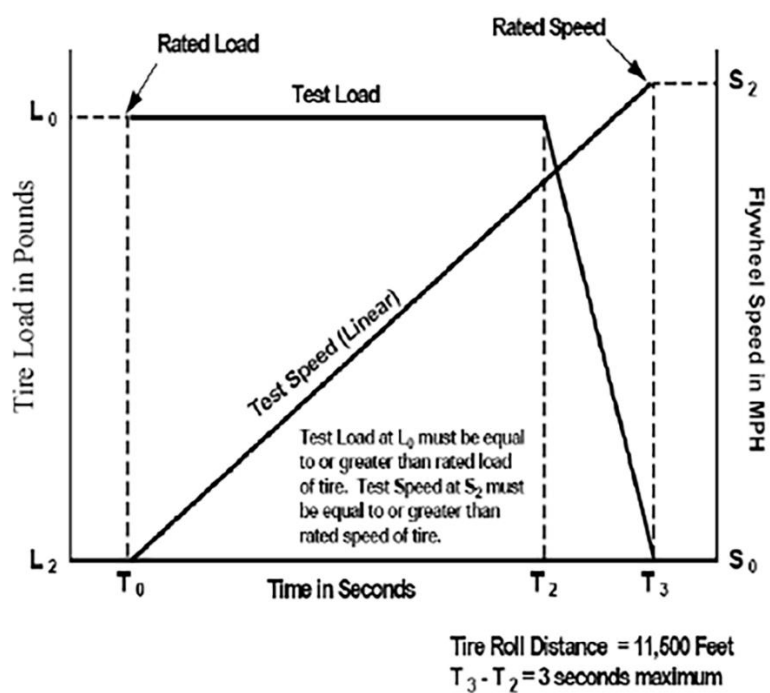
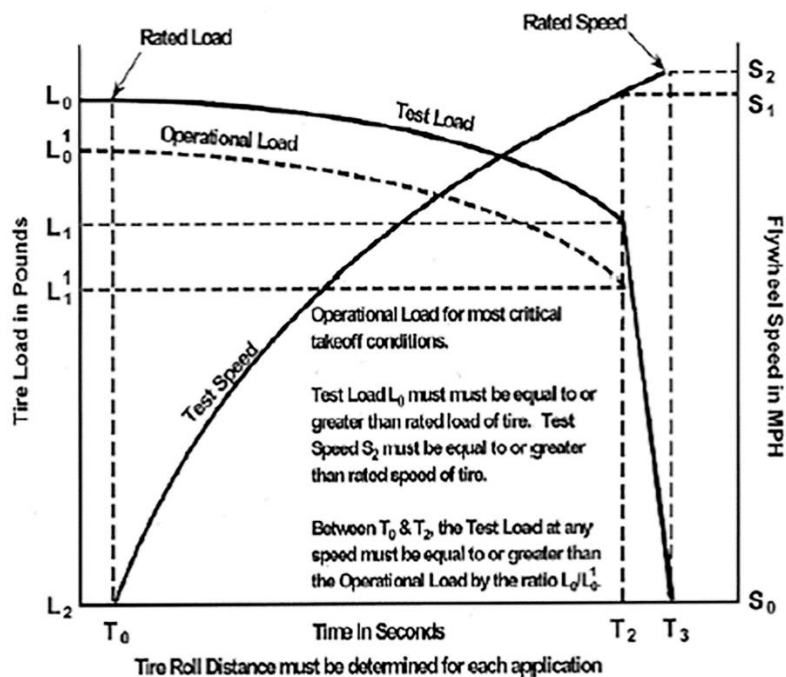


Figure 3 – Graphic Representation of a Typical Rational Load-Speed-Time Test Cycle



- (3) Test load: the minimum allowable load at the start of the test is the rated load of the tire. The test loads must conform to Figures 1 or 2 (as applicable), or Figure 3. Figures 1 and 2 define a test cycle generally applicable to any aircraft. If you use Figure 3 to define the test cycle, select the loads based on the most critical takeoff conditions you established. At any speed throughout the test cycle, the ratio of the test load to the operational load must be the same as, or greater than, the ratio at the start of the test.
- (4) Test inflation pressure: the pressure needed to provide the same loaded radius on the flywheel as was obtained on a flat surface at the rated tire load and inflation pressure. Make both determinations at the same ambient temperature. Do not adjust the test inflation pressure to compensate for changes created by temperature variations during the test.
- (5) Test temperatures and cycle interval: the temperature of the gas in the tire or the casing temperature measured at the hottest point of the tire may not be:
 - (a) Lower than 40,6°C (105°F) at the start of the overload takeoff cycle and at the start of at least 45 of the 50 takeoff cycles, and
 - (b) Lower than 48,9°C (120°F) at the start of at least 9 of the 10 taxi cycles.

For the remaining cycles, the contained gas or casing temperature may not be lower than 26,7°C (80°F) at the start of each cycle. Rolling the tire on the dynamometer flywheel is an acceptable method for obtaining the minimum starting temperature.

- (6) Dynamometer takeoff cycle speeds: see Table 1 for the dynamometer test speeds for the corresponding maximum aircraft takeoff speeds.
- (7) Taxi cycles: tire must withstand 10 taxi cycles on a dynamometer under the test conditions in Table 2 below.

TABLE 2. Test Conditions

Number of Taxi Runs	Min Tire Load (lbs)	Min Speed (mph)	Tire speed rating 120/160 mph Min Rolling Distance (ft)	Tire speed rating Over 160 mph Min Rolling Distance (ft)
8	Rated	40	25,000	35,000
2	1.2 x Rated	40	25,000	35,000

- (8) Overload takeoff cycle: the overload takeoff cycle shall duplicate the test described in paragraph 5.a.(2) with the test load increased by a factor of 1.5 throughout. Good condition of the tire tread is not required after completion of this test cycle, if you run this test last. If the overload takeoff cycle is not run last, the tire must withstand the cycle without detectable signs of deterioration, other than normal expected tread surface abrasion.
 - (9) Diffusion test: after completing the 61 test cycles, the tire must retain the inflation pressure to within 10% of the initial test pressure for a period of 24 hours. Measure the ambient temperature at the start and finish of this test to ensure that any pressure change was not caused by an ambient temperature change.
 - (10) Tire/wheel slippage: tires should not slip on the wheel rim during the first five dynamometer cycles. Any slippage that subsequently occurs must not damage the tube valve of tube type tires, or the gas seal of the tire bead of tubeless tires.
- b. Alternate qualification procedures: 120 mph rated tires. For 120 mph speed rating tires, you may use the following variable mass flywheel procedure:
- (1) Test load: load must meet or exceed the tire rated load throughout the entire test roll distance.
 - (2) Test inflation pressure: pressure needed to provide the same loaded radius on the flywheel as was obtained on a flat surface at the rated tire load and inflation pressure. Make both determinations at the same ambient temperature. Do not adjust the test inflation pressure to compensate for changes created by temperature variations during the test.

- (3) Temperature and cycle interval: the temperature of the gas in the tire, or the casing temperature measured at the hottest point of the tire, may not be lower than 40,6°C (105°F) at the start of at least 180 of the 200 landing cycles. For the remaining cycles, the contained gas or casing temperature may not be lower than 26,7°C (80°F) at the start of each cycle. Rolling the tire on the dynamometer is an acceptable method for obtaining the minimum starting temperature.
- (4) Kinetic energy: calculate the kinetic energy of the flywheel to be absorbed by the tire using this equation:

$$KE = CW(V^2) = \text{Kinetic energy (ft – lbs)}$$

where

C = 0.0113

W = Load rating of the tire (lbs)

V = 120 mph

- (5) Dynamometer cycle requirements: tire must satisfactorily withstand 200 landing cycles on a variable mass dynamometer flywheel. If you cannot use the exact number of flywheel plates to obtain the calculated kinetic energy value, select a greater number of plates and adjust the dynamometer speed to obtain the required kinetic energy. Divide the total number of dynamometer landings into two equal parts having the speed ranges provided in paragraphs 5.b.(5)(a) and 5.b.(5)(b).
- (a) 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. Adjust the landing speed so the tire will absorb 56% of the kinetic energy calculated using the equation in paragraph 5.b.(4) above. If the adjusted landing speed is calculated to be less than 80 mph, then determine the landing speed by adding 28% of the calculated kinetic energy (see paragraph 5.b.(4) above) to the flywheel kinetic energy at 64 mph, and determine the unlanding speed by subtracting 28% of the calculated kinetic energy from the flywheel kinetic energy at 64 mph.
- (b) 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. Adjust the unlanding speed as needed to ensure that the tire will absorb 44% of the calculated kinetic energy (see paragraph 5.b.(4) above).

6. REQUALIFICATION TESTS.

- a. Re-qualify altered tires, with changes in materials, design and/or manufacturing processes that could adversely affect the performance and reliability, to the dynamometer tests described under paragraph 5. Some examples include (1) or (2) below, or both:
 - (1) Changes in casing construction, such as the number of plies and/or bead bundles, ply cord makeup (material, denier, number of strands) and configuration (radial and bias).
 - (2) Changes in tread construction, such as number or composition of tread reinforcing and/or protector plies, tread compound formulations, number and location of tread grooves, and an increase in skid depth.
- b. Re-qualification by similarity (based on load rating). Re-qualifying a given load rated tire due to a change in material or tread design, automatically qualifies the same changes in a lesser load tire of the same size, speed rating, and skid depth, if:
 - (1) The lesser load rated tire was qualified to the applicable requirements specified in this ETSO, and
 - (2) The ratio of qualification test load to rated load for the lesser load rated tire does not exceed the same ratio to the higher load rated tire at any given test condition.
- c. Re-qualification by similarity (blanket change). You can gain re-qualification of any change that affects all sizes by similarity, if:
 - (1) Five representative sizes, including tires of the highest load rating, speed rating and angular velocity, were qualified to the minimum performance standard with the change, and
 - (2) You submit data supporting the change in the listed sizes to EASA.

(Amdt ETSO/7]

ETSO-C63e

ED Decision 2018/002/R

AIRBORNE WEATHER RADAR EQUIPMENT

1 Applicability

This ETSO provides the requirements that airborne weather radar equipment that is designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

This ETSO standard addresses weather detection and ground mapping, forward-looking wind shear detection, forward-looking turbulence detection, and atmospheric threat awareness capability. It does not include flight guidance system functionality in support of an approved wind shear detection and avoidance system.

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-220A, Minimum Operational Performance Standards (MOPS) for Airborne Weather Radar Systems, dated March 17, 2016, for the equipment classes defined in Table 1.

Equipment Class	Equipment Type	Minimum Performance Standards
A	Forward-Looking Wind shear Detection Capability	The following sections of RTCA DO-220A: Section 2.2, with the following exclusions: paragraphs 2.2.1.3.6, 2.2.1.3.7, 2.2.2, 2.2.4, and 2.2.5., and Sections 2.3 (performance under environmental conditions) and 2.4 (test requirements) as applicable to the class
B	Forward-Looking Turbulence Detection Capability	The following sections of RTCA DO-220A: Section 2.2, with the following exclusions: paragraphs 2.2.1.3.5, 2.2.1.3.7, 2.2.2, 2.2.3, and 2.2.5., and Sections 2.3 (performance under environmental conditions) and 2.4 (test requirements) as applicable to the class
C	Airborne Weather and Ground Mapping Pulsed Radar	The following sections of RTCA DO-220A: Section 2.2, with the following exclusions: paragraphs 2.2.1.3.5, 2.2.1.3.6, 2.2.1.3.7, 2.2.3, 2.2.4, and 2.2.5., and Sections 2.3 (performance under environmental conditions) and 2.4 (test requirements) as applicable to the class

D	Atmospheric Threat Awareness Capability	The following sections of RTCA DO-220A: Section 2.2, with the following exclusions: paragraphs 2.2.1.3.5, 2.2.1.3.6, 2.2.2, 2.2.3, and 2.2.4. Sections 2.3 (performance under environmental conditions) and 2.4 (test requirements) as applicable to the class

Table 1 - Airborne Weather Radar Equipment Classes and Applicable MPS

Any of these classes may be implemented individually or in combination. Therefore, a piece of equipment may be eligible for one or more classes.

Functionality

This ETSO standard applies to equipment intended to:

- (1) Provide airborne wind shear detection (equipment Class A). Equipment Class A provides forward-looking wind shear detection functionality. However, this ETSO does not include flight guidance system functionality in support of an approved wind shear detection and avoidance system;
- (2) Provide advanced and advisory indication of potentially hazardous turbulence conditions detectable by weather radar, together with other flight information, to assist pilots with turbulence avoidance decisions (Equipment Class B);
- (3) Detect and display echoes from precipitation to assist in flight crew analysis of weather. Maintain contact with geographic features such as international shoreline boundaries as a supplement to navigational orientation (Equipment Class C); and
- (4) Provide timely and advisory information to pilots to enhance their situational awareness of atmospheric activity and assist with atmospheric threat avoidance decisions (Equipment Class D).

3.1.2 Environmental Standard

See CS-ETSO [Subpart A](#) paragraph 2.1

3.1.3 Software

See CS-ETSO [Subpart A](#) paragraph 2.2

3.1.4 Electronic Hardware

See CS-ETSO [Subpart A](#) paragraph 2.3

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

Failure of the function defined in paragraphs 3.1.1(2) or 3.1.1(4) resulting in unannounced malfunction of the function is a minor failure condition.

Failure of the function defined in paragraph 3.1.1(1) or 3.1.1(3) resulting in unannounced malfunction of the function or missed detection is a major failure condition.

Loss of the functions defined in paragraph 3.1.1 is a minor failure condition.

3.2.2 Installation Manual

The applicant should provide a manual(s) containing the following items:

- (1) Operating instructions and equipment limitations sufficient to describe the equipment's operational capability;
- (2) For Equipment Class B, identify the installation instructions for the identified aircraft class selected from RTCA/DO-220A, paragraph 2.2.4.1, Table 2-4;
- (3) Expected radome performance for the electromagnetic signals passing through it (paragraph 2.2 of RTCA DO-213A, Minimum Operational Performance Standards for Nose-Mounted Radomes, dated March 17, 2016);
- (4) Weather performance index (range) in accordance with the requirements of RTCA DO-220A; and
- (5) Wind shear detection range in accordance with the requirements of RTCA DO-220A.

4 Marking

4.1 General

Marking is detailed in CS-ETSO [Subpart A](#) paragraph 1.2.

4.2 Specific

The marking must also include the equipment class, as defined in Table 1.

5 Availability of Referenced Document

See CS-ETSO [Subpart A](#) paragraph 3.

[Amdt ETSO/13]

ETSO-C64b

ED Decision 2016/029/R

OXYGEN MASK ASSEMBLY, CONTINUOUS FLOW, PASSENGER**1 Applicability**

This ETSO gives the requirements which new models of oxygen mask, continuous flow, passenger, that is designed and 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 8025A, 'Passenger Oxygen Mask' dated (revised) January 1999, as modified in Appendix 1 of this ETSO.

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 requirements in CS-ETSO Subpart A, be marked with the words 'Oxygen mask' and performance classification number as specified in SAE AS 8025 Paragraph 1.3. Additionally, the elastomer cure date (AS 8025A, paragraph 3.3.4), as well as a picture in accordance with AS8025A, paragraph 5.11, have to be marked on the article.

5 Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.

[Amdt ETSO/12]

APPENDIX 1 TO ETSO-C64B – MPS FOR PASSENGER OXYGEN MASK ASSEMBLY, CONTINUOUS FLOW

ED Decision 2016/029/R

The applicable standard is SAE AS8025A, Passenger Oxygen Mask, dated (revised) January 1999 and shall be modified as follows:

SAE AS8025A Paragraph	Action
Section 1, SCOPE	To be disregarded.
Paragraph 3.2, Deviations	To be disregarded.
Paragraph 3.3.1, General	Shall be revised: 'Construct the device, including packaging, of materials that will not contribute significantly to fire propagation and that comply with CS 25.853(a). Mask materials typically used should meet CS-25 Appendix F, Part I(a)(1)(ii) and/or Part I(a)(1)(iv).'
Paragraph 3.3.3, Cleaning and sterilization	Shall be revised: 'Cleaning and Sterilizing: The material of the oxygen mask shall permit cleaning and sterilizing without adverse effects, and without major disassembly. The cleaning method must be either manufacturer-recommended, or according to SAE ARP 1176, <i>Oxygen System Component Cleaning and Packaging</i> . Cleaning and sterilizing procedures shall be included in the CMM.'
Paragraph 3.3.4, Elastomer Components	The following sentence shall be added: 'Life limits and inspection procedures shall be included in the CMM.'
Paragraph 3.11, Identification Markings	To be Disregarded. Marking requirements are specified in paragraph 4 of this ETSO.
Paragraph 4.5.2	Flow indication must comply with AS 916B, <i>Oxygen Flow Indicators</i> , as applicable

[Amdt ETSO/12]

ETSO-C69c

ED Decision 2003/10/RM

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 TO ETSO-C69c – FEDERAL AVIATION ADMINISTRATION MINIMUM PERFORMANCE STANDARD FOR EMERGENCY EVACUATION SLIDES, RAMPS, RAMP/SLIDES, AND SLIDE/RAFTS

ED Decision 2003/10/RM

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 it's 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.

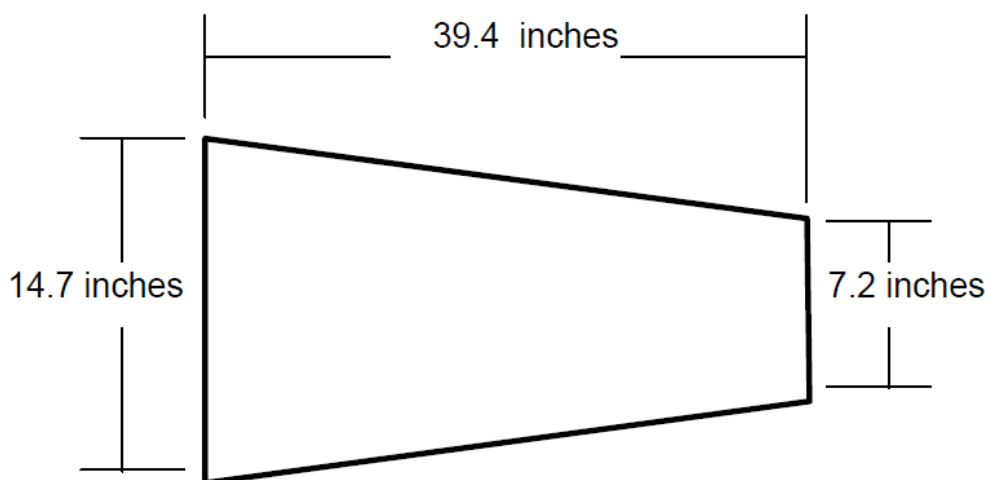
4.21 Device Surface.

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 ft²/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 ft²/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 ft²/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 ½-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:

Test Method		
Tests Required	Federal Test Method Standard	Other Test Method
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.)

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 ± 5 degrees F for not less than 168 hours. After exposure, the samples must be allowed to cool to 70 ± 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 ± 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 ± 4 degrees F and a relative humidity of 95 ± 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.

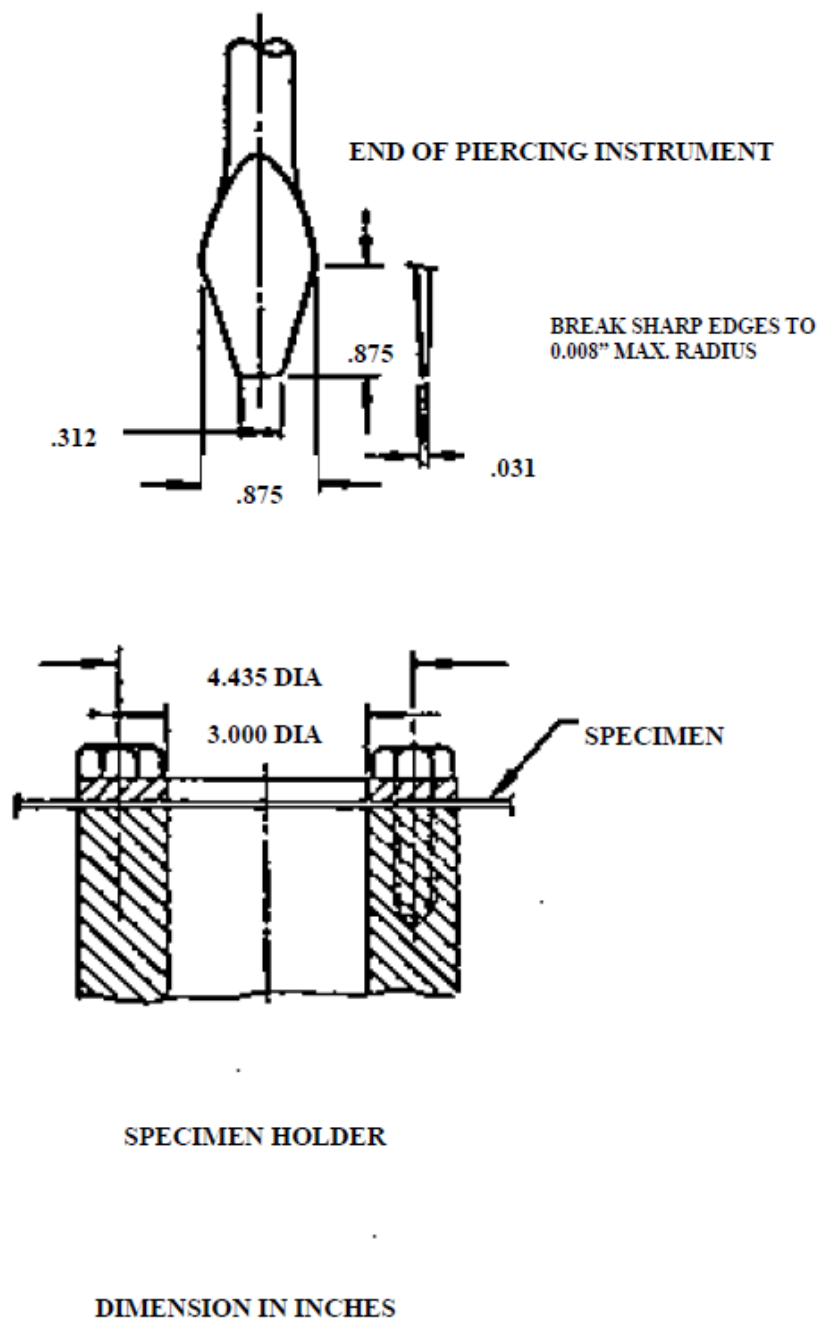


FIGURE 1. PIERCING INSTRUMENT AND SPECIMEN HOLDER

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/ft²-sec (1.7 W/cm²), 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/ft²-sec (5 W/cm²) 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.

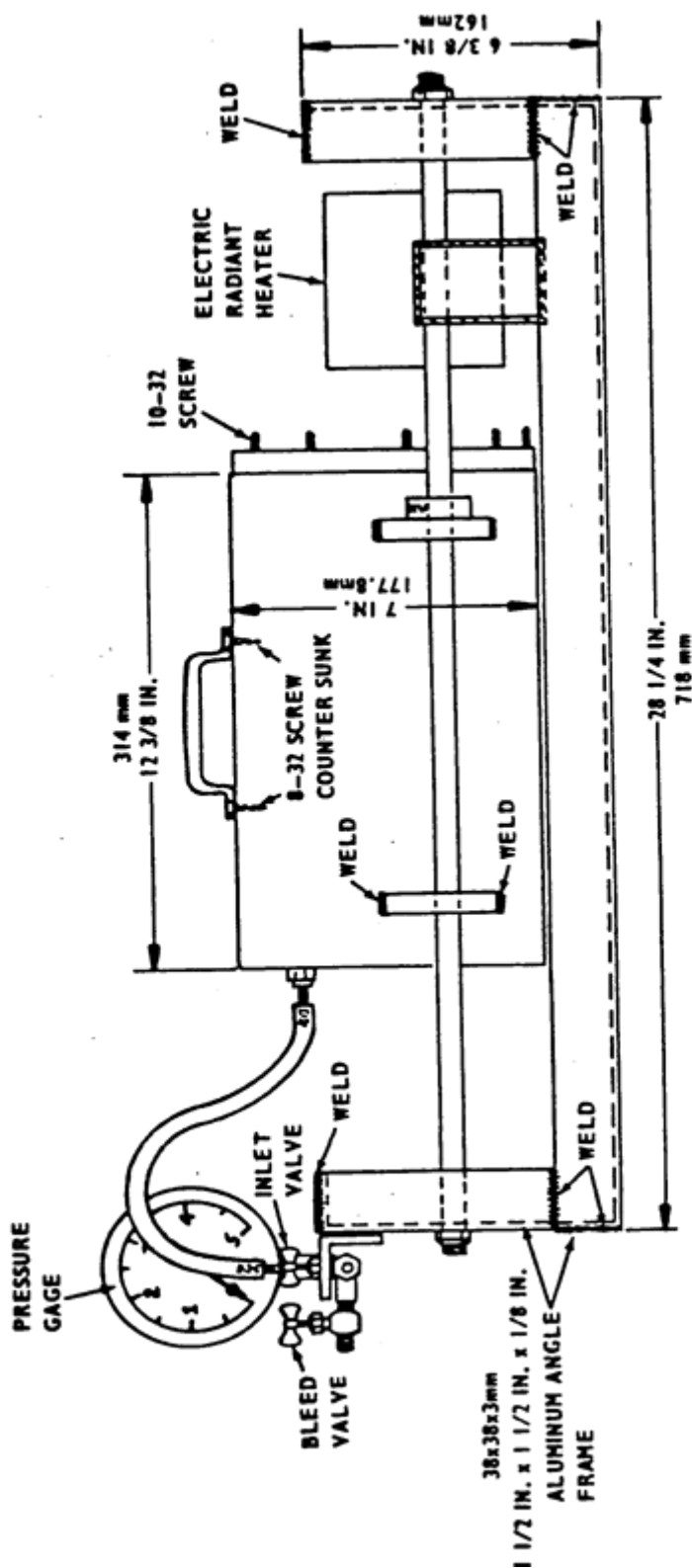


FIGURE 2. LABORATORY TEST (FRONT)

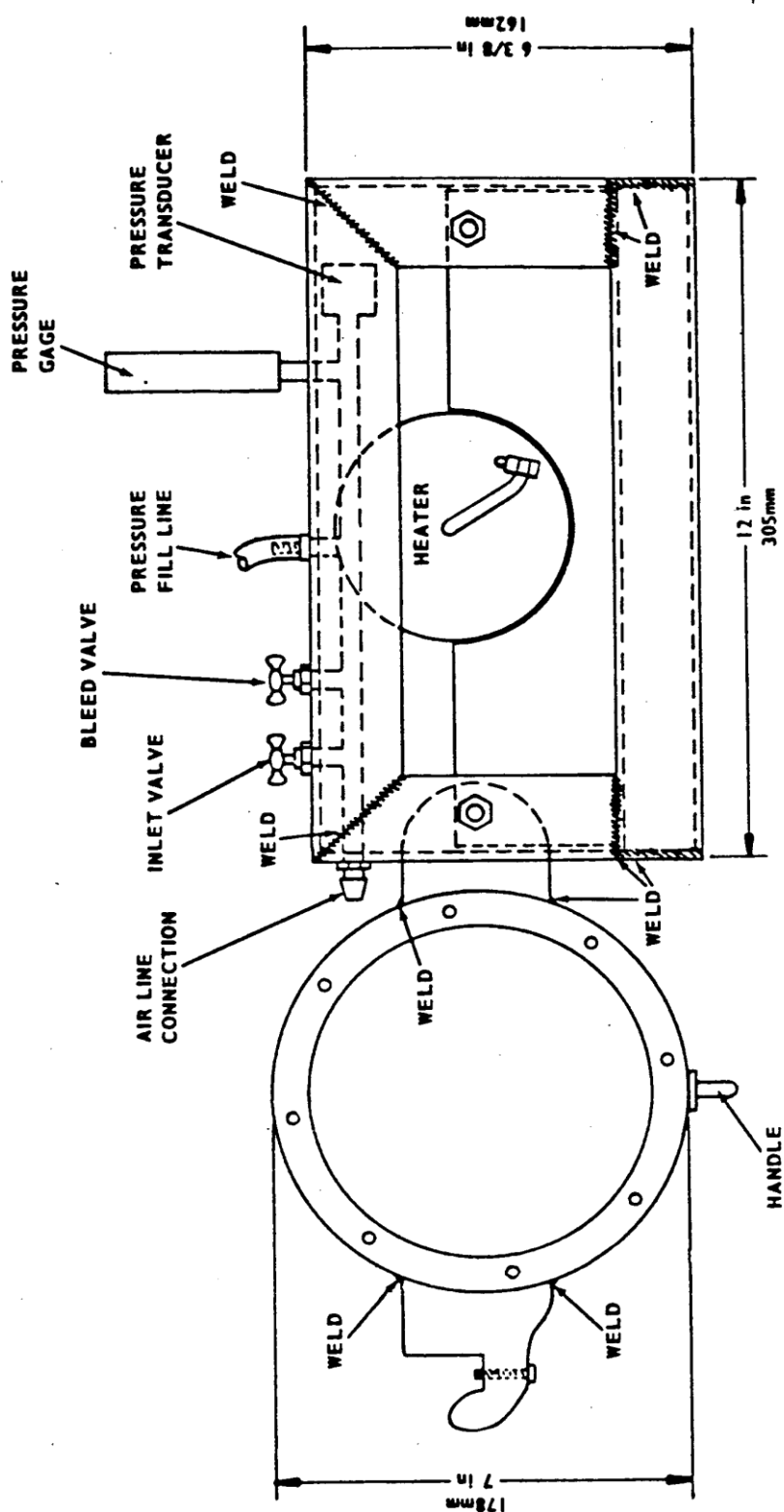


FIGURE 2. LABORATORY TEST (SIDE VIEW)

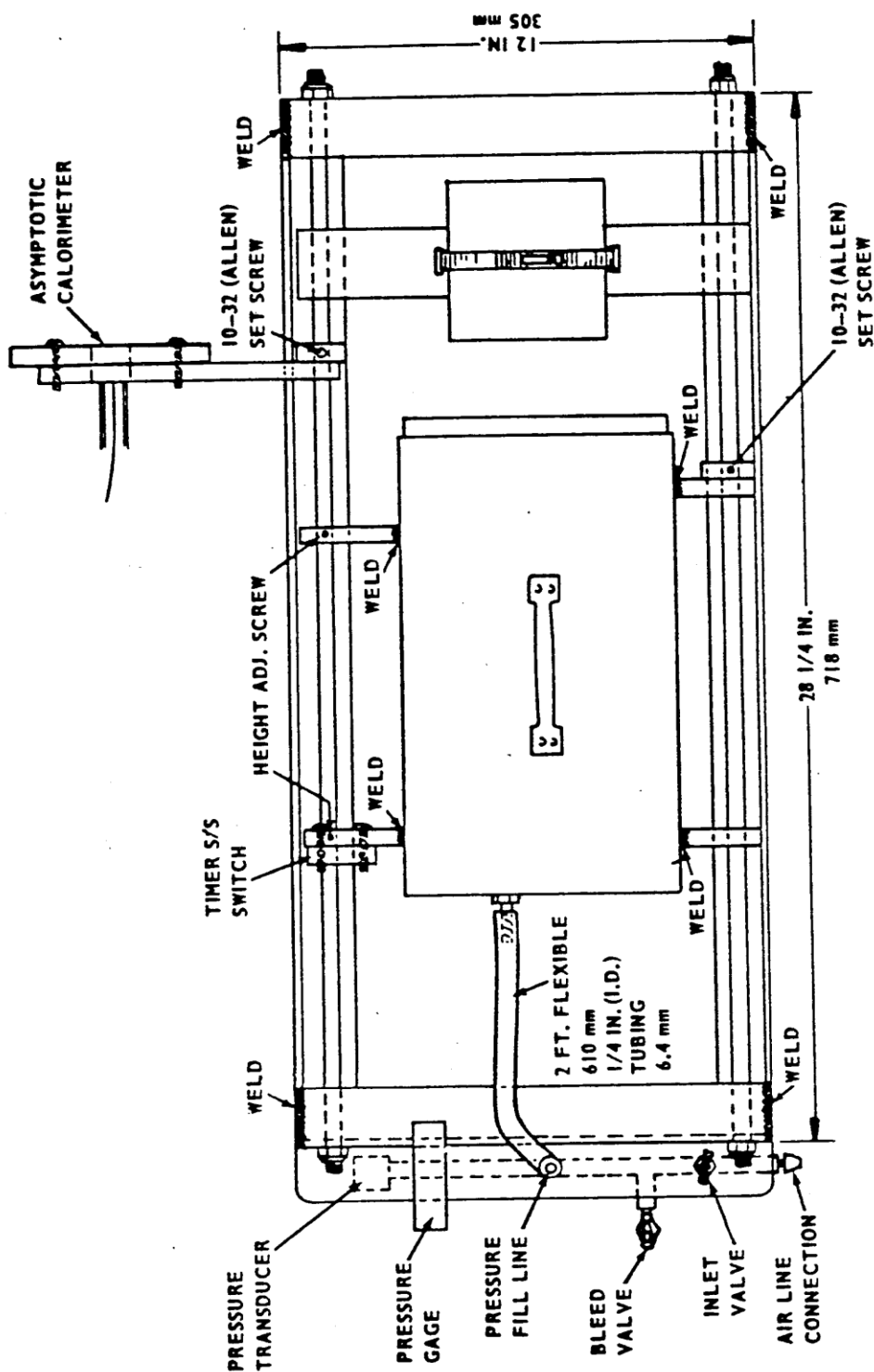


FIGURE 3. LABORATORY TEST (TOP VIEW)

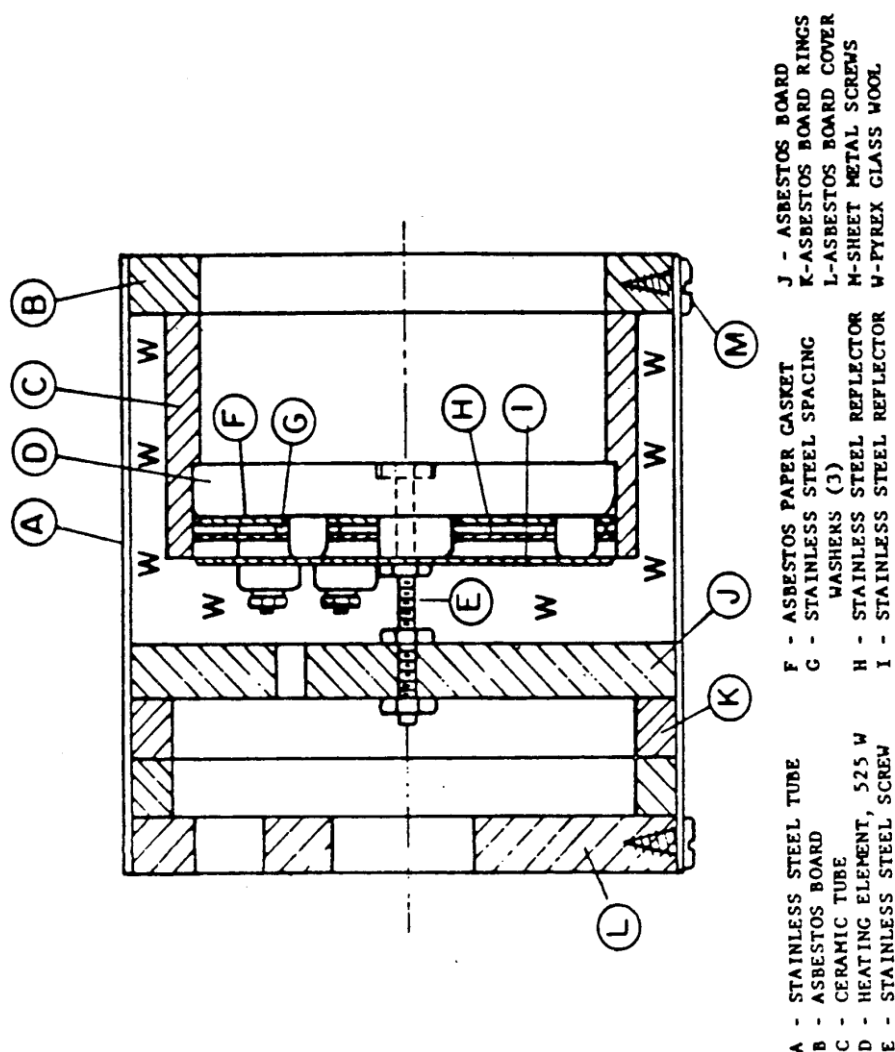


FIGURE 4. FURNACE SECTION

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 ± 3 degrees F (21 ± 3 degrees C) and 50 ± 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/ft²-sec (2.3 W/cm²) 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/ft²-sec (1.7 W/cm²) 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/ft²-sec (1.7 W/cm²). 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 ≥ 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).

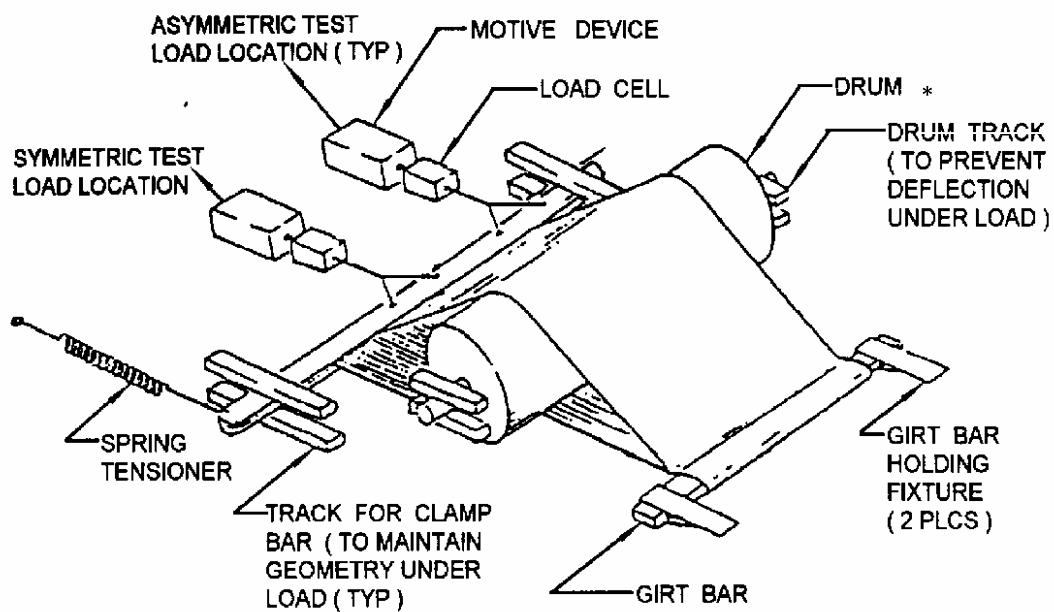
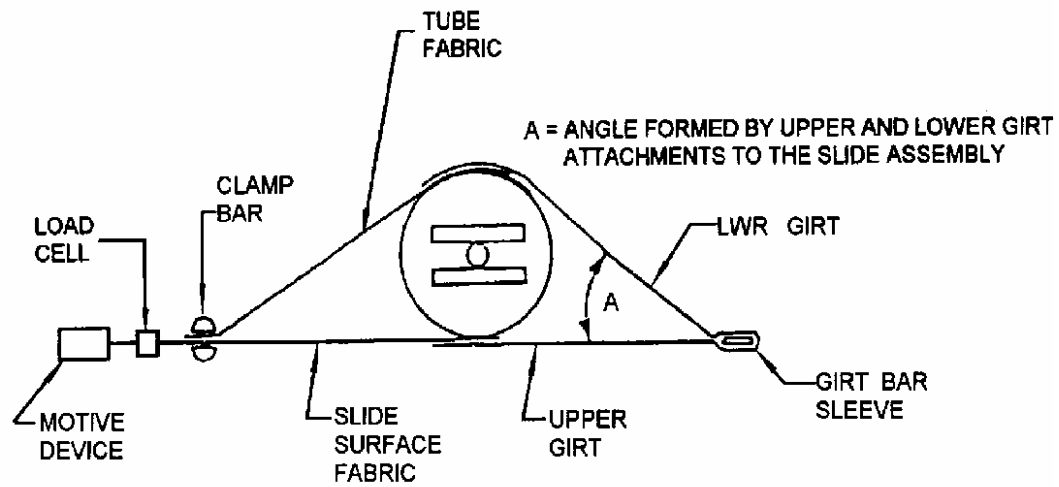
5.5.4.4.5 The device, without repair, shall meet the requirements of paragraph 4.10.1 of this appendix after being subjected to this test.

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 ± 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:

Condition	Temperature (degrees F)
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 TO ETSO-C69c – GLOSSARY OF TERMS

ED Decision 2003/10/RM

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 TO ETSO-C69c – MEASUREMENT OF LOADS ON THE ATTACHMENT(S) TO THE AIRPLANE

ED Decision 2003/10/RM

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 TO ETSO-C69c – CALORIMETER SPECIFICATION AND CALIBRATION PROCEDURE

ED Decision 2003/10/RM

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 $\text{W}/\text{cm}^2/\text{mV}$ or $\text{BTU}/\text{ft}^2\text{-sec}/\text{mV}$.
 - b. Sensor Sensitivity – the ratio between the transducer output signal and the incident heat flux, expressed in $\text{mV}/\text{W}/\text{cm}^2$ or $\text{mV}/\text{BTU}/\text{ft}^2\text{-sec}$.
 - 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 $\text{W}/\text{cm}^2/\text{mV}$ or $\text{BTU}/\text{ft}^2\text{-sec}/\text{mV}$.
 - 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 $0.125'' \pm 0.0625$ 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:
- 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;
 - the exhaust fan shall be turned on;
 - the heater shall be gradually heated electrically until all rubber cement burns away and a good bond is achieved at both ends;
 - the heater shall be energized with sufficient electric current to produce a dull red heat; and
 - 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 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.
 - If the full scale range of the test transducer is 50 BTU/ft²-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.
 - If the full scale range of the test transducer is greater than 50 BTU/ft²-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.

ETSO-C70b

ED Decision 2016/013/R

LIFE RAFTS**1 Applicability**

This ETSO provides the requirements which life rafts that are designed and 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 SAE International Aerospace Standard AS1356, Life Rafts, dated July 2012, as modified by [Appendix 1](#) to this ETSO.

3.1.2 Environmental Standard

As specified in AS1356, Life Rafts, dated July 2012, as modified by [Appendix 1](#) to this ETSO.

3.1.3 Computer Software

None

3.1.4 Electronic Hardware Qualification

None

3.2 Specific

None

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

4 Marking**4.1 General**

Marking is detailed in CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

As specified in SAE AS1356, subsection 7.9.

5 Availability of Referenced Document

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/11]

APPENDIX 1 TO ETSO-C70B MPS FOR LIFE RAFTS

ED Decision 2016/013/R

The applicable standard is SAE AS1356, Life Rafts, dated July 2012.

It shall be modified as follows:

AS1356 section:	Action:
Section 1	To be disregarded.
Section 2	All subsections shall be applied unless disregarded or modified as below:
Section 2.1	To be replaced: 2.1 Applicable Documents The following publications form a part of this document to the extent specified herein. The applicable issue of cited publications shall be the issue in effect on the date of the publication of this document, unless otherwise specified. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.
Section 2.2	To be disregarded.
Section 2.3	Shall be applied as written, the definitions of the following terms shall be replaced with the following text: APPROVED: The status of equipment that meets EASA standards. NOMINAL OPERATING PRESSURE: The median of the Normal Conditions Pressure Range. NORMAL CONDITIONS PRESSURE RANGE: The range of pressures attained during all types of inflations conducted at Normal Temperature Conditions. READILY ACCESSIBLE: Capable of being quickly obtained for operation without requiring removal of obstacles. On page 10, Section 2.3, the following definition shall be added: PRIMARY BUOYANCY CHAMBER: Any buoyancy chamber which independently provides sufficient buoyancy (at Minimum Operating Pressure) to achieve the minimum required freeboard around the entire periphery of the life raft with the life raft loaded at both rated and overload capacity. A minimum of two primary buoyancy chambers are required.
Section 2.4	The definition of 'should' shall be replaced as follows: SHOULD: Indicates a criterion for which an alternative, including non-compliance, may be applied if an equivalent level of safety is documented, justified, and approved.
Section 3.1.3(a)	To be replaced by: Type I Marking: INTENDED FOR USE IN OPERATIONS REQUIRING A LIFE RAFT Type II Marking: NOT INTENDED FOR USE FOR EXTENDED OVER-WATER OPERATIONS NOR IN TRANSPORT CATEGORY AIRCRAFT.

AS1356 section:	Action:
Section 3.2.4.2	To be replaced by: 3.2.4.2 Extended Marine Exposure The life raft shall be demonstrated by a test and/or analysis based on the test to meet the pressure retention requirements of 5.2.1 and the canopy protection of 6.5.5.1 and 6.5.7 after exposure of the fully-inflated life raft to a saltwater marine environment for at least 15 days. Installed/attached features such as the overpressure protection mechanism (e.g., pressure relief valve), manual inflation means, boarding means, sea anchor, and lifeline attachments shall retain their full functionality.
Section 3.2.5	To be replaced by: The life raft assembly shall be constructed of material meeting the requirements of CS-25 Appendix F, Part I. Survival kit contents need not meet this requirement, provided that they are fully enclosed within a container that passes the 12 s vertical burn test in Appendix F. A listing of all the survival kit equipment that does not meet the requirements of CS-25 Appendix F, Part I, must be documented.
Section 4.3.2 and 4.3.3	The following note shall be added: Note: The deflation of each of the primary buoyancy chambers must be evaluated with the remaining primary buoyancy chamber(s) inflated to minimum operating pressure. Secondary compartments and inflatable floor, if present, are not considered 'buoyancy chambers' and, therefore, must also be deflated.
Section 5.1.4	The following note shall be added: Note: This standard was developed for mechanically activated life raft inflation systems. Electric, electro/mechanical, or software based actuation systems are not adequately addressed by this standard.
Section 7.6	To be replaced by: The text, OPERATING INSTRUCTIONS, shall be marked, adjacent to the inflation instructions, in letters of 2 inches (5.1 cm) tall, followed by the below three instructions, or their equivalent, rendered in letters at least 0.5 inches (12.7 mm) tall: - ATTACH TO AIRCRAFT - THROW/PUSH AWAY FROM AIRCRAFT - PULL UNTIL INFLATION OCCURS Comprehensibility of any variation(s) to these instructions shall be demonstrated in accordance with 2.3: Comprehensible. Life rafts stowed remotely and deployed automatically from remote location are eligible for partial approval under this ETSO. Any specific design features related to these kind of life rafts will not be covered by this ETSO approval and must be approved at installation level.

AS1356 section:	Action:
Section 7.7	To be replaced by: 7.7 Identification in Stowage The text, LIFE RAFT, shall be marked in block letters of at least 2 inches (5.1 cm) tall, and FOR EMERGENCY USE ONLY shall be marked in block letters at least 1 inch (2.54 cm) tall, on all surfaces of the Container/Valise. Life raft assemblies intended to be stored in a dedicated compartment or location may be marked only on the surfaces that will be visible when accessed if the installation instructions and limitations provided with the life raft provide that level of detail.
Section 8.8.4	To be replaced by: 8.8.4 Lithium-containing batteries used in any emergency device shall meet the requirements of ETSO-C142a or equivalent. Note: An ETSO authorisation does not constitute an installation approval on an aircraft. However, special conditions may be required to gain installation approval if the design includes non-rechargeable (i.e. primary) lithium batteries.
Section 9.3	The first sentence shall be replaced by: 9.3 Content Survival information should be prioritised and shall contain the following, at a minimum:
Section 10	To be disregarded.

[Amdt ETSO/11]

ETSO-C71

ED Decision 2003/10/RM

**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.

FAA STANDARD ASSOCIATED WITH ETSO-C71 FOR AIRBORNE STATIC („DC TO DC“) ELECTRICAL POWER CONVERTER

ED Decision 2003/10/RM

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:

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

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 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 121/2% 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 121/2% from that obtained at standard test conditions.
- (b) The requirements of paragraphs 2.1, 2.2, and 2.3 shall be met.

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.*

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

FAA STANDARD ASSOCIATED WITH ETSO-C71 – APPENDIX A - TEST PROCEDURES AIRBORNE STATIC („DC TO DC“) ELECTRICAL POWER CONVERTER

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- 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 tests 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 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.

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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

ED Decision 2003/10/RM

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 ±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.

ETSO-C73

ED Decision 2003/10/RM

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

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MINIMUM PERFORMANCE STANDARDS FOR AIRBORNE STATIC ELECTRICAL POWER INVERTERS

JULY 25, 1963

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APPENDIX A ENVIRONMENTAL TEST PROCEDURES: Electrical Equipment Electrical Power Inverters

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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:
- Be capable of continuous operation under full load without degradation of performance over an input voltage range of ± 2 volts.
 - Operate electrically at an input voltage of 20 volts.
 - 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 ± 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 ± 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 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

- 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.¹ 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.¹

¹ 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° ±27°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° ± 27°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, 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

Types	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 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 ± 1 milliseconds. The intensity should be within ± 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 51/2 milliseconds. The shock should be applied in the following directions:

- Vertically, 3 shocks in each direction.
- Parallel to the major horizontal axis, 3 shocks in each direction.
- 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.

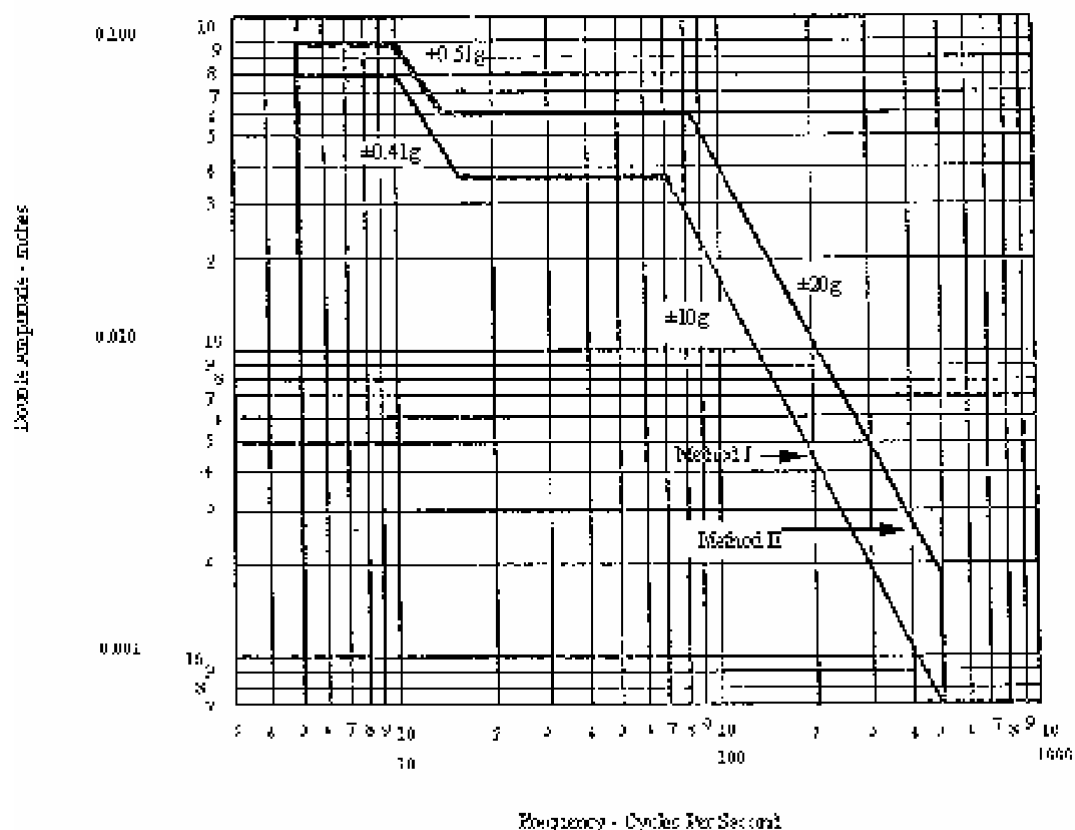


Figure I – Range Curves for Vibration Tests

ETSO-C76b

ED Decision 2016/013/R

FUEL DRAIN VALVES**1 Applicability**

This ETSO provides the requirements which Fuel Drain Valves that are designed and 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 [Appendix 1](#), MINIMUM PERFORMANCE STANDARD (MPS) FOR FUEL DRAIN VALVES, dated 18 april 2012.

3.1.2 Environmental Standard

As specified in Section 3 of [Appendix 1](#).

3.1.3 Computer Software

None.

3.1.4 Electronic Hardware Qualification

None.

3.2 Specific

None.

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

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.

[Amdt ETSO/11]

APPENDIX 1 TO ETSO-C76B MINIMUM PERFORMANCE STANDARD (MPS) FOR FUEL DRAIN VALVES

ED Decision 2016/013/R

1. **PURPOSE:** This Appendix provides the MPS 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 into a container for inspection. Depending on the intended application and configuration of specific equipment, the performance may be enhanced, or made superior to this specification. The number of test samples shall be completed in accordance with **Table 1**.
2. **SCOPE:** The MPS 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**
 - a. **Materials**
 - (1) High-quality materials that are suitable for use with aviation fuels having an aromatic content from 0–30 % shall be used.
 - (2) Synthetic rubber parts age-dated in accordance with the SAE International's Aerospace Recommended Practice (ARP) 5316C 'Storage of Elastomer Seals and Seal Assemblies Which Include an Elastomer Element Prior to Hardware Assembly', dated 6 December, 2010, shall be used.
 - (3) The fuel drain valve shall be designed by using corrosion and galling resisting metals or metals protected to resist corrosion and galling during the normal service life of the valve.
 - (4) The use of magnesium or any magnesium alloy is **prohibited**.
 - b. **Design and Construction.**
 - (1) **Fuel Spillage.** The drain valve shall be designed to allow operation without spilling or leaking fuel on personnel. The valve shall be designed to a 'Fail-Closed' condition.
 - (2) **Position Indication.**
 - (a) An indication for the open and closed position of valves shall be provided.
 - (b) A legend for position indication marking shall be used.
 - (c) Detents or other suitable means to keep the valve in the full-closed position shall be used.
 - (d) The valve must automatically return to the closed position when manually released from the open position.
 - (3) **Self-locking.** A means to prevent accidental opening or opening of the valve due to vibration or air loads shall be provided.
 - (4) **Seals.** The valve shall be designed so that:
 - (a) The inlet fuel pressure does not open the valve, and
 - (b) The inlet pressure keeps the valve in the closed and sealed position.

- (5) Loss of Parts.
 - (a) Fuel drain valves shall be designed to prevent the loss of parts.
 - (b) The valve shall be designed so the main seal will remain in place to prevent fuel from leaking in the event of possible damage or loss of the valve stem from operational loads anticipated in service.
 - (c) If threaded fittings are used to support the valve, the fittings shall be designed to prevent operational loads from rotating the valve body out of its boss or closed position.
- (6) Screens. The valve shall be designed so that fuel tank features, such as screens or baffles, do not impair the valves effectiveness in draining fuel containing water and other contaminants.
- c. Test Conditions.
 - (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, ± 2 inches, and an ambient temperature of approximately 25 °C, ± 2 °C. When testing with atmospheric pressure or temperature different from these values, any variation due to the test setup shall be accounted for. The reason for varying from the specified conditions must be justified.
 - (2) Fluids. The type of fluid used must be specified unless commercial grade aviation fuels are used for all tests.
- d. Test Methods and Performance Requirements.
 - (1) Functional. The ability of the valve to meet the design requirements specified in paragraphs 3.b.(1) through 3.b.(6) of this Appendix shall be demonstrated.
 - (2) Flow Test. The drain valve shall be connected to a suitable container and the time required to pass 1 quart of fuel with a maximum head of 6 inches of fuel shall be determined. The time to flow 1 quart must not take longer than 1 minute.
 - (3) Leakage Tests.
 - (a) Fuel Leakage. The fuel leakage test shall be conducted at pressures of 4 inches of fuel, 1 psi ± 0.1 psi, 20 psi ± 2 psi, and 60 psi ± 2 psi. The pressure to the drain valve inlet shall be applied with the valve in the closed position. The fuel drain valve must not leak any fuel from discharge or outlet port. Refer to **Figure 1** for test profile.
 - (b) Air Leakage. The air leakage test shall be conducted with the valve installed in a suitable test setup so the valve inlet port is covered by fuel. Air pressure shall be applied varying successively from 0.0 to 5.0 psi, with a tolerance of ± 10 % in each applied pressure, to the valve outlet port with the valve in the closed position. The fuel drain valve must not leak any air into the valve inlet. Refer to **Figure 2** for test profile.
 - (4) Fuel Resistance and Extreme Temperature. The fuel resistance and extreme temperature tests shall be conducted as specified in **Table 2**.

(5) Vibration

- (a) Resonance. The valve shall be subjected to a resonant frequency survey of the range specified in Table 3 to determine if there are any resonant frequencies of the parts. If resonance is encountered, the valve shall be vibrated successively axis by axis along the three axes for four hours at the critical frequency.
- (b) Cycling. The valve shall be mounted on a vibration device and fluid pressure shall be applied to the inlet port in the closed position. The valve shall be subjected to the three vibration scanning cycle tests in accordance with Table 3.
- (c) With pressures of 0.5 psi $\pm$ 0.1 psi and 5.0 psi $\pm$ 0.5 psi, the valve shall be subjected to vibration cycle tests listed in Table 3. There must not be any fluid leaking during the tests.
- (d) With air pressure varying successively from 0.0 to 5.0 psi gauge at the outlet port, the valve shall be subjected to vibration cycle tests listed in Table 3. Air leakage must not exceed 10 cc. per minute of free air during the 5.0 psi air suction test.
- (e) The valve must not have damaged or loose parts as a result of the vibration tests.

(6) Proof Pressure

- (a) With the valve in the closed position, a fuel pressure of 100 $\pm$ 2 psi for one minute at the inlet port shall be applied, with the outlet port open to atmospheric pressure.
- (b) The valve must not show any evidence of permanent distortion or other damage. The valve must not have any external leaking when the pressure is uniformly reduced to 60 psi. Refer to **Figure 3** for test profile.

- (7) Flammability. All materials used must be self-extinguishing when tested in accordance with applicable requirements of RTCA/DO-160E or later as defined in CS-ETSO, Subpart A, paragraph 2.1., Section 26, Category C, Flammability Test. This requirement does not apply to small parts (where the greatest dimension of equipment (L) is less than 50 mm, such as knobs, fasteners, seals, grommets and small electrical parts) that would not propagate a fire.

(8) Reliability Tests. (Cycling Operations)

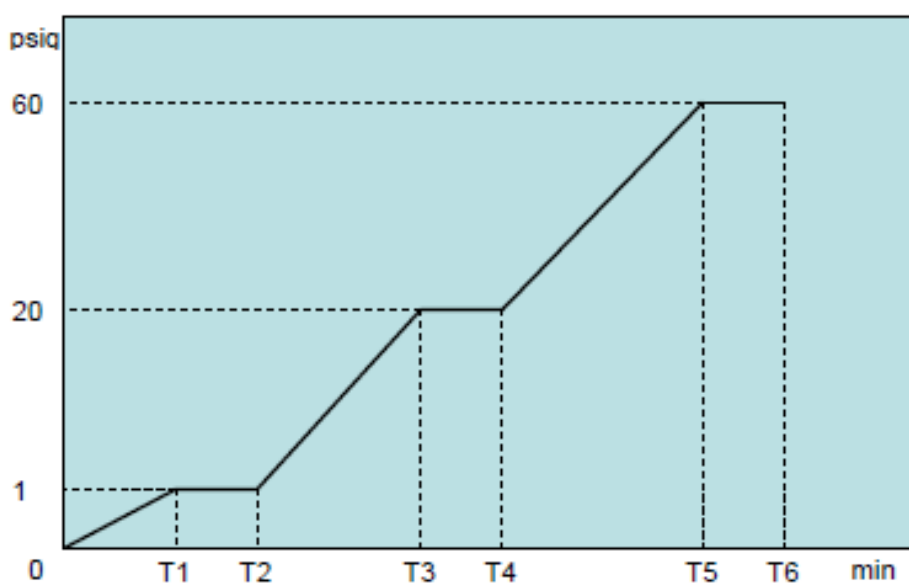
- (a) Dry Test. The valve shall be dried in an oven at 158° $\pm$ 2° F for four hours. Then the valve shall be subjected to 2 000 complete cycles of operation in the dry condition.
- (b) Wet Test. The valve shall be moistened with fuel, supplied with a 6-inch head of fuel and then subjected to 6 000 complete cycles of operation. The fuel head must remain at six inches during the test.
- (c) Post Reliability Test. After the cycling operations, the leakage test shall be performed. The valve must not leak as a result of the reliability test.

e. Test Samples.

Table 1 Test Samples

Tests	Paragraph 2 of this Appendix	Samples
Functional	d.(1)	Valve 1
Flow Test	d.(2)	Valve 2
Fuel Leakage	d.(3)	Valve 3
Air Leakage	d.(3)	Valve 3
Fuel Resistance and Extreme Temperature	d.(4)	Valve 4
Resonance	d.(5)	Valve 5
Cycling	d.(5)	Valve 6
Proof Pressure	d.(6)	Valve 7
Fire Flammability Test	d.(7)	Valve 8
Reliability Test, Dry	d.(8)	Valve 9
Reliability Test, Wet	d.(8)	Valve 9
Post Reliability Test	d.(8)	Valve 9

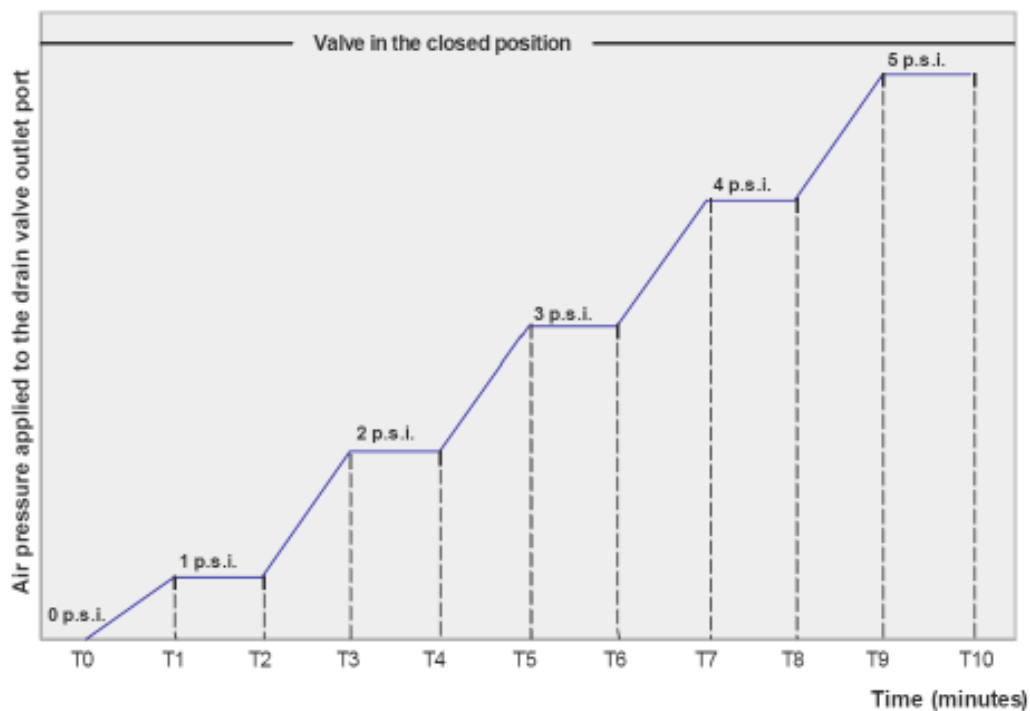
Figure 1 – Fuel Leakage Test



Notes:

- T0 to T1 ---- No time restriction
- T1 to T2 ---- 5 minutes minimum
- T2 to T3 ---- No time restriction
- T3 to T4 ---- 5 minutes minimum
- T4 to T5 ---- No time restriction
- T5 to T6 ---- 5 minutes minimum

Figure 2 – AIR Leakage Test



Notes :

- T0 to T1 -- no time restriction
- T1 to T2 -- 1 minute, minimum.
- T2 to T3 -- no time restriction.
- T3 to T4 -- 1 minute, minimum.
- T4 to T5 -- no time restriction.
- T5 to T6 -- 1 minute, minimum.
- T6 to T7 -- no time restriction.
- T7 to T8 -- 1 minute, minimum.
- T8 to T9 -- no time restriction.
- T9 to T10 -- 1 minute, minimum
- T10 -- end of test.

Table 2 - Fuel Resistance and Extreme Temperature Test Schedule

Test	Fuel Resistance		
Period Note 1	Phase I — Soak	Phase I — Dry	Low Temperature
Component configuration	Note 2	Drained and blown dry, normal condition as expected under service conditions, ports open	Mounted as expected under normal service conditions Note 2
Test Fluid	*ASTM D471 Reference Fuel B	None	*ASTM D471 Reference Fuel A
Period duration	96 hours (4 days)	24 hours	18 hours
Ambient and test fluid temperature	158° ±2° F (70° ±2° C) or the normal operating temperature of the system where the component is used, whichever is higher	Circulating air at 158° ±2° F (70° ±2° C) or the normal operating temperature of the system in which the component is used, whichever is higher Note 4	Fluid temperature lowered to -67°±2°F, (- 55° ±2° C) then the fluid temperature shall be maintained at - 67°±2° F (- 55° ±2° C) for a minimum of 18 hours
Operation or tests during period	Component actuated at least 4 cycles per day in a normal manner Note 3	None	None
Operation or tests Immediately after period	Leakage test shall be conducted, using *ASTM D471 Reference Fuel B	(a) Components actuated for 5 cycles. (b) Functional and leakage tests to be conducted in accordance with paragraphs 3.d.(1) and 3.d.(3) of this appendix, using *ASTM D471, Reference Fuel A Note 3	With temperature not higher than -65° F (-54° C), functional and leakage tests to be conducted in accordance with paragraphs 3.d.(1) and 3.d.(3) of this appendix, using *ASTM D471, Reference Fuel A

Notes:

- Each period shall be followed immediately (45 minutes maximum) after the preceding one in the order noted.
- The component shall be maintained to ensure complete contact of all non-metallic parts with the test fluid as would be expected under normal service conditions.
- There is no restriction in the actuation of the valve.
- There is no restriction in the circulating velocity of air or mass flow.

* ASTM: American Society for Testing of Materials, International

Table 3 — Vibration Test

Scanning cycle test	1	2	3
Axis of vibration	X	Y	Z
Fluid pressure	60 psi ± 2 psi	60 psi ± 2 psi	60 psi ± 2 psi
Scanning cycle time	15 min	15 min	15 min
Number of scanning cycles per test	2	2	2
Procedure	1.The valve shall be tested along three mutually perpendicular X, Y, and Z-axes; the X axis lies along centre lines of the valve. 2.The frequency time shall be increased uniformly through a range from 10 to 500 c.p.s. with an applied double amplitude of 0.036 inch up to 75 c.p.s. and an applied vibration acceleration not less than ±10g. 3.Double amplitude indicates the total displacement from positive to negative maximum. 4.The frequency shall be decreased so the complete cycle is accomplished in the specified cycle time.		

[Amdt ETSO/11]

ETSO-C78a

ED Decision 2018/002/R

CREWMEMBER DEMAND OXYGEN MASK**1 Applicability**

This ETSO provides the requirements which crewmember demand oxygen masks that are designed and 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**

Crewmember demand oxygen masks must meet the standards set forth in SAE International (SAE) Aerospace Standard (AS) 8026A, Crewmember Demand Oxygen Mask for Transport Category Aircraft, dated October 2001, as modified by Appendix 1 of this ETSO.

Crewmember oxygen masks are separated into four types;

- Type I: Quick donning mask with integral breathing valve(s);
- Type II: Quick donning mask without integral breathing valve(s);
- Type III: Non-quick donning mask with integral breathing valve(s); and
- Type IV: Non-quick donning mask without integral breathing valve(s)

This ETSO standard applies to crewmember demand oxygen masks to be used with straight-demand, diluter-demand and pressure-demand oxygen systems on transport category aircraft. The oxygen mask design should be either oronasal, covering the mouth and nose, or full face, covering the mouth, nose and eyes.

3.1.2 Environmental Standard

Refer to CS-ETSO, Subpart A, as well as SAE AS8026A, paragraph 4.5.

3.1.3 Software

See CS-ETSO Subpart A, paragraph 2.2.

3.1.4 Electronic Hardware

See CS-ETSO Subpart A, paragraph 2.3.

3.2 Specific

4 Marking

4.1 General

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

4.2 Specific

4.2.1 Each demand flow mask shall be marked to indicate:

- (a) whether it is a 'non-pressure demand' or a 'pressure demand' mask;
- (b) the maximum environmental (cabin) altitude for which it is qualified.
- (c) its type in accordance with paragraph 3.1.1; and
- (d) its size (if more than one size is manufactured).

5 Availability of Referenced Document

See CS-ETSO, Subpart A, paragraph 3.

[Amdt ETSO/3]

[Amdt ETSO/13]

APPENDIX 1 TO ETSO-C78A – MPS FOR CREWMEMBER DEMAND OXYGEN MASKS

ED Decision 2018/002/R

This Appendix prescribes the MPS for crewmember demand oxygen masks. The applicable standard is SAE AS8026A, Crewmember Demand Oxygen Mask for Transport Category Aircraft, dated October 2001. It is modified as follows.

SAE AS8026A:	Modification:
Section 1, SCOPE	To be disregarded.
Paragraph 3.1.1	To be revised: 'General: Materials of a type, grade and quality that experience and/or tests have shown suitable for the purpose shall be used. Materials that contaminate oxygen or are adversely affected by continuous service with oxygen shall not be used. The following test methods shall be used to verify compliance with material requirements established in a design specification.'
Paragraph 3.1.1	
a. Resistance to Flammability	To be revised: 'Except for small parts like knobs, triggers, fasteners, seals, and electrical parts that don't contribute significantly to fire propagation, materials including packaging shall comply with CS 25.853(a) and Appendix F, Part I(a)(1)(iv)'
Paragraph 3.1.3	To be revised: 'Cleaning and Sterilizing: The oxygen mask shall be made of materials that permit cleaning and sterilising without adverse effects, and without major disassembly. The cleaning method shall be either manufacturer recommended, or according to SAE ARP1176, Oxygen System Component Cleaning and Packaging. Cleaning and sterilising procedures shall be included in the Component Maintenance Manual (CMM).'
Paragraph 3.1.4	To be revised: 'Elastomeric Components: A tag or leaflet describing service life limits of elastomeric components and a suggested method to inspect for deterioration in these components shall be attached to the mask. If not attached, the tag shall be included with the packaged mask as delivered to the user. Silicone rubber parts, having unlimited shelf life, are exempt from this requirement. Life limits and inspection procedures shall be included in the CMM.'
Paragraph 3.3	To be disregarded. Marking is specified in paragraph 4 of this ETSO.
Paragraph 3.5	To be revised: 'The oxygen mask face-piece of Type I and Type II masks shall be stored in a container, mounted (panel or sidewall) or attached to a suspension device. The mask assembly must be donned using only one hand and operating in 5 seconds or less, without disturbing eyeglasses. After donning, the mask must not prevent immediate communication between crewmembers of the airplane intercommunications system.' Type III and Type IV oxygen masks may be similarly installed, and may be designed to require use of two hands and/or take more than 5 seconds to don.
Paragraph 3.12	To be revised: 'Oxygen mask design shall permit the installation of a microphone and connecting communications cable. When microphones are furnished with the masks, these must conform to the current revision of ETSO-C139.'
Paragraph 5.1.4	To be disregarded.
Paragraph 5.1.5	To be disregarded.

[Amdt ETSO/3]

[Amdt ETSO/13]

ETSO-C79

ED Decision 2003/10/RM

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.

FEDERAL AVIATION ADMINISTRATION STANDARD ASSOCIATED WITH ETSO-C79 – FIRE DETECTORS-RADIATION SENSING TYPE

ED Decision 2003/10/RM

- 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	-30 to 50 C
Nonpressurized or External Areas (Both types of engine)	-55 to 70 C

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
Piston Engines			
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.
Turbine Engines			
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 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 ± 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 21/2 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.

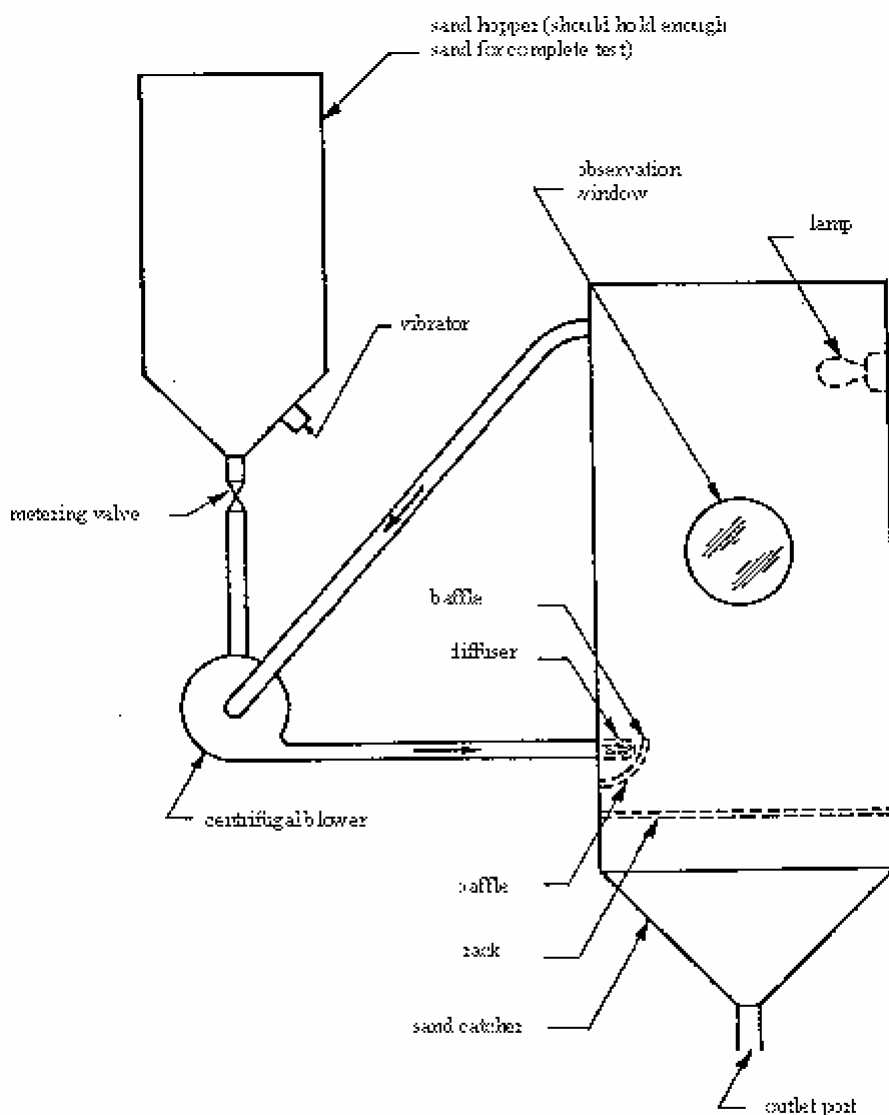


Figure 1. Schematic Sand Test Arrangement (Ref. Section 7.8)

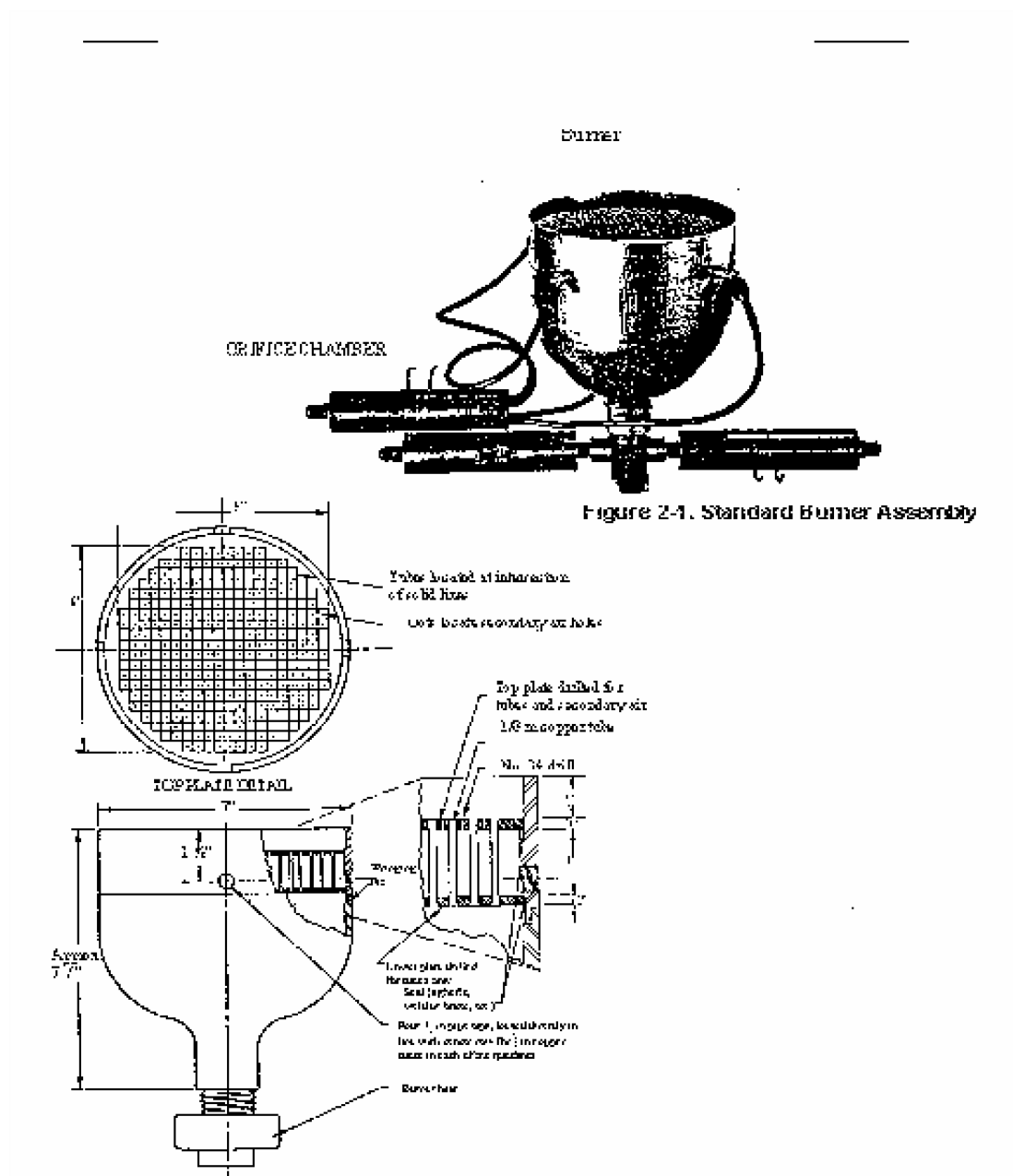


Figure 2-1. Standard Burner Assembly

Figure 2-2. Standard Burner

Standard Burner Assembly.

The complete standard burner assembly is shown in Fig. 2-1. Details of the components of this assembly are given in Figs. 2-2, 2-3, and 2-4.

Fig. 2-2 shows the details of the burner and the burner grill which consists of two plates connected by 1/8-inch copper tubes. Gas and Air are mixed in the burner base and travel upward through the tubes. The burning takes place above the top plate of the burner. Cooling air is admitted to the burner

through the four 1/8-inch pipe-tapped holes between the plates of the burner grill. This air passes upward through the No. 38 drill holes in the top plate and serves as a means for controlling the overall temperature of the flame. The location of the four 1/8-inch pipe-tapped holes is critical. They must be located directly in line with the center row of 1/8-inch copper tubes in each of the four quadrants. Improper location of these connections will result in an unequal radial distribution of cooling air and will affect the distribution of the flame temperature in a like manner.

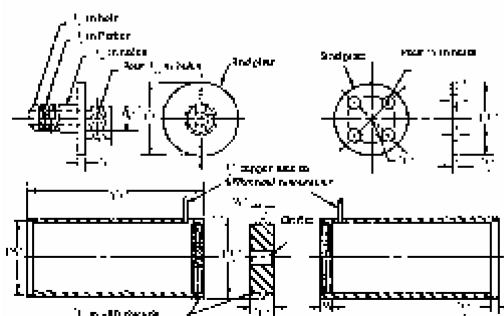
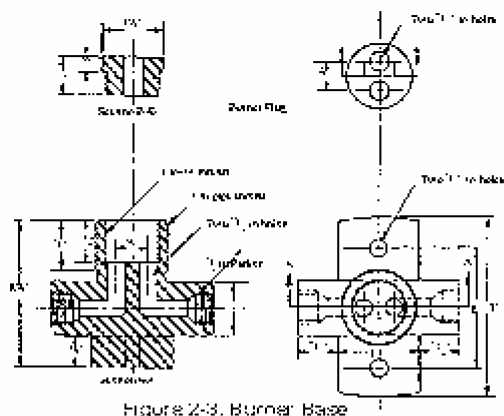


Fig. 2-3 shows the details of the burner base. When the two 11/32-inch-diameter holes in the burner plug are drilled, care should be taken that the center line connecting these holes will be at right angles to the center line connecting the two 19/64-inch diameter holes in the base. When these 11/32-inch diameter holes are properly located the 19/64-inch-diameter holes cannot be seen when one looks vertically downward into the burner base. This misalignment of holes aids in the mixing of the gas and air before they ascend to the burner grill.

Fig. 2-4 shows the details of an orifice and of an orifice chamber. Three are required. Two of these orifice chambers have end plates with the 3/8-inch Parker thread fittings on both ends and are fastened directly into the burner base. The third orifice chamber has an end plate with a Parker thread fitting on one end and the plate with four 1/4-inch diameter holes in the other end. This end of the chamber is connected to the burner by four copper tubes, each 1/4 inch in outside diameter (OD) and 13 1/2 inches long. One of the orifice chambers connected to the base is for measuring the gas supplied to the burner and has an orifice 5/32 (0.01625) inch in diameter. The other orifice chamber connected to the base is for measuring the mixing air supplied to the burner and has an orifice 1/4 (0.25) inch in diameter. The third orifice chamber connected to the burner by four 1/4-inch OD copper tubes is for measuring cooling air supplied to the burner and has an orifice 5/16 (0.3125) inch in diameter. The gas should deliver approximately 2500 British thermal units (BTU) per cubic foot. The burner should consume 26 cubic feet of gas per hour for the 2000°F (1100°C) flame. The flame produced should be uniform and steady with no yellow tips.

The differential manometer readings of the pressure drops across the orifice should be:

1. Gas orifice (5/32-inch diameter), 0.99 inch of water.
2. Mixing-air orifice (1/4-inch diameter), 9.25 inch of water.
3. Cooling-air orifice (5/16-inch diameter), 11.0 inches of water.

In order that the burner might produce the right amount of heat, the differential pressure for the gas and the mixing air should be accurately controlled. A slight variation in the cooling air may be necessary in order to obtain the proper temperature.

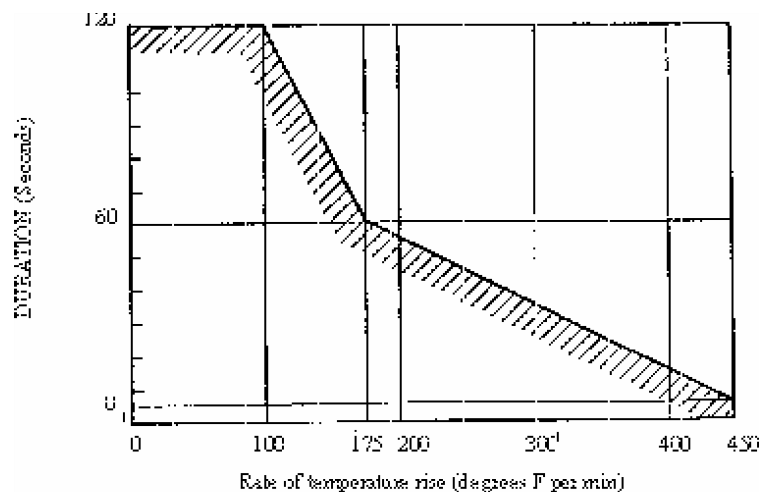


Figure 3 (a). Local temperature rise condition
(Ref. Section 7.2.1)

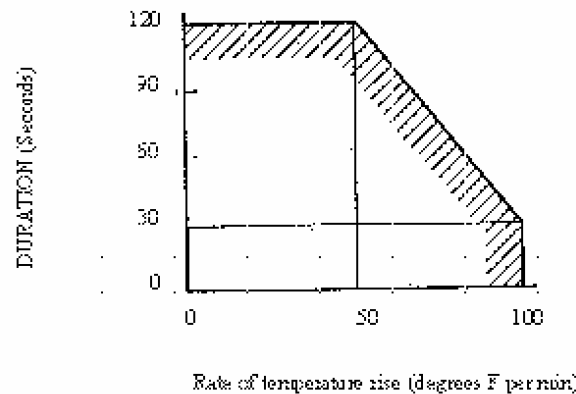


Figure 3 (b). General temperature rise condition
(Ref. Section 7.2.2)

ETSO-C80

ED Decision 2003/10/RM

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 TO ETSO-C80 – FEDERAL AVIATION ADMINISTRATION STANDARD FOR FLEXIBLE FUEL AND OIL CELL MATERIAL

ED Decision 2003/10/RM

- 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

Tests	Par. No.	Oil	Fuel
Leakage ¹	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 ²	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.
- Fuel Tank: Test fluid conforming to MIL. Spec. MIL-S-3136, Type III.
 - Oil Tank: Oil conforming to MIL. Spec. MIL-L-6082, Grade 1100.
 - 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 sins 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:
- Slosh for 25 hours at 16 to 20 c.p.m., or
 - 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 $130^{\circ}\pm 3^{\circ}\text{F}$. and 100 percent relative humidity
- b. 4 hours cooling to approximately $70^{\circ}\pm 3^{\circ}\text{F}$.
- c. 8 hours at $70^{\circ}\pm 3^{\circ}\text{F}$. and 100 percent relative humidity.
- d. 4 hours heating to $130^{\circ}\pm 3^{\circ}\text{F}$. 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:

Inner Liner Type	Bolt Torque
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 $77^{\circ}\pm 5^{\circ}\text{F}$.

The contaminated test fluid shall be decanted off, and the nonvolatile gum residue determined by Method 3302 of Federal Test Method Standard No. 791,4 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 $572^{\circ}\pm 9^{\circ}\text{F}$. for 30 minutes. After cooling in a closed container, the beakers shall be weighed. The staved 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. 601,5 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. 601,5 Method 4111 before and after immersion in the test fluid specified in paragraph 4.2a. for 72 hours at a temperature of $135^{\circ}\pm 3^{\circ}\text{F}$. The tensile strength shall also be determined before and after immersion in water for 72 hours at a temperature of $135^{\circ}\pm 3^{\circ}\text{F}$. 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-191,5 Method 5100 before and after immersion in test fluid specified in paragraph 4.2a. for 72 hours at a temperature of $135^{\circ}\pm 3^{\circ}\text{F}$. The tensile strength shall also be determined before and after immersion in water for 72 hours at a temperature of $135^{\circ}\pm 3^{\circ}\text{F}$. 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 $135^{\circ}\pm 3^{\circ}\text{F}$. 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. 601,5 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 staining 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° 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.

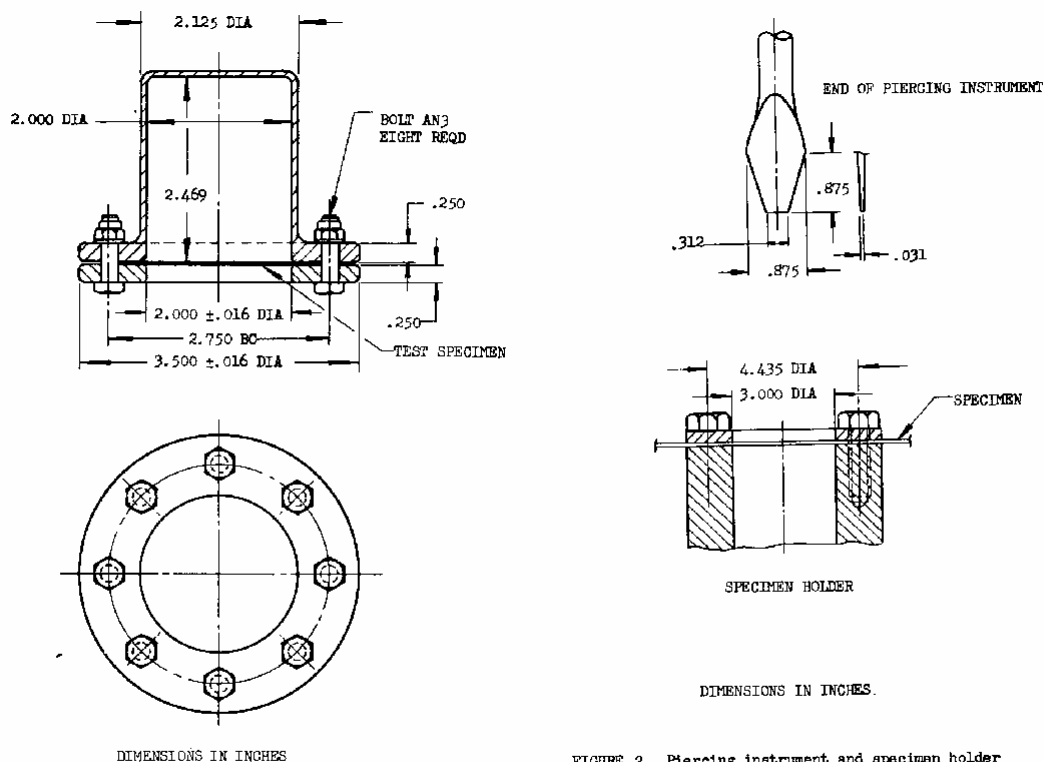


FIGURE 1. Permeability cup assembly

FIGURE 2. Piercing instrument and specimen holder

ETSO-C85b

ED Decision 2016/029/R

SURVIVOR LOCATOR LIGHTS**1 Applicability**

This ETSO gives the requirements which survivor locator lights that are designed and 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 Society of Automotive Engineers, Inc. (SAE), Aerospace Standard (AS) 4492, „Survivor Locator Lights,“ dated January 1995, reaffirmed November 18, 2004, as amended by [Appendix 1](#) of this ETSO.

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.

[Amdt ETSO/12]

APPENDIX 1 TO ETSO-C85B – MPS FOR SURVIVOR LOCATOR LIGHTS

ED Decision 2016/029/R

The applicable standard is SAE AS4492, Survivor Locator Lights, dated January 1995, reaffirmed November 18, 2004 which shall be modified by adding the following:

- (a) Locator light and battery pack must be constructed of materials that comply with CS-25, Appendix F, Part I (a)(1)(v) or Appendix F, Part I (a)(1)(ii) instead.
- (b) Insulation on electrical wire connected to the locator light and battery pack must be self-extinguishing in compliance with CS 25.869(a)(4) respectively CS-25, Appendix F part I (a)(3).

[Amdt ETSO/12]

ETSO-C87a

ED Decision 2013/12/R

AIRBORNE LOW-RANGE RADIO ALTIMETER

1 Applicability

This ETSO gives the requirements which Airborne Low-range Radio Altimeters 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-30 Minimum Performance Standards for Airborne Low-Range Radar Altimeter Equipment, dated March 1980 as modified by [Appendix 1](#) to this ETSO.

The applicable Chapter 2 and Chapter 3 requirements are defined in Table 1 for the appropriate functional class.

Table 1

Low-Range Radio Altimeter Functional Class	Low-Range Radio Altimeter Class Description	Applicable requirements in ED-30
A	Approach and landing	2.1-2.8, 3.1.1, 3.2.1 (all), 3.3.1
B	Terrain Avoidance (ground proximity warning systems)	2.1-2.8, 3.1.2, 3.2.3 (all), 3.3.2

Note: It is possible for a radio altimeter to meet both functional classes.

3.1.2 Environmental standard

See CS-ETSO, [Subpart A](#), paragraph 2.1

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2

3.1.4 Airborne electronic hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific**3.2.1 Failure condition classification**

There is no standard minimum failure condition classification for this TSO. The failure condition classification appropriate for the equipment will depend on the intended use of the equipment in a specific aircraft.

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.

[Amdt ETSO/8]

APPENDIX 1 TO ETSO-C87A – MODIFICATIONS AND ADDITIONS TO EUROCAE ED-30 FOR MINIMUM PERFORMANCE STANDARDS FOR LOW-RANGE RADIO ALTIMETERS

ED Decision 2013/012/R

1.0. ED-30 REQUIREMENT MODIFICATIONS

- 1.1. **ED-30 Paragraph 1.3 (Radio Altimeters with Auto-Surveillance).** [ETSO-C87a](#) does not include a separate category for monitoring. Design the radio altimeter to support the failure condition classification of the intended installation.
- 1.2. **ED-30 Paragraph 2.2 (Transmitter Operating Frequency).** Add the following requirement to ED-30, paragraph 2.2: The radio altimeter shall meet the International Telecommunication Union (ITU) regulations, if applicable.
- 1.3. **ED-30 Paragraph 2.5 (Failure Warning).** Add the following sentence to the beginning of ED-30, paragraph 2.5, to clarify that a failure detection system is required: ‘A failure detection system must be incorporated in the equipment to indicate to the pilot, and to any systems utilizing the radio altimeter data, of a failure of the radio altimeter to accomplish its intended function because of the following conditions: (1) Loss of power, and (2) Loss of signal or altitude sensing capability when within the manufacturer’s stated operating altitude range.’
- 1.4. **ED-30 Paragraph 3.2.2 (Category A2).** [ETSO-C87a](#) does not include Category A2. If alternate accuracy requirements not meeting the requirements of paragraph 3.2.1 are desired, the applicant should apply for a deviation in accordance with paragraph 3.g. of this ETSO.
- 1.5. **ED-30 Paragraph 3.2.4 (Category C).** [ETSO-C87a](#) does not include Category C. If the radio altimeter has been designed and tested to tighter accuracy requirements, include the design information, test results, and limitations with the application for ETSO and document the performance in the installation manual.
- 1.6. **ED-30 (Appendix).** The ED-30 appendix references TSO-C87 and RTCA/DO-123 for external loop loss standards. As TSO-C87 and DO-123 are no longer current, reference RTCA/DO-155, Minimum Performance Standards Airborne Low-Range Radar Altimeters, Appendix B, for external loop loss standards instead.

- 2.0. **REQUIREMENT ADDITIONS to ED-30: Rate Data.** The equipment need not provide a rate data output as a condition of compliance with this minimum performance standard. Altimeters with rate outputs must meet the following accuracy requirements for at least 95 percent of all observations for heights from the terrain to the antenna:

RATE DATA		
Height (ft)	Range (ft/sec)	Accuracy (ft/sec)
3–100	0–15	$\pm (1.5 \text{ ft.} + 0.01 \text{ h} + 0.1 /r/)$
100–200	0–20	$\pm (2.0 \text{ ft.} + 0.01 \text{ h} + 0.1 /r/)$

Where: h = altitude in feet; and /r/ = absolute value of rate (feet/sec.)

[Amdt ETSO/8]

ETSO-C88b

ED Decision 2016/013/R

AUTOMATIC PRESSURE ALTITUDE REPORTING CODE GENERATING EQUIPMENT**1 Applicability**

This ETSO provides the requirements which Automatic Pressure Altitude Reporting Code-Generating Equipment that are designed and 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 AS8003, Automatic Pressure Altitude Reporting Code Generating Equipment, dated July 1974.

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.

3.1.4 Electronic Hardware Qualification

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific

None.

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 of this ETSO resulting in misleading information is a major failure condition. Failure of the function defined in paragraph 3.1.1 of this ETSO resulting in loss of information is a minor failure condition.

4 Marking**4.1 General**

Marking as 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.

[Amdt ETSO/11]

ETSO-C89a

ED Decision 2016/013/R

CREW MEMBER OXYGEN REGULATOR, DEMAND**1 Applicability**

This ETSO provides the requirements which Crew Member Oxygen Regulator, Demand that are designed and 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 AS8027, Crew Member Oxygen Regulator, Demand, dated 1 June 2004, as modified by [Appendix 1](#) to this ETSO.

Crew member oxygen regulators are separated into four types:

Type I: Remote-mounted, panel or portable,

Type II: Man-mounted, not mask-mounted,

Type III: Mask-mounted, less valving, and

Type IV: Mask-mounted, with integral valving.

The four types of oxygen regulators are further separated into five classes:

Class A: Straight demand,

Class B: Diluter demand,

Class C: Straight demand, pressure breathing,

Class D: Diluter demand, pressure breathing to 40 000 ft, and

Class E: Diluter demand, pressure breathing to 45 000 ft.

3.1.2 Environmental Standard

Refer to SAE AS8027, paragraph 4.5

3.1.3 Computer Software

None.

3.1.4 Electronic Hardware Qualification

None.

3.2 Specific

None.

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

4 Marking**4.1 General**

Marking is detailed in CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

Type and class (refer to paragraph 3),

Maximum altitude (per AS8027, paragraph 1.2.3),

Inlet supply pressure range (per AS8027, paragraph 3.1.7).

5 Availability of Referenced Document

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/11]

APPENDIX 1 TO ETSO-C89A – MPS FOR CREW MEMBER OXYGEN GENERATORS, DEMAND

ED Decision 2016/013/R

The applicable standard is SAE AS8027, Crew Member Oxygen Regulator, Demand, dated 1 June 2004. It shall be modified as follows:

AS 8027 section:	Action:
Paragraph 1.1, Scope	Shall be disregarded
Paragraph 3.1.1	To be revised: Materials of a type, grade and quality shall be used where experience and/or tests have shown their suitability for the purpose. Materials contaminating oxygen or materials that are adversely affected by continuous service with oxygen must not be used. Except for small parts like knobs, triggers, fasteners, seals, and electrical parts that do not contribute significantly to fire propagation, materials including packaging must comply with CS 25.853, Appendix F, Part 1 (a)(1)(iv).
Paragraph 3.1.2	To be revised: Filters have to be provided at oxygen inlet ports to prevent entrance of particles, which may be hazardous to the user or impair the function of the device. Filters must be equivalent to that of a 200 mesh screen.
Paragraph 3.1.3	To be revised: For Class B, D, and E devices (diluter demand) an air inlet port has to be provided. The port shall be designed to prevent entrance of particles, which may impair performance of the device. A 100 mesh screen or equivalent filter shall be used.
Paragraph 3.2.1.2	To be revised: Outlet Proof Pressure (Class A and B except Type IV)
Paragraph 3.2.1.3	To be revised: Outlet Proof Pressure (Class C, D and E except Type IV)
Paragraph 3.4, Applicability Matrix, Table 7	To be revised: 3.2.1.2 Outlet Proof Pressure (Except Type IV) 3.2.1.3 Outlet Proof Pressure (Except Type IV) 3.2.8 Relief Valve (Except Type IV)
Paragraph 4.5.1	To be revised: High-temperature exposure: The device shall be soaked for 12 hours at not less than 160° F (71.1 °C). Then the device shall be transferred to 70° F (21.1 °C), ambient temperature. Within 30 minutes of doing this, the device shall be tested to the requirements of paragraphs 4.4.3 through 4.4.9.
Paragraph 4.5.2	To be revised: Low temperature exposure: The device shall be soaked for 2 hours at not less than -65° F (-54°C). Then the device shall be transferred to 0° F (-17.8°C) for 2 hours to stabilise it. After this, the device shall be transferred to 70° F (21.1 °C), ambient temperature. Within 30 minutes of doing this, the device shall be tested to the requirements of paragraphs 4.4.3 through 4.4.9.
Paragraph 5.1, Identification	To be disregarded.

[Amdt ETSO/11]

ETSO-C90d A1

ED Decision 2016/013/R

CARGO PALLETS, NETS AND CONTAINERS (UNIT LOAD DEVICES)**1 Applicability**

This ETSO provides the requirements which Cargo Unit Load Devices that are designed and 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**

For new models of Type I ULDs standards set forth in standard of Aerospace Industries Association of America, Inc. (AIA), National Aerospace Standard, NAS 3610, 'Cargo Unit Load Devices.- Specification for', Revision 10, dated November 1, 1990

When using NAS 3610 Revision 10, the following errors must be corrected:

- in lieu of Figure 31, sheet 87, substitute Figure 31, sheet 88;
- for Figure 32 (missing from NAS 3610 Revision 10), use Figure 32 of NAS 3610 Revision 8 dated April 1987, or Revision 9 dated September 1987.

For new models of Type II ULDs standards set forth in the Society of Automotive Engineers, Inc. (SAE) Aerospace Standard (AS) 36100, 'Air Cargo Unit Load Devices - Performance Requirements and Test Parameters', Revision A, dated April 2006.

For Type I and II ULDs, the standards set forth in SAE AS36102, Air Cargo Unit Load Devices - Testing Methods, dated March 2005 are applicable.

3.1.2 Environmental Standard

See CS-ETSO, [Subpart A](#), paragraph 2.1.

3.1.3 Computer Software

None.

3.1.4 Electronic Hardware Qualification

None.

3.2 Specific

Environmental degradation due to ageing, ultra-violet (UV)-exposure, weathering, etc. for any non-metallic materials used in the construction of pallets, nets and containers must be considered.

In lieu of NAS 3610 Rev. 10, paragraph 3.7 and SAE AS36100 Rev. A, paragraph 4.7 use the following paragraph which provides the fire protection requirements for ULDs:

The materials used in the construction of pallets, nets and containers must meet the appropriate provisions in CS-25, Appendix F, Part I, paragraph (a)(2)(iv).

Textile Performance: See SAE Aerospace Information Report (AIR) 1490B, Environmental Degradation of Textiles, dated December 2007, for available data for textile performance when exposed to environmental factors. These data shall be taken into account for consideration of the effects of environmental degradation on nets commensurate with the expected storage and service life to satisfy SAE AS36100 Rev. A, paragraph 4.11.

Note: Environmental degradation data other than that documented in AIR1490B may be used if substantiated by the applicant and approved by EASA.

3.2.1 Failure Condition Classification

N/A

4 Marking

4.1 General

Marking is detailed in CS-ETSO [Subpart A](#) paragraph 1.2.

4.2 Specific

In addition, the following information shall be legibly and permanently marked on the ULD:

1. The identification of the article in the code system explained in
 - a. NAS 3610, Revision 10, paragraph 1.2.1, for Type I ULDs.
 - b. SAE AS36100, Rev. A, paragraph 3.5 for Type II ULDs.
2. The nominal weight of the article in kilogram and pound in the format: Weight: ...kg (...lb)
3. If the article is not omni-directional, the words 'FORWARD', 'AFT', and 'SIDE' must be conspicuously and appropriately placed.
4. The manufacturer's serial number of the article, with the option to add the date of manufacture.
5. The burning rate determined for the article under paragraph 3.2 of this ETSO.
6. If applicable, the expiration date in the format 'EXP YYYY-MM' must be marked on the ULD.

5 Availability of Referenced Document

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/11]

ETSO-C92c

ED Decision 2003/10/RM

GROUND PROXIMITY WARNING-GLIDE SLOPE DEVIATION ALERTING EQUIPMENT

1 Applicability

This ETSO gives the requirements which ground proximity warning-glide slope deviation alerting 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 General

3.1.1 Minimum Performance Standard

Standards set forth in paragraph 2.0 of Radio Technical Commission for Aeronautics (RTCA) Document DO-161A revised May 27, 1976.

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

3.2.1 Fire Protection. 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 25.853 and Appendix F.

3.2.2 Aural and Visual Warnings. The required aural and visual warnings must initiate simultaneously. Each aural warning shall identify the reason for the warning such as „terrain,“ „too low,“ „glide slope,“ or other acceptable annunciation.

3.2.3 Deactivation Control. If the equipment incorporates a deactivation control other than a circuit breaker, the control must be a switch with a protective cover. The cover must be safety wired so that the wire must be broken in order to gain access to the switch. A frangible lock or similar device may also be used to perform this function.

3.2.4 Mode 4 Flap Warning Inhibition. A separate guarded control may be provided to inhibit Mode 4 warnings based on flaps being in other than the landing configuration.

3.2.5 Speed shall be included in the logic that determines GPWS warning time for Modes 2 and 4 to allow additional time for the aircrew to react and take corrective action.

3.2.6 Smart Callouts. Smart callouts of altitude above the terrain shall be provided during nonprecision approaches. These advisories are normally, but are not limited to 500 feet above the terrain or the height above airport (HAA) used in the terminal (approach) procedures.

3.3 Exceptions.

3.3.1 An alternate means, with demonstrated equal or better accuracy, may be used in lieu of barometric altitude rate (accuracy specified in ETSO-C10b, Altimeter, Pressure Actuated, Sensitive Type, or later ETSO-C92c revisions) and/or radio altimeter altitude (accuracy specified in ETSO-2C87, Low range radio altimeters) to meet the warning requirements described in RTCA Document No. DO-161A.

3.3.2 In RTCA Document No. DO-161A, paragraph 2.3, the complete cycle of two tone sweeps plus annunciation is extended from „1.4“ to „2“ seconds.

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.

ETSO-C95a

ED Decision 2012/009/R

MACH METERS**1 Applicability**

This ETSO gives the requirements which mach meters 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) 8018A „Mach Meters“, dated 01/09/1996.

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

3.1.4 Electronic Hardware Qualification

See CS-ETSO [Subpart A](#) paragraph 2.3.

3.2 Specific**3.2.1 Failure Condition Classification**

See CS-ETSO [Subpart A](#) paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a major failure condition.

4 Marking**4.1 General**

Marking is detailed in CS-ETSO [Subpart A](#) paragraph 1.2.

4.2 Specific

None, marking in accordance with AS 8018A addendum 1 section 2 is optional.

5 Availability of Referenced Document

See CS-ETSO [Subpart A](#) paragraph 3.

[Amdt ETSO/7]

ETSO-C96b

ED Decision 2018/002/R

ANTICOLLISION LIGHT SYSTEMS**1 Applicability**

This ETSO provides the requirements which anticollision light systems that are designed and 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) AS8017C 'Minimum Performance Standard for Anticollision Light Systems', dated June 2011.

3.1.2 Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 Specific**3.2.1 Failure Condition Classification**

See CS-ETSO, Subpart A, paragraph 2.4.

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.

[Amdt ETSO/13]

ETSO-C99a

ED Decision 2016/013/R

FLIGHT DECK (SEDENTARY) CREW MEMBER PROTECTIVE BREATHING EQUIPMENT

1 Applicability

This ETSO provides the requirements which Flight Deck (Sedentary) Crew Member Protective Breathing Equipment that are designed and 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 AS8031A, Personal Protective Devices for Toxic and Irritating Atmospheres Air Transport Flight Deck (Sedentary) Crew members, dated 3/1/1999 as amended by [Appendix 1](#) to this ETSO.

3.1.2 Environmental Standard

To be tested in accordance with the procedures in SAE AS8026A, Crewmember Demand Oxygen Mask for Transport Category Aircraft, dated July 1996, paragraph 4.5.

3.1.3 Computer Software

None.

3.1.4 Electronic Hardware Qualification

None.

3.2 Specific

None.

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

4 Marking

4.1 General

Marking as detailed in CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

In addition to 4.1, the mask assembly shall be marked with the following:

- (1) Size (if more than one size is manufactured),
- (2) Type (as specified in [ETSO-C89a](#), paragraph 3), and
- (3) 'Beards will not seal', if applicable.

5 Availability of Referenced Document

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/11]

APPENDIX 1 TO ETSO-C99A – MPS FOR FLIGHT DECK (SEDENTARY) CREW MEMBER PROTECTIVE BREATHING EQUIPMENT

ED Decision 2016/013/R

The applicable standard is SAE AS8031A, Personal Protective Devices for Toxic and Irritating Atmospheres Air Transport Flight Deck (Sedentary) Crewmembers, dated March 1999. It shall be modified as follows:

AS8031A section:	Action:
Section 1, SCOPE	To be disregarded.
Paragraph 7.1 a. Resistance to Flammability	To be revised: The device shall be designed, including packaging, (except small parts like knobs, triggers, fasteners, seals, and electrical parts) of materials that don't contribute significantly to the propagation of a fire, and that comply with CS 25.853(a), Appendix F, Part I(a)(1)(iv).
Paragraph 7.1j	To be revised: 'ANSI/ASSE Z87.1-2003, "Occupational and Educational Eye and Face Protection Devices."
Paragraph 7.1k	To be revised: 'ANSI/ASSE Z87.1-2003, (Table 8) "Optical Quality, Normal Corrective Vision." Clear versus yellow tint and vision distortion testing for thermal protection.'
Paragraph 8.1	To be revised: 'Cleaning and Sterilising: Except for non-reusable or disposable systems, it must be ensured that cleaning and sterilising the device is possible without major disassembly and adverse effects on operation and performance. The cleaning method must be either manufacturer-recommended, or according to SAE ARP 1176, Oxygen System Component Cleaning and Packaging. Cleaning and sterilising procedures shall be included in the CMM.'
Section 8, IDENTIFICATION	To be disregarded except of paragraph 8h
Paragraph 9.1	The following values shall be used: X=.05, Y=.10 and Z=.05.
Paragraph 10.1 For Flight deck Crewmembers	To be revised: An integral microphone shall be included in the protective device when it is necessary to allow the user to communicate (speak) through the aircraft's communication system. The microphone must be approved or meet the requirements of ETSO-C139a or later.

[Amdt ETSO/11]

ETSO-C100c

ED Decision 2016/013/R

AVIATION CHILD SAFETY DEVICE (ACSD)**1 Applicability**

This ETSO provides the requirements which Aviation Child Safety Devices (ACSD) that are designed and 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 AS5276/1, Performance Standard for Child Restraint Systems in Transport Category Airplanes, dated 11/1/2000, as amended by [Appendix 1](#) to this ETSO.

3.1.2 Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 Computer Software

None.

3.1.4 Electronic Hardware Qualification

None.

3.2 Specific

None.

3.2.1 Failure Condition Classification**4 Marking****4.1 General**

Marking as detailed in CS-ETSO, Subpart A, paragraph 1.2.

4.2 Specific

In addition, the ACSD shall be marked with the ACSD type designation (reference SAE AS52761, paragraph 2.5, as amended by Appendix 1).

Also, any applicable limitations or restrictions shall be marked to allow aircraft-specific or operational-specific installation limitations, such as: 'FOR USE ON [insert aircraft type or serial number] ONLY'; 'FOR USE ON AIRCRAFT USED IN PART [insert number] OPERATIONS ONLY'; 'FOR MILITARY USE ONLY'; or 'SEE DRAWING NO. [insert number] FOR INSTALLATION LIMITATIONS.'

5 Availability of Referenced Document

See CS-ETSO, Subpart A, paragraph 3.

[Amdt ETSO/11]

APPENDIX 1 TO ETSO-C100c – MPS FOR AVIATION CHILD SAFETY DEVICE

ED Decision 2016/013/R

The applicable standard is SAE AS5276/1, 'Child Restraint Systems in Transport Category Airplanes', dated November 2000, with the following modifications:

AS 5276/1 section:	Action:
Entire document:	Throughout the document, 'Aviation Child Safety Device (ACSD)' shall be used instead of 'CRS'. SAE AS5276/1 incorporates, as references, the following test standards: 1. SAE RP J211, Instrumentation for Impact Tests. 2. SAE AS8049A, Performance Standard for Seats in Civil Rotorcraft, Transport Aircraft and General Aviation Aircraft. 3. SAE ARP4466, Dimensional Compatibility of Child Restraint System and Passenger Seat Systems in Civil Transport Airplanes. 4. 49 CFR part 572, Anthropomorphic Test Dummies. 5. CS 25.853(a) (Appendix F, Part I(a)(iv)).
Section 1	To be disregarded.
Paragraph 2.1	To be replaced with: 2.1 Documents: The following publications form part of this AS to the extent specified herein. Other publications are provided for reference. In the event of conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.
Paragraph 2.1.1	To be revised: 2.1.1 SAE Publications: RP J211, Instrumentation for Impact Tests AS8049B, Performance Standard for Seats in Civil, Rotorcraft and Transport Aircraft and General Aviation Aircraft ARP4466, Dimensional Compatibility of Child Restraint Systems and Passenger Seat Systems in Civil Transport Airplanes
Paragraph 2.1.2	To be revised: 2.1.2 Federal Aviation Administration (FAA) Regulations, Advisory Circulars, European Technical Standard Orders and Reports: EASA Part-21, Certification Procedures for Products and Parts CS-25, Airworthiness Standards: Transport Category Airplanes AC 91-62A, Use of Child Seats in Aircraft AC 120-87B, Use of Child Restraint Systems on Aircraft ETSO-C22g, Safety Belts ETSO-C39c, AIRCRAFT SEATS and BERTHS CERTIFIED BY STATIC TESTING ONLY ETSO-C127b, Rotorcraft, Transport Airplane, and Normal and Utility Airplane Seating Systems

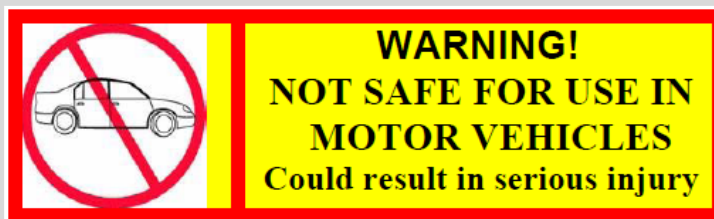
AS 5276/1 section:	Action:																
	DOT/FAA/AAM/-94/19, The Performance of Child Restraint Devices in Transportation Category Seats, Gowdy and DeWeese, FAA Office of Aviation Medicine Report, September 1994 DOT/FAA/AR-00/12, Aircraft Materials Fire Test Handbook																
Paragraph 2.1.3	To be revised: 2.1.3 National Highway Traffic Safety Administration (NHTSA) Regulations and Documents: 49 CFR 571.213, Federal Motor Vehicle Safety Standard No. 213 Child Restraint Systems 49 CFR 571.225, Federal Motor Vehicle Safety Standard No. 225 Child Restraint Anchorage Systems 49 CFR 572, Anthropomorphic Test Dummies NHTSA Drawing Package SAS-100-1000, dated June 1, 1993																
Paragraph 2.1.4	To be revised: 2.1.4 ANSI Publications: ANSI Z535.4 -1998 Product Safety Signs and Labels																
Paragraph 2.3	To be revised: 2.3 Classification of Children: The physical characteristics of small children govern the proper ACSD for use. Mass, standing height, and developmental maturity (i.e. age) are important for proper ACSD configuration and orientation. As children develop at different rates, combined application of these characteristics in selecting an ACSD may be difficult. To assist in this process, Table 1 defines three stages of child development each with a single dominant characteristic <u>underlined</u> . Where an occupant falls between categories, the dominant characteristic is used to determine the proper ACSD configuration and orientation. Table 1 — Definitions of Child Categories <table><tr><th>Child category</th><th>Mass, kg (lb)</th><th>Height, cm (in.)</th><th>Age, month</th></tr><tr><td>Newborn</td><td><u>Birth to 5 (11)</u></td><td>Birth to 65 (26)</td><td>N/A</td></tr><tr><td>Infant</td><td>5-10 (11-22)</td><td>65-85 (26-34)</td><td><u>under 12</u></td></tr><tr><td>Toddler</td><td>10-18 (22-40)</td><td><u>85-110 (34-44)</u></td><td>over 12</td></tr></table>	Child category	Mass, kg (lb)	Height, cm (in.)	Age, month	Newborn	<u>Birth to 5 (11)</u>	Birth to 65 (26)	N/A	Infant	5-10 (11-22)	65-85 (26-34)	<u>under 12</u>	Toddler	10-18 (22-40)	<u>85-110 (34-44)</u>	over 12
Child category	Mass, kg (lb)	Height, cm (in.)	Age, month														
Newborn	<u>Birth to 5 (11)</u>	Birth to 65 (26)	N/A														
Infant	5-10 (11-22)	65-85 (26-34)	<u>under 12</u>														
Toddler	10-18 (22-40)	<u>85-110 (34-44)</u>	over 12														
Paragraph 2.5d	To be revised: d. Any child that has attained his or her first birthday, with a mass greater than 10 kg (22 lb) and having a standing stature of less than 110 cm (44 in.) in height is considered a ‘toddler’ and should be seated in a forward-facing ACSD with both upper and lower torso restraint (Type III).																
Paragraph 2.6	New paragraph to be added: 2.6 Definitions: Refer to 49 CFR 571.213 S4. for aircraft child safety device definitions.																
Paragraph 3.2	To be revised: 3.2 ACSD Design/Functional Performance:																
Paragraph 3.2.5	To be revised: 3.2.5 If an ACSD is equipped with a means of attaching to a rigid bar anchorage system, as prescribed by 49 CFR 571.225 S9, then the provided attachment																

AS 5276/1 section:	Action:
	hardware must comply with the requirements of 49 CFR 571.213 S5.9(a). If rigid prongs are provided for that attachment, they shall be retractable to the extent necessary to ensure proper positioning of the ACSD in an airplane passenger seat not equipped with rigid bar lower anchorages to avoid damage to the airplane seat or injury to nearby seat occupants.
Paragraph 3.2.6	New paragraph 3.2.6 to be added: Except for components designed to attach to a child restraint anchorage system, an ACSD must not have any means designed for attaching the system to an aircraft seat cushion or aircraft seat back and any component (except belts) that is designed to be inserted between the aircraft seat cushion and the aircraft seat back. An ACSD shall be capable of meeting the requirements of this standard when installed solely by the passenger seat lap belt (pelvic portion of the restraint). If the ACSD is equipped with a child restraint anchorage system, then it shall also be capable of meeting the requirements of this standard when installed solely by attachment to rigid bar lower anchorages as prescribed by 49 CFR 571.225 S9. No passenger seat belt may contact the child-occupant of the ACSD. Each belt that is part of an ACSD and that is designed to restrain the child using the system, shall, when tested in accordance with Section 4 of this standard, impose no loads on the child as a result from the mass of the system or from the mass of the standard seat assembly specified therein.
Paragraph 3.2.7	New paragraph 3.2.7 to be added: 3.2.7 An ACSD shall comply with the force distribution requirements of 49 CFR 571.213 S5.2.1.1, S5.2.1.2, S5.2.2.1 (a), (b) and (c), S5.2.2.2, and S5.2.4.
Paragraph 3.2.8	New paragraph 3.2.8 to be added: 3.2.8 ACSD belt systems shall comply with the requirements of 49 CFR 571.213 S5.4.1.2, S5.4.1.3, S5.4.2, S5.4.3.1, S5.4.3.3, S5.4.3.5. References to paragraph S6.1 therein shall be considered to refer to Section 4 of this standard.
Paragraph 3.3	To be revised: 3.3 Fire Protection: Cushions, upholstery, and all other exposed materials used in the ACSD except small parts (knobs, triggers, fasteners, seals and electrical parts) that would not contribute significantly to the propagation of a fire shall meet the fire protection provisions of CS 25.853(a) (Appendix F, Part I (a)(1)(ii)). Seat belts and shoulder harnesses shall meet the provisions of CS 25 (Appendix F, Part I (a)(iv)).
Paragraph 4	To be revised: 4. PERFORMANCE TEST SPECIFICATIONS: The dynamic test described in this section is used to evaluate the performance of the ACSD in a horizontal impact where the force is applied against the longitudinal axis of a forward-facing airplane passenger seat that holds the ACSD. The structural adequacy of the ACSD, the effectiveness of the ACSD attachments, and the adequacy of restraint of the child occupant, as prescribed in paragraph 4.1 of this AS, are the issues evaluated. One dynamic impact test shall be performed, with the ACSD secured using the passenger seat lap belt, for each category of child-occupant, as defined in paragraph 2.3 of this AS, for which the ACSD is intended for use. ACSD equipped with lower anchorage attachment hardware per 49 CFR 571.213 S5.9(a) must be tested with each category of child occupant when secured using the rigid bar lower anchorages, except when the ACSD is in full compliance with 49 CFR 571.213.

AS 5276/1 section:	Action:
Paragraph 4.1	To be revised: 4.1 Child-Occupant Simulation: One or more ATD representing the child categories for which the ACSD is intended for use shall be used to simulate a child-occupant in the dynamic test. Selection of the ATD shall be based on compliance with the following requirements: a. A newborn infant ATD, per 49 CFR part 572, Subpart K, shall be used to test a Type I ACSD. b. A newborn infant ATD and a 12-month-old child ATD, per 49 CFR part 572, Subpart R, shall be used to test a Type II ACSD. c. A 12-month-old child ATD and a 3-year-old child ATD, per 49 CFR part 572, Subpart P, shall be used to test a Type III ACSD.
Paragraph 4.1.2	To be revised: 4.1.2 ATD Preparation and Clothing: All three types of ATDs used shall have a target point marker on each side of the head that is located on the transverse axis passing through the centre of mass of the ATD's head and perpendicular to the head's midsagittal plane. The 12-month-old and 3-year-old ATD's must also have target points located on each knee pivot axis. ATDs must be clothed and prepared for use, as prescribed in 49 CFR 571.213 S9.
Paragraph 4.2	To be revised: 4.2 Test Fixtures: The fixture on which the ACSD is installed for the dynamic test is based on the FMVSS-213 standard seat assembly test fixture defined in 49 CFR 571.213 S6.1.1(a)(1)(i). For the test specified by this AS, the back cushion, seat cushion, lap belts, and belt anchor points are different from the FMVSS-213 standard seat test fixture configuration. Appendix A to this AS presents the locations, dimensions, and materials used to reconfigure the FMVSS-213 standard seat assembly test fixture for the test specified by this AS.
Paragraph 4.2.1	To be revised: 4.2.1 Passenger Seat Restraints: Airplane passenger seat lap belts shall be installed on the seat test fixture as the primary means of attaching the ACSD to the seat test fixture depicted in Appendix A to this AS. The buckle shall be a lift latch type release mechanism. The belts shall meet the requirements of ETSO-C22g and conform to the length dimensions shown in Appendix A, Figure A5, to this AS. The webbing shall be made of nylon.
Paragraph 4.2.2	New paragraph 4.2.2 to be added: 4.2.2 Rigid Bar Lower Anchorages: If testing ACSD equipped with lower anchorage attachment hardware, the aforementioned modified seat test fixture must have rigid bar lower anchorages installed per Figures 1A and 1B of 49 CFR 571.213.
Paragraph 4.5	The last sentence of paragraph 4.5 Photometric Instrumentation shall be revised: The resolution of the images shall be sufficient to enable accurate measurements of the maximum excursion of the head and knee of the ATD in Type III ACSD tests, or the maximum rotation of the ACSD in aft-facing Type I and Type II ACSD tests.
Paragraph 4.6	To be revised:

AS 5276/1 section:	Action:
	4.6 Test Severity: The dynamic impact pulse shall meet the requirements specified for Type A seats in AS8049B, i.e. the 16 g, 13.4 m/s (44 ft/s) horizontal test condition for transport category airplane seats. The pulse described in Figure 2A of 49 CFR 571.213 is acceptable to show compliance with this requirement. The yaw and floor deformation specified in AS8049B are not required.
Paragraph 4.7	New paragraph 4.7 to be added: 4.7 Test Conditions: During the test, maintain the environmental conditions specified in 49 CFR 571.213 S6.1.1(d).
Paragraph 5.1	To be revised: 5.1 ACSD Installation: Install the ACSD at the centre of the seating position of the modified FMVSS-213 standard seat assembly test fixture in accordance with the manufacturers instructions provided with the system except that no tether strap shall be used. For the belted test condition, use only the aircraft lap belt. For tests with a child restraint anchor system, use only the lower anchorages of the child restraint anchor system.
Paragraph 5.2	New paragraph 5.2 to be added: 5.2 ATD Installation: The ATD shall be placed in the ACSD. Position it, and attach the child restraint belts, if appropriate, per 49 CFR 571.213 S10.
Paragraph 5.3	To be revised: 5.3 ACSD Integral Restraint Adjustment: The ACSD integral restraint system shall be routed through the ACSD and fastened over the ATD as called for by the manufacturer's instructions and per 49 CFR 571.213 S6.1.2(d)(1)(i).
Paragraph 5.4	To be revised: 5.4 ACSD Attachment Adjustment: The aircraft lap belt or child restraint anchor system straps attaching the ACSD to the standard seat assembly test fixture shall be adjusted per 49 CFR 571.213 S6.1.2(d)(1)(ii) or (iii) as appropriate.
Paragraph 6.1	To be revised: 6.1 Excursion Limits: The ATD and ACSD excursions and initial positions described below shall be obtained by measuring the high-speed film or video images recorded during the test, or in the case of initial position, measured directly prior to the test.
Paragraph 6.1.1	To be revised: 6.1.1 Test of Forward-Facing ACSD: The ACSD shall retain the ATD's torso within the system. No portion of the ATD head shall pass through a vertical transverse plane passing through a point 813 mm (32 in.) forward of the seat back pivot axis on the standard seat assembly test fixture shown in Appendix A, Figure A2. This limit is referred to as the head excursion limit.
Paragraph 6.1.2	The second paragraph shall be revised: 6.1.2 Test of Aft-Facing ACSD: The angle between the ACSD back child support surface and the vertical transverse plane shall not exceed 70 degrees at any time during the test. The initial (pre-test) angle between the ACSD back child support surface and the vertical transverse plane shall not be less than 45 degrees.

AS 5276/1 section:	Action:
	All portions of the ATD torso shall be retained within the ACSD. The centre of the target points on either side of the ATD head shall not pass through the transverse orthogonal planes whose intersection contains the forward-most and top-most points on the ACSD surfaces.
Paragraph 6.2	To be revised: The Head Injury Criterion (HIC36) is calculated according to the following equation: $HIC = \left\{ (t_1 - t_2) \left[(1/(t_2 - t_1)) \int_{t_1}^{t_2} a(t) dt \right]^{2.5} \right\} Max$ Where: t1, t2 = Any two points in time during the head impact which are not separated by more than a 36 millisecond time interval a(t) = The resultant head acceleration at the centre of gravity of the ATD head expressed as a multiple of g (the acceleration of gravity). The maximum value of the HIC36 computation from data acquired during the impact test, including rebound motion of the ATD and ACSD, shall not exceed a value of 1 000.
Paragraph 6.4	A new second paragraph shall be added: The ACSD shall also meet the requirements of 49 CFR 571.213 S5.1.1. References to paragraph S6.1 therein shall be considered to refer to Section 4 of this standard.
Paragraphs 7.1a through 7.1e	Paragraphs 7.1a. through e. shall be disregarded. Marking of the article shall be in accordance with paragraphs 7.1f. through 7.1h., and paragraph 4 of this ETSO.
Paragraph 7.1g	The second paragraph shall be revised: ‘Place this Type I, II and III child restraint in a rear-facing position when using it with an infant weighing less than ____ pounds (____ Kg).’
Paragraphs 7.1h through 7.1m	To be disregarded.
Paragraph 7.1h	New paragraph 7.1h to be added: 7.1h The following statement on yellow background with black text, regarding the installation and use of ACSD: <i>‘WARNING! DEATH OR SERIOUS INJURY CAN OCCUR. Follow all instructions on this aviation child restraint and in the manufacturer’s written instructions located [insert location].</i> —Do not place this device behind any wall or seat back in an airplane that has an airbag. —Do not use in any passenger seat that has an inflatable seat belt. —Use only in a forward-facing seat. Do not use in a rear-facing seat or a side-facing seat. —Attach this aviation child restraint with the airplane passenger seat lap belt or rigid bar anchorage system if so equipped. —This aviation child restraint is not designed to be used with a shoulder strap or any other tether strap to the seat or airplane.

AS 5276/1 section:	Action:
	— <i>Snugly adjust the belts provided with this aviation child restraint around your child.</i>
Paragraph 7.1i	New paragraph 7.1i to be added: 7.1i Additional label for ACSD that do not meet FMVSS-213. Any ACSD that meets the MPS of this TSO, but does not met the requirements of FMVSS-213, the label in new Figure A6 must be permanently affixed to the webbing of the ACSD so that it is clearly visible when the ACSD is installed.
Figure A1	Figure A1 shall be revised as follows: The horizontal distance between the seat back pivot axis to the lap belt anchor axis shall be changed from 269 (10.6) to 246 (9.7).
Figure A2	Figure A2 shall be revised as follows: The horizontal distance between the seat back pivot axis to the lap belt anchor axis shall be changed from 269 (10.6) to 246 (9.7). A new item 9 shall be added: Aluminium rod: 25.4 (1.0) Dia. welded to the front edge of item 1 such that the rod surface is tangent to the plane of the bottom of the aluminium plate.
Figure A3	Figure A3 shall be revised as follows: The vertical dimension of the anchor pivot shall be changed from 47.8 (1.88) to 50.8 (2.0), and the vertical dimension of the anchor height from 60.5 (2.38) to 63.5 (2.5).
Figure A4	Figure A4 shall be revised as follows: A depiction of the 25.4 (1.0) Dia. rod defined in Figure A2 shall be added.
Figure A6	Figure A6 shall be replaced as follows: FIGURE A6 — Label for ACSD Not Meeting FMVSS-213  – Box outline of label is red, 6-point line width. – Box is 4.75 inches long by 1.25 inches high. – Interior of box is yellow background. – Text is Arial bold black letters. – Large text is 18 point. – Smaller text is 16 point.

[Amdt ETSO/11]

ETSO-C101

ED Decision 2003/10/RM

OVERSPEED WARNING INSTRUMENTS**1 Applicability**

This ETSO gives the requirements which overspeed 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**

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) 8007 „Overspeed Warning Instruments“ dated February 1978.

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.

ETSO-C102

ED Decision 2003/10/RM

AIRBORNE RADAR APPROACH AND BEACON SYSTEMS FOR HELICOPTERS**1 Applicability**

This ETSO gives the requirements which airborne radar approach and beacon systems for helicopters 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**

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-172 change 1 dated March 25, 1983 as amended and supplemented by this ETSO:

Exceptions

The provisions of paragraph 3.0, Beacon Requirements of paragraph 3 of RTCA document DO-172 pertain to ground based equipment and, therefore, are excluded from this ETSO.

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.

ETSO-C103

ED Decision 2003/10/RM

**CONTINUOUS FLOW OXYGEN MASK ASSEMBLY
(FOR NON-TRANSPORT CATEGORY AIRCRAFT)****1 Applicability**

This ETSO gives the requirements which continuous flow aviation 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**

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) 1224A „Continuous Flow Aviation Oxygen Masks,, dated September 15, 1971, revised January 15, 1978, as amended and supplemented by this ETSO:

- Exception. Masks defined as open-port or restrictive-dilution masks without rebreathing or reservoir bag as defined by Aerospace Standard AS 1224A, paragraph 1.4(d) are not eligible for approval under this ETSO.

3.1.2 Environmental Standard

As per Aerospace Standard AS 1224A, paragraph 3.4.1.

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.

ETSO-C105

ED Decision 2003/10/RM

**OPTIONAL DISPLAY EQUIPMENT FOR WEATHER AND GROUND MAPPING RADAR
INDICATORS****1 Applicability**

This ETSO gives the requirements which optional display equipment for weather and ground mapping radar indicators 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 Radio Technical Commission for Aeronautics (RTCA) document DO-174 „Minimum Operational Performances Standard for Optional Equipment which Displays Non-Radar Derived Data on Weather and Ground Mapping Indicators“, dated March 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.

ETSO-C106 A1

ED Decision 2013/012/R

AIR DATA COMPUTER**1 Applicability**

This ETSO gives the requirements which air data computers 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 standards set forth in the SAE Aerospace Standard (AS) AS 8002 „Air Data Computer“, dated April 1, 1985, as amended by this ETSO:

- Paragraph 4.2 of document AS 8002 shall be deleted and replaced by the following:

Static source error correction (if applicable)

Unless otherwise noted, outputs may be corrected for static source errors of the specific aircraft model in which the computer is intended to be used.

The tolerance of correction value produced from the correction profile (correction curve) residing in the computer shall be the sum of the following:

- A $\pm 15\%$ of theoretical value of correction or equivalent of ± 8.44 Pa (.0025 inch Hg) static pressure, whichever is greater.
- B Value of correction curve slope times the tolerance of independent variable programming the correction curve.

When testing corrected parameters (altitude, airspeed or Mach) the nominal value of the parameter at each test point indicated in Tables 1, 3 or 4 shall be adjusted to include the correction value with tolerance limits set per A and B above.

- Exception TABLE 3, CALIBRATED AIRSPEED: A looser tolerance of ± 6.5 km/h (3.5 knots) may be used at the 148 km/h (80 knots) reference point.

3.1.2 Environmental Standard

See [Subpart A](#), paragraph 2.1.

3.1.3 Software

See [Subpart A](#), paragraph 2.2.

3.1.4 Airborne electronic hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3

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.

[Amdt ETSO/8]

ETSO-C109

ED Decision 2003/10/RM

AIRBORNE NAVIGATION DATA STORAGE SYSTEM**1 Applicability**

This ETSO gives the requirements which airborne navigation data storage 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 Global Systems, Inc., document „Minimum Performance Standard for the Airborne Navigation Data Storage Systems“, dated March 31 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.

ETSO-C110a

ED Decision 2003/10/RM

AIRBORNE PASSIVE THUNDERSTORM DETECTION SYSTEMS**1 Applicability**

This ETSO gives the requirements which new models of airborne passive thunderstorm detection 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 Radio Technical Commission for Aeronautics (RTCA) Document No. DO-191, document „Minimum Operational Performances Standard for an Airborne Thunderstorm Detection Equipment“, dated May 1986.

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.

ETSO-C112e

ED Decision 2016/013/R

SECONDARY SURVEILLANCE RADAR MODE S TRANSPONDER**1 Applicability**

This ETSO provides the requirements which Secondary Surveillance Radar Mode S Transponder that are designed and 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 EUROCAE ED-73E, Minimum Operational Performance Standards for Secondary Surveillance Radar Mode S Transponders, dated May 2011 as amended by [Appendix 1](#) to this ETSO.

Note: Level 2 transponders are expected to comply with the Overlay Command Capability as per ED-73E section 3.23.1.12 and 3.18.4.40.

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.

3.1.4 Electronic Hardware Qualification

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific

None.

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 of this ETSO resulting in misleading information is a major failure condition.

Failure of the function defined in paragraph 3.1.1 of this ETSO resulting in loss of function is a minor failure condition.

4 Marking

4.1 General

Marking as detailed in CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

The marking must also include the transponder's functional level and optional additional features as provided in ED-73E, Section 1.4.2.2, as well as minimum peak output power identified by the transponder class as defined in ED-73E, Section 1.4.2.4.

5 Availability of Referenced Document

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/11]

APPENDIX 1 TO ETSO-C112E – SECONDARY SURVEILLANCE RADAR MODE S TRANSPONDER AMENDMENT TO EUROCAE ED-73E REQUIREMENTS

ED Decision 2016/013/R

This Appendix lists the EASA modification to MPS for Secondary Surveillance Radar Mode S Transponder.

The applicable standard is EUROCAE ED-73E Secondary Surveillance Radar Mode S Transponder, dated May 2011, amended as described below.

Text from EUROCAE ED-73E is provided here as needed to provide context. Text to be added is underlined. Text to be removed is ~~lined through~~.

- 1 *EUROCAE ED-73E, page 59, Section 3.23.1.12.d*, is modified here to ensure multiple Comm-B message changes are processed properly.

d. Comm-B Broadcast

Note 1: A Comm-B broadcast is a message directed to all active interrogators in view. Messages are alternately numbered 1, 2, and are available for 18 seconds unless a waiting air-initiated Comm-B interrupts the cycle. Interrogators have no means to cancel the Comm-B broadcast.

Note 2: If there is more than one Comm-B message waiting for transmission, the timer is only started once the message becomes the current Comm-B broadcast.

A Comm-B broadcast starts, when no air-initiated Comm-B transaction is in effect, with the loading of the broadcast message into the Comm-B buffer, insertion of DR codes 4, 5, 6 or 7 into downlink transmissions of DFs 4, 5, 20, 21 and with the starting of the B-timer for the current Comm-B message. On receipt of the above DR codes, interrogators may extract the broadcast message by transmitting RR=16 with DI≠3 or 7 or with DI=3 or 7 and RRS=0 in subsequent interrogations. The change of the DR value is used by the interrogator to detect that a new Comm-B broadcast is announced and to extract the new Comm-B message. A new Comm-B broadcast shall not interrupt a current Comm-B broadcast. When the B-timer runs out after 18 ± 1 seconds, the transponder will reset the DR codes as required, will discard the previous broadcast message, and changes the broadcast message number from 1 to 2 (or vice versa).

If an air-initiated Comm-B transaction is initiated during the broadcasting interval (i.e., while the B-timer is running), the B-timer is stopped and reset, the appropriate code is inserted into the DR field, and the Comm-B transaction proceeds per Figure 3-18. The previous Comm-B broadcast message remains ready to be reactivated for 18 ± 1 seconds after conclusion of the air-initiated Comm-B transaction.

Waiting Comm-B broadcasts shall be retained for transmission once the current Comm-B broadcast is finished. If the contents of a waiting Comm-B broadcast changes, only the most recent value shall be broadcast. This prevents multiple changes from generating a sequence of broadcasts. Currently only BDS registers 1,0, Downlink Capability Report and, 2,0, Flight ID, make use of the Comm-B Broadcast protocol.

2. A test procedure is added here to ensure the modified requirements in Section 1 of this Appendix are met. This test is intended to be introduced in EUROCAE ED-73E, Section 5.5.8.23, on pages 253 and 254.

5.5.8.23 Procedures #21A and #21B Comm-B Broadcast

(§3.23.1.12 d protocol)

5.5.8.23.1 Test Procedure #21A Comm-B Broadcast

Note 1: The command to the transponder that a Comm-B broadcast message shall be sent originates in a peripheral device or in the device that holds the extended capability report.

Note 2: The Comm-B broadcast does not affect the existing Comm-B protocol, air- or ground-initiated. The existing test procedures remain unchanged.

Note 3: Verification of interface patterns is already part of the Comm-B test procedures and need not be repeated for the Comm-B Broadcast.

This test procedure verifies that the DR code command and the MB field of the Comm-B broadcast protocol is carried out correctly.

a. STEP 1 — General Broadcast Protocol Test

During the Comm-B protocol test procedure (Procedure #18) insert the appropriate DR Code command and the MB field of the Comm-B broadcast into the transponder.

Verify that:

- (1) The transponder can correctly show the DR codes 4, 5, 6, 7 when NO air initiated Comm B is in progress and that it cannot show DR codes 4, 5, 6, 7 when an air initiated Comm B is in progress.
- (2) The Comm-B broadcast message can be extracted by the interrogator for 18 ± 1 seconds.
- (3) The Comm-B broadcast annunciation (DR = 4, 5, 6, or 7) and the Comm-B broadcast MB field are interrupted by an air-initiated Comm-B and reappear when that transaction is concluded. For transponders implementing the enhanced air-initiated Comm-B protocol, the transponder will be independently interrupted by up to 16 Comm-B messages that are assigned to each II code. After the Comm-B is concluded for each II code, the Comm-B broadcast is again available to that interrogator. Verify that the next waiting broadcast message is not announced to any interrogators until the current broadcast message has timed out.
- (4) After interruption another 18 ± 1 seconds of broadcast time is available to the interrogator. For transponders implementing the enhanced air-initiated Comm-B protocol, the transponder will be independently interrupted by up to 16 Comm-B messages that are assigned to each II code. After interruption, another 18 ± 1 seconds of broadcast time is available for each II code.

- (5) A subsequent and different Comm-B broadcast message is announced with the alternate DR code and that this DR code also follows the verifications above. For transponders implementing the enhanced air-initiated Comm-B protocol, the transponder will be independently interrupted by up to 16 Comm-B messages that are assigned to each II code. The subsequent Comm-B broadcast is announced only after each Comm-B broadcast timer has expired for all II codes.
- b. STEP 2 — Transponder-Initiated Broadcast
- (1) Enter an AIS Flight Identification into the transponder.
Verify that a broadcast is automatically initiated by the transponder.
Extract the broadcast and verify the correct flight ID.
Wait 20 seconds to allow the broadcast timer to time out and enter the same AIS value again.
Verify that no new broadcast is initiated by the transponder.
Repeat the test with a different AIS flight identification.
 - (2) Enter a datalink capability report into the transponder.
Verify that a broadcast is automatically initiated by the transponder.
Extract the broadcast and verify the correct datalink capability report.
Wait 20 seconds to allow the broadcast timer to time out and enter the same datalink capability report again.
Verify that no new broadcast is initiated by the transponder.
Repeat the test with a different datalink capability report.

5.5.8.23.2 Test Procedure #21B Processing of multiple Comm-B messages

Note 1: The command to the transponder that a Comm-B broadcast message shall be sent originates in a peripheral device or in the device that holds the extended capability report.

Note 2: The Comm-B broadcast does not affect the existing Comm-B protocol, air- or ground-initiated. The existing test procedures remain unchanged.

Note 3: Verification of interface patterns is already part of the Comm-B test procedures and need not be repeated for the Comm-B Broadcast.

This test procedure verifies that multiple Comm-B broadcast messages are queued and processed correctly.

Generate one flight identification change followed by a data link capability report change and two more flight identification changes in less than 18 seconds.

Verify that:

- (1) The first Flight ID change is available as a Comm-B Broadcast.
- (2) The data link capability report change is made available as a Comm-B broadcast after the Flight ID Broadcast times out.
- (3) The last flight ID change is made available as a Comm-B Broadcast after the Data Link Capability Broadcast times out.
- (4) All three Comm-B Broadcasts are available for 18 ± 1 seconds each.

[Amdt ETSO/11]

ETSO-C113b

ED Decision 2020/011/R

AIRBORNE MULTIPURPOSE ELECTRONIC DISPLAYS**1 Applicability**

This ETSO provides the requirements which Airborne Multipurpose Electronic Displays that are designed and 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**

The 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**

The applicable standards are those provided in SAE AS8034C, Minimum Performance Standards for Airborne Multipurpose Electronic Displays, dated 30 July 2018, as modified by paragraph 3.1.1.1 of this ETSO. Additional requirements on colour can be found in [Appendix 1](#) to this document.

To be eligible to this ETSO standard, the equipment shall at least contain a display unit that provides the visualisation function.

It should be noted that this ETSO standard does not provide minimum performance standards for head-up displays or head-worn displays. ETSO-C210 provides requirements for head-up displays.

3.1.1.1 Modifications to AS8034C Section 5

SAE AS8034C, Section 5, second bullet, page 22, is modified as follows:

‘During the specified testing, ~~(5.5, 5.20)~~ it is up to the applicant to prove that the touchscreen functions as intended during the test and that no false positive touches are received. ~~Touch screen compliance may be demonstrated by testing during DO-160G, outside of the DO-160G testing, analysis or some combination thereof.~~ Software simulation cannot be used in lieu of physical activation.’

SAE AS8034C, Section 5.1, is amended as follows:

— Modify the text of Section 5.1 to replace ‘The following performance requirements (5.1.1 through 5.1.6)’ with ‘The following performance requirements (5.1.1 through 5.1.7)’.

— An additional section is added:

‘5.1.7 Touchscreen

The display system shall meet the touchscreen display characteristics of the following paragraphs:

a. 4.7.1 Latency

b. 4.7.3 Touchscreen Selection Accuracy’

For SAE AS8034C, Section 5.4.4.3, Overpressure Test, the last sentence is amended as follows:

‘When the equipment is subjected to the overpressure test, the requirements of 5.1 (excluding 5.1.7) shall be met.’

3.1.2 Environmental Standard

See CS-ETSO, [Subpart A](#), paragraph 2.1.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

4 Marking

4.1 General

Marking as detailed in CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

None.

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/11]

[Amdt ETSO/16]

APPENDIX 1 TO ETSO-C113B – COLOUR

ED Decision 2020/011/R

SAE AS8034C, Section 4.3.4, lays down colour-coding requirements. This Appendix provides additional guidance on colours.

1. Display features, precipitation, and turbulence areas should be colour-coded as depicted in Table A1 and Table A2 respectively, unless otherwise specified by the ETSO application being displayed.

Table A1

Display Feature	Colour
Warnings	Red
Flight envelope and system limits, non-normal sources	Red/Amber/Yellow/White as appropriate
Cautions	Amber/Yellow
Scales and associated figures	White ^{Note}
Earth	Tan/Brown
Sky	Cyan/Blue
Engaged Modes/normal conditions/safe operation	Green

Note: Use of the colour green for tape elements (for example, airspeed and altitude) has also been found to be acceptable if the colour green does not adversely affect flight crew alerting.

Table A2

Precipitation and Turbulence	Colour
Precipitation up to 4 millimetres per hour (mm/hour)	Green
Precipitation 4–12 mm/hour	Amber/Yellow
Precipitation 12–50 mm/hour	Red
Precipitation Above 50 mm/hour	Magenta
Turbulence	White or Magenta

2. Background colour (grey or other shade) may be used to enhance the display presentation.
However, the colour selected should not impair the use of the overlaid information elements. Labels, display-based controls, menus, symbols, and graphics should all remain identifiable and distinguishable.
3. Colours should track the brightness so that the chrominance and the relative chrominance separation are maintained as much as possible during day-night operations.

[Amdt ETSO/11]

[Amdt ETSO/16]

ETSO-C114 A1

ED Decision 2013/012/R

TORSO RESTRAINT SYSTEMS**1 Applicability**

This ETSO gives the requirements which torso restraint 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 SAE Aerospace Standard (AS) document: AS 8043 'Aircraft Torso Restraint System', dated March, 1986.

3.1.2 Environmental standards

- (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 B117-19, 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.

3.1.3 Tests methods

- (i) American Association of Textile Chemists and Colorists (AATCC) Standard Test Method 8-1981, Colorfastness to Crocking.
- (ii) AATCC Standard Test Method 107-I 981, Colorfastness to Water.
- (iii) Federal Test Method Standard 191 Method 5906.
- (iv) AATCC Chart for Measuring Transference of Color.

3.1.4 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.
- AATCC Chart for Measuring Transference of Color and Standard Test Materials 8-1981 and 107-1981 may be purchased from the American Association of Textile Chemists and Colorists, P.O. Box 12215, Research Triangle Park, NC 27709.
- 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.

[Amdt ETSO/8]

ETSO-C115d

ED Decision 2018/002/R

REQUIRED NAVIGATION PERFORMANCE (RNP) EQUIPMENT USING MULTI-SENSOR INPUTS

1 Applicability

This ETSO provides the requirements which required navigation performance (RNP) equipment using multi-sensor inputs that is designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

This ETSO supports performance-based operations using RNP values from RNP 0.3 through RNP 4.0 and advanced RNP functions.

This ETSO does not address RNP operations with authorisation required (RNP AR), localizer performance without vertical guidance/localizer performance with vertical guidance (LP/LPV), ground-based augmentation system landing system (GLS) approach operations or the positioning requirements to support ADS-B out capability.

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 RTCA DO-283B, Minimum Operational Performance Standards for Required Navigation Performance for Area Navigation, dated December 15, 2015, section 2, as modified by [Appendix 1](#) of this ETSO. Section 1.8 of this standard defines 2 classes, A and B, of equipment. Requirements applicable to Class A and Class B equipment are specified in RTCA DO-283B, Table 2-13.

The applicant shall state the minimum RNP supported by the equipment, as well as the equipment class, in the DDP.

3.1.2 Environmental standard

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 Airborne electronic hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 Specific

For databases that are used in the ETSO article but are not part of the ETSO article, the configuration number of the data quality requirements (DQR) shall be defined and provided to the user.

DQR documentation shall be in a form available to the Type 2 Database Provider (refer to Regulation (EU) 2017/373 Article 2(5)(b) for the definition of a Type 2 Database Provider).

3.2.1 Failure condition classification

See CS-ETSO, Subpart A, paragraph 2.4.

Design the system to the appropriate failure condition classification(s) as detailed in the guidance material for the different types of navigation specification (for instance RNP1, Advanced RNP, RNP-APCH...).

4 Marking

4.1 General

Marking as 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.

[Amdt ETSO/8]

[Amdt ETSO/13]

APPENDIX 1 TO ETSO-C115D – MODIFICATIONS TO RTCA DO-283B REQUIREMENTS

ED Decision 2018/002/R

Scope

This Appendix describes modifications and additions to the requirements found in RTCA DO-283B that the RNP equipment shall meet for compliance with this ETSO. EASA expects the RNP equipment to execute published instrument procedures designed to provide maximum efficiency, flexibility, and aircraft eligibility. These instrument procedure designs may include RNAV components and/or leg types associated with conventional procedures. The modifications and additions below are necessary to ensure RNP equipment can properly execute current and future instrument procedure designs.

The modifications below refer to or add chapters in reference to RTCA DO-283B.

2.2.1.2.1 Leg Types

Add the following required leg types to Table 2-1:

- FM Fix to Manual Termination
- VA Heading to Altitude Leg
- VI Heading to Intercept
- VM Heading to Manual Termination
- CA Course to Altitude Leg

Add the following requirement and note after the sentence ‘Refer to Appendix D for additional details for each of the leg types’:

The equipment shall have the ability to use an IF that is a fly-by waypoint, fly-over waypoint, or the initial fix defining an RF leg segment. Additionally, the equipment shall have the ability to proceed ‘direct to’ an IF.

Note: This requirement is needed to support RNP departure procedures, particularly those with an RF leg as the first leg segment, where the IF defines the beginning of the RF leg. With LNAV available immediately after take-off, the equipment should provide guidance direct to the IF and sequence the next leg; particularly when the IF is the initial fix of an RF leg.

2.2.1.2.2 Flight Planning

Insert a new paragraph and note between the last paragraph and next to last paragraph as follows:

The equipment shall have the ability to use a single waypoint supporting multiple RNP terminal procedures (SID, DP, STAR) and multiple approach procedures using different tracks. When a single waypoint supports an arrival and an RNP instrument approach using different tracks, the equipment shall continue following the arrival procedure to the procedure’s termination fix and shall not automatically sequence onto the RNP approach procedure using that same waypoint.

Note: Some waypoints may serve as: a transition fix for an instrument approach; an initial approach fix (IAF) for an instrument approach; the first fix in a terminal arrival procedure; and an intermediate waypoint on a terminal RNP procedure (SID, DP or STAR) (see Figure 1 below). This requirement ensures the equipment completes RNP procedures as assigned by ATC, and loaded by the flight crew into the active flight plan from the on-board navigation database.

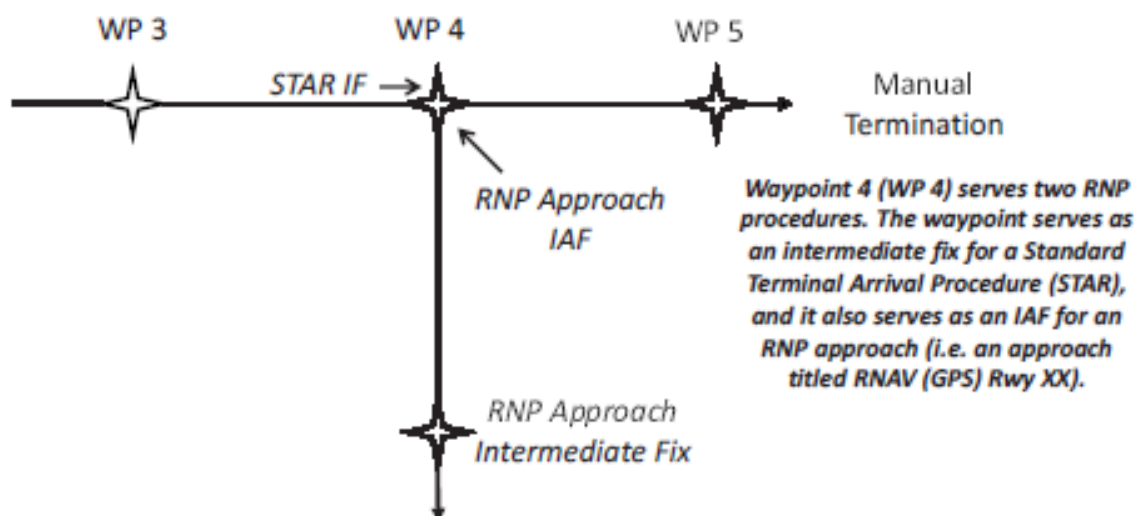


Figure 1- Single Waypoint Serving Multiple RNP Procedures

Add the following requirement and note after the last paragraph in Section 2.2.1.2.2:

The equipment shall not permit the flight crew to select a procedure or route, either manually or automatically, that is not supported by the equipment. For example, a procedure is not supported if it incorporates advanced RNP functions and the equipment does not provide those advanced RNP functions.

Note: Procedures (approaches, arrivals, departures, routes) are defined by a series of waypoints and leg types.

2.2.1.2.9 Transitions Between Legs

Change the first paragraph and note 1 as follows:

The navigation system shall provide a means to automatically transition from one leg to another. Three categories of transition between fixed path segments can be defined:

- Fly-by transitions;
- Flyover transitions; and
- Fixed radius transitions.

The navigation system shall be capable of accomplishing all three transitions. Fly-by transitions shall be the default transition when the transition type is not specified.

Note 1: For fly-by and flyover transitions, no predictable and repeatable path is specified because the optimum path varies with airspeed and bank angle. Fly-by and flyover transitions use a transition area. The aircraft should remain within the transition area for fly-by transitions.

2.2.1.2.9.1.1 Fly-Over Transitions

Insert a new Section 2.2.1.2.9.1.1 after Section 2.2.1.2.9.1 Fly-By Transitions as follows:

The navigation system shall define a path to accomplish fly-over transitions that passes through the transition waypoint. There are no requirements that apply to the transition area, as the equipment provides guidance relative to the two straight segments to and from the transition waypoint (see figure 2-4.1).

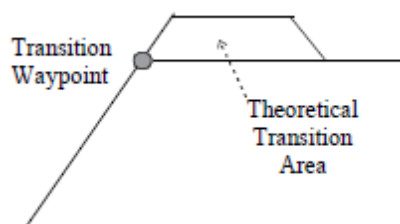


Figure 2-4.1: Fly-Over Theoretical Transition Area

2.2.1.2.9.2 Fixed Radius Transitions

Change the second paragraph as follows and delete the third paragraph:

The RNP system shall use the discrete, navigation database-specified FRT turn radius associated with an en route waypoint transition to execute a Fixed Radius Transition (FRT) from the airway inbound course to the outbound course. The RNP system shall output lateral guidance commands relative to the FRT path. The discrete turn radius is defined by a 3-digit numeric field representing the radius to one decimal place (tenths, decimal point suppressed) in nautical miles. A blank entry in the database field indicates that no fixed radius transition is required.

2.2.1.4. Displays and System Alerting

Add the following second sentence to the paragraph and Note 2:

If the equipment incorporates an electronic map display to provide a graphical depiction of navigation information, it shall meet the requirements of RTCA/DO-257A ‘Minimum Operational Performance Standards for the Depiction of Navigational Information on Electronic Maps’.

Note 2: Manufacturers should use RTCA/DO-257A with RTCA/DO-283A, Appendix K until RTCA/DO-257B is published.

2.2.2.2.6.1 Descent Path Construction

Add the following requirement and notes to the list of general requirements:

6. The RNP equipment shall always use the procedure-defined flight path angle to define the final approach segment of an RNP instrument approach procedure offering vertical guidance (RNP procedures offering LNAV/VNAV minima).

Note 1: Some RNP instrument approach procedures define the final approach fix with an ‘AT’ altitude constraint (‘hard altitude’) and the intent of this requirement is to use the published FPA, the designated end of the runway (DER) and the threshold crossing height for vertical path construction. The equipment should not generate a geometric, point-to-point vertical path between two ‘AT’ constraints on a final approach segment.

Note 2: This requirement is not intended to prohibit the optional use of baro-VNAV temperature compensation as described in RTCA/DO-283B Appendix H.

2.4.3.1 Test Scenario(s)

Add the following leg types to the list in paragraph (a):

FM, VA, VI, VM, CA.

Appendix D

Add the following leg type definitions to Appendix D:

D.10 Fix to Manual Termination (FM)

An FM leg defines a specified track over the ground from a database fix until a manual termination of the leg.

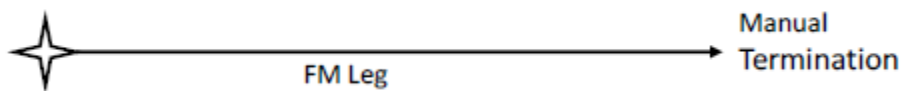


Figure D-6: Fix to Manual Termination (FM) Leg

D.11 Heading to Altitude (VA)

A VA leg defines a specified heading to a specific altitude termination at an unspecified position. No correction is made for wind.

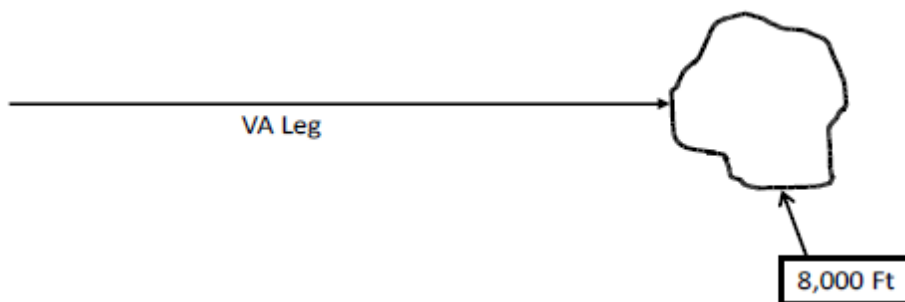


Figure D-7: Heading to Altitude (VA) Leg

D.12 Heading to Intercept (VI)

A VI leg defines a specified heading to intercept a subsequent leg at an unspecified position. No correction is made for wind.

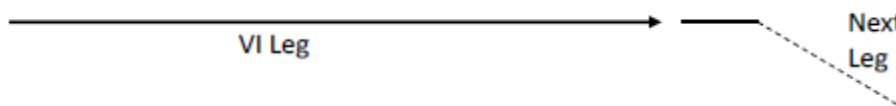


Figure D-8: Heading to Intercept (VI) Leg

D.13 Heading to Manual Termination (VM)

A VM leg defines a specified heading until a manual termination of the leg. No correction is made for wind.



Figure D-9: Heading to Manual Termination (VM) Leg

D.14 Course to Altitude (CA)

A CA leg defines a specified course to a specific altitude at an unspecified position. The course is flown making adjustment for wind.



Figure D-10: Course to Altitude (CA) Leg

[Amdt ETSO/13]

ETSO-C116a

ED Decision 2016/013/R

CREW MEMBER PORTABLE PROTECTIVE BREATHING EQUIPMENT**1 Applicability**

This ETSO provides the requirements which Crewmember Portable Protective Breathing Equipment that are designed and 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 AS8047, Performance Standard for Cabin Crew Portable Protective Breathing Equipment for Use During Aircraft Emergencies, dated 6/1/2002, as modified by [Appendix 1](#) to this ETSO.

Crew member portable PBE are separated into four classes suitable for use by crew members during the following scenarios:

Class 1: For an in-flight cabin or accessible compartment smoke/fire conditions at normal cabin altitude (up to 8 000 ft equivalent).

Class 2: In addition to the requirements of Class 1, protection against a subsequent depressurisation to 40 000 ft while wearing the unit.

Class 3: Emergency ground evacuation of the aircraft during fire/smoke conditions, operating escape systems and assisting passengers.

Class 4: In-flight emergency and ground evacuation during smoke/fire conditions (as per Class 1 & 3 combined).

3.1.2 Environmental Standard

See paragraph 6.3 of Appendix 1 to this ETSO.

3.1.3 Computer Software

None.

3.1.4 Electronic Hardware Qualification

None.

3.2 Specific

None.

3.2.1 Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

4 Marking

4.1 General

Marking as detailed in CS-ETSO, Subpart A, paragraph 1.2.

4.2 Specific

In addition, the crew member's portable PBE shall be marked permanently and legibly with the class (see paragraph 3.1.1 above).

5 Availability of Referenced Document

See CS-ETSO, Subpart A, paragraph 3.

[Amdt ETSO/11]

APPENDIX 1 TO ETSO-C116A – MPS FOR CREWMEMBER PORTABLE PBE

ED Decision 2016/013/R

The applicable standard is SAE AS8047, Performance Standard for Cabin Crew Portable Protective Breathing Equipment for Use During Aircraft Emergencies, dated 6/1/2002. It shall be modified as follows:

SAE AS 8047 section:	Action:
Section 1.1 Scope:	To be disregarded.
Paragraph 2.1 Applicable Documents:	The following documents shall be added: AS 8026A, Crewmember Demand Oxygen Mask for Transport Category Aircraft AS 1303A, Portable Chemical Oxygen To be revised: CS-25, Certification Specifications Large Aeroplanes AS 8010C, Aviator's Breathing Oxygen Purity Standard AS 8031A, Personal Protective Devices for Toxic and Irritating Atmospheres, Air Transport Crew Members ETSO-C99a, Flight Deck (Sedentary) Crewmember Protective Breathing Equipment ETSO-C69c, Emergency Evacuation Slides, Ramps and Slide/Ramp Combinations ASTM D1149, Standard Test Method for Rubber Deterioration — Surface Ozone Cracking in a Chamber ASTM D624, Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers ASTM D750, Standard Test Method for Rubber Deterioration Using Artificial Weathering Apparatus ASTM D228, Abrasion Resistance ASTM D1922-REVA, Standard Test Method for Propagation Tear Resistance of Plastic Film and Thin Sheeting by Pendulum Method ASTM D1004, Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting ASTM D2582, Standard Test Method for Puncture-Propagation Tear Resistance of Plastic Film and Thin Sheeting
Paragraph 3.1.1	Following paragraphs to be added: 3.1.1 Unit must be a self-contained device, (containing a supply or source of breathable gas) which will not increase the risk to the user or the aircraft during storage or use, and must satisfy the requirements of the applicable sections of CS 25.1439 and the required operational regulations. 3.1.1.1 Breathable gas source may be either oxygen or air. 3.1.1.2 Use of a chemical oxygen generator is an acceptable alternative. 3.1.1.3 Breathable gas must meet the gas standard for purity, SAE AS8010 Rev C, Aviator's Breathing Oxygen Purity Standard. For air, compliance with the purity standards in AS8010C, Table 2, Constituent Maximum Concentrations for Chemical Oxygen, has to be shown. Type IV chemically-generated oxygen for emergency-use shall be used.

SAE AS 8047 section:	Action:
Paragraph 3.1.2	To be revised: 3.1.2 Portable PBE unit must adequately protect any adult (within the 5th percentile female (107 lbs, 11.1-inch neck circumference) to 95th percentile male (220 lbs, 16.4-inch neck circumference) body dimensions), including spectacle users. To demonstrate compliance with spectacles, eyeglasses must be a minimum of 152 mm (6 inches) wide by 51 mm (2 inches) high. 3.1.2.1 Facepiece designers should consider extremes of Naison-Menton, Bizygomatic, Bigonial and Naison-Supramentale measurements and other applicable anthropometric data to provide a device with adequate fit. Sources of data are listed in paragraph 2. 3.1.2.2 Limitations/recommendations shall be included in the IM/CMM (required in paragraph 5.b of this ETSO) for using portable PBE with long hair and/or beards. 3.1.2.3 The size of the portable PBE unit when donned must allow the wearer to pass through any access opening 18 inches (460 mm) × 18 inches (460 mm) to investigate and/or combat an in-flight fire.
Paragraph 3.1.4	To be revised: 3.1.4 Failure of the unit to operate or to cease operation must be apparent to the user. This must be accomplished with aural and/or visual warning that also must activate at gas supply exhaustion.
Paragraph 3.1.5	To be disregarded.
Paragraph 3.1.6	To be revised: 3.1.6 Unit must not cause a hazard when stored, in use, or during inadvertent operation.
Paragraph 3.1.8	To be revised: 3.1.8 The portable PBE unit must have a 98 % minimum reliability factor at 90 % confidence level during its design service life. A shelf life, operational limit and/or maintenance interval must be established and included in the CMM.
Paragraph 3.1.10	To be revised: 3.1.10 Portable PBE must wear comfortably in use leaving both hands free. It must not displace during normal tasks of locating and combating a fire, such as crawling, kneeling or running.
Paragraph 3.1.11	To be revised: 3.1.11 Hoods, Full-Face Masks with Lenses, and/or Integral Goggles 3.1.11.1 Range of Vision: Portable PBE must permit peripheral vision in the horizontal meridian of at least 120 degrees (60 degrees on each side of the centre point) and in the vertical meridian of at least 60 degrees (40 degrees above and 20 degrees below the centre point) when evaluated by standard arc perimeter techniques. 3.1.11.2 Fogging: The portable PBE shall be designed to minimise moisture condensation on the inside surface, or include a means of preventing or removing any moisture that may condense on surfaces during use.

SAE AS 8047 section:	Action:
Paragraph 3.1.12	To be revised: 3.1.12 Portable PBE must allow intelligible two-way communication, including the use of airplane interphone (handset or microphone) and megaphone. User must be able to communicate with another user or non-user at a distance of at least four meters. Use a background noise of 65db and a user communication sound level of 85db or equivalent method.
Paragraph 3.1.15	New paragraph to be added: 3.1.15 Material used to fabricate the unit must be puncture/tear-resistant.
Paragraph 3.2.1	To be revised: 3.2.1 Average inspiratory limits must be within the following: – Carbon dioxide concentration level at mouth/nose must not exceed 4 % at sea level. Concentration may increase to 5 % at sea level for a period not to exceed 2 minutes. – Carbon monoxide level must not exceed 50 ppm, time-weighted average. – Chloride level must not exceed 1 ppm, time weighted-average.
Paragraph 3.2.2	To be revised: 3.2.2 When a user puts on portable PBE, the unit must be self-purging by enough breathable gas to ensure one complete dead volume displacement within 20 seconds of initial operation.
Paragraph 3.2.3	To be revised: 3.2.3 Portable PBE must protect the user against toxic fumes and smoke. The test procedures in AS 8031A shall be used. An alternative challenge gas may be used. Aerosols, such as sodium chloride (NaCl) or corn oil are not acceptable as an alternative. Component sensitivity to particle size and the potential to precipitate on the unit surface make aerosols unacceptable to measure a contaminant protection factor. User's eyes, nose, and mouth must be protected to 0.05 mean contaminant protection factor during the work profiles specified in paragraph 3.2.4.
Paragraph 3.2.4	First sentence to be revised: 3.2.4 Portable PBE must provide the minimum required protection for the following work profiles, at an ambient 70 °F (21.1 °C) for the intended population (generally 107 to 220 lb).
Paragraph 3.2.5	To be revised: 3.2.5 Internal temperature of the portable PBE must not exceed 104 °F (40 °C) wet bulb at an ambient temperature of + 70 °F (21.1 °C).
Paragraph 3.2.6	To be revised: 3.2.6 Portable PBE must function satisfactorily in a 212 °F (100 °C) environment, where the internal temperatures must not exceed 122 °F (50 °C) wet bulb for a 2-minute exposure.

SAE AS 8047 section:	Action:
Paragraph 3.2.9	To be revised: 3.2.9 Portable PBE must operate at a mean positive pressure and incorporate a relief valve(s) to prevent over-pressurisation.
Paragraph 3.2.10	To be revised: 3.2.10 Portable PBE must support peak flows of 250 liters per minute (LPM) and must be capable of supporting a minute breathing minute volume of 80 litres for a 30-second period at any time throughout its operation.
Paragraph 3.2.11	To be revised: 3.2.11 Portable PBE must be easily put on and activated, after the user gains access to the stowed unit within 15 seconds. The unit shall be designed so it can be donned and worn by users wearing eyeglasses, as specified in paragraph 3.1.2. Unit face must not displace eyeglasses or be flexible enough to allow adjustment of eyeglasses.
Section 4 CONSTRUCTION	To be disregarded.
Paragraph 6	To be revised: TESTING PROCEDURES:
Paragraph 6.1	First sentence to be revised: Manufacturer of the portable PBE is responsible for performing the required tests in paragraph 3.2 to verify its performance.
Paragraph 6.2	To be disregarded.
Paragraph 6.2	New paragraph to be added: 6.2 FLAMMABILITY. All materials used in the portable PBE and any stowage container/case (including insulation on electrical wires) in a typical installed arrangement must be self-extinguishing. Materials must comply with CS 25.853(a), Appendix F, Part I (a)(1)(iv). 6.2.1 Any exposed portions of the portable PBE and stowage container/case must withstand a radiant heat flux of 1.0 BTU/ft ² per second for 60 seconds, and remain functional when exposed to it. 6.2.2 Radiant heat flux source must be of sufficient size so the portable PBE, any stowage container/case, and exposed parts of the unit are exposed in a manner that creates the heat flux at all the surfaces, in a typical as installed arrangement. 6.2.3 Portable PBE must protect the user's head and neck from dripping 392 °F (200 °C) plastic materials and withstand an 1 832 °F (1 000 °C) flame for 5 seconds without material penetration while operating. 6.2.3.1 Protection from dripping plastic material may be tested by several methods. One is to ignite a polypropylene rod and allow the drops to impinge on the various external materials, seams, and transparency. Adjust the drop height so that the drop contact temperature is at least 392 °F (200 °C).

SAE AS 8047 section:	Action:
Paragraph 6.2 (<i>continued</i>)	6.2.3.2 The 5-second 1 832 °F (1 000 °C) test is meant to protect a crew member wearing the portable PBE from an unexpected flame lick. Two main concerns are failure of the unit that would injure the wearer, and leakage of the breathable atmosphere that could produce an explosion or hazard. The test rig must expose the unit, while operating, to a 1 832 °F (1 000 °C) flame envelope. One company has used German Teklu burners with a flow rate of about 21 liters per minute. The flow rate and distance of the burner to the surface of the PBE unit being tested shall be adjusted to obtain the required temperature. In most cases the flame plume developed will not expose the complete unit. A segment can be passed through the flame plume to obtain the 5-second exposure period and then the unit can be rotated to the next segment and passed through the flame plume, and so forth, until the complete unit has been tested. Making a visual (videotape) record of this test might be useful documentation, in addition to the measured parameters. 6.2.4 Heat Release and Smoke Density. Exposed panels/surfaces totalling more than one square foot in surface area must meet the heat release and smoke density requirements of CS 25.853, Appendix F, Parts IV and V. Guidance on these test requirements can be found in the Aircraft Materials Fire Test Handbook, DOT/FAA/AR-00/42, at www.fire.tc.faa.gov/handbook.stm. 6.2.5 Battery Qualification. If the equipment uses a lithium battery as a power source, battery must meet the applicable battery standards: 6.2.5.1 ETSO-C142a, Non-Rechargeable Lithium Cells and Batteries (see RTCA, Inc. document RTCA/DO-227, Minimum Operational Performance Standards for Lithium Batteries, dated June 23, 1995), or most current revision. 6.2.5.2 ETSO-C179a, Rechargeable Lithium Cells and Lithium Batteries (see UL 1642, Standard for Safety for Lithium Batteries, fourth edition, dated September 19, 2005).
Paragraph 6.3	New paragraph to be added: 6.3 Environmental Qualification 6.3.1 High-Temperature Exposure: The portable PBE shall be soaked for 12 hours at not less than 160 °F (71.1 °C). Then the PBE shall be transferred to 70 °F (21.1 °C) ambient temperature. Within 30 minutes of doing this, the portable PBE shall be tested to the requirements of paragraph 3.2. 6.3.2 Low-Temperature Exposure: The portable PBE device shall be soaked for 2 hours at not greater than – 65 °F (– 54 °C). Then the PBE shall be transferred to 0 °F (– 17.8 °C) for 2 hours to stabilise it. After this, the PBE shall be transferred to 70 °F (21.1 °C) ambient temperature. Within 30 minutes of doing this, the portable PBE shall be tested to the requirements of paragraph 3.2. 6.3.3 Operational Shock: The PBE shall comply with the test requirements in RTCA DO-160 release defined in CS-ETSO, Subpart A, paragraph 2.1, Section 7, paragraph 7.2. 6.3.4 Humidity: The PBE shall comply with the test requirements in RTCA DO-160 release defined in CS-ETSO, Subpart A, paragraph 2.1, Section 6, Category A.

SAE AS 8047 section:	Action:
	6.3.5 Waterproofness: The PBE shall comply with the test requirements in RTCA DO-160 release defined in CS-ETSO, Subpart A, paragraph 2.1, Section 10, Category R. 6.3.6 Fungus Resistance: The PBE shall comply with the test requirements in RTCA DO-160 release defined in CS-ETSO, Subpart A, paragraph 2.1, Section 13, Category F. 6.3.7 Decompression (Class 2 only): Devices covered by this document must meet the requirements of paragraph 3.2 when subjected to decompression testing.

[Amdt ETSO/11]

ETSO-C117b

ED Decision 2020/011/R

AIRBORNE WIND SHEAR WARNING AND ESCAPE GUIDANCE SYSTEMS (REACTIVE TYPE) FOR TRANSPORT AEROPLANES

1 Applicability

This ETSO provides the requirements that airborne wind shear warning and escape guidance systems (reactive type) for transport aeroplanes that are designed and manufactured on or after the date of this ETSO, must meet in order to be identified with the applicable ETSO marking. It is not applicable to systems that look ahead to sense wind shear conditions before the phenomenon is encountered, nor to systems that use atmospheric and/or other data to predict the likelihood of a wind shear alert.

[Appendix 1](#) to this ETSO describes the MPS for the airborne wind shear warning and escape guidance systems for transport category aeroplanes.

[Appendix 2](#) to this ETSO describes the wind field models used to evaluate the performance of a wind shear warning and escape guidance system.

[Appendix 3](#) to this ETSO describes the conversion of the velocity equations in Appendix 2 to rectangular coordinates.

[Appendix 4](#) to this ETSO contains data that defines the Dryden turbulence model and the discrete gust model used in conducting the required wind shear alert tests.

[Appendix 5](#) to this ETSO describes shear intensity.

[Appendix 6](#) to this ETSO provides a sample computer listing for a simplified aeroplane simulation model for evaluating the effectiveness of various guidance schemes.

2 Procedures

2.1 General

The 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

The applicable standards are provided in the attached 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.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

A failure of the function defined in 3.1.1 above that results in an unannounced malfunction or a missed wind shear detection is a major failure condition.

A loss of the function defined in 3.1.1 above is a minor failure condition.

4 Marking

4.1 General

See CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

None.

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/16]

APPENDIX 1 TO ETSO-C117B – EASA PERFORMANCE STANDARD FOR AIRBORNE WIND SHEAR WARNING AND ESCAPE GUIDANCE SYSTEMS FOR TRANSPORT AEROPLANES

ED Decision 2020/011/R

1. PURPOSE

This Appendix establishes the minimum performance standard (MPS) for airborne wind shear warning and escape guidance systems for transport category aeroplanes.

2. SCOPE

The scope of this Appendix is to provide MPS for airborne wind shear warning and escape guidance systems for transport category aeroplanes. All the paragraph references cited herein are in reference to this Appendix only.

This performance standard applies only to wind shear warning systems which identify wind shear phenomena by sensing an encounter with conditions that exceed the threshold values contained in this performance standard. In addition to wind shear warning criteria, this performance standard provides criteria that are applicable to systems that provide optional wind shear caution alert capabilities. Wind shear escape guidance is provided to assist the pilot in obtaining the desired flight path during such an encounter.

3. DEFINITION OF TERMS

a. Airborne wind shear warning system

A device or system which uses various sensor inputs to identify the presence of wind shear once the phenomenon is encountered, and provides the pilot with a timely warning. The system may include both wind shear warning and wind shear caution alerts. A warning device of this type does not provide escape guidance information to the pilot to satisfy the criteria for warning and flight guidance systems.

b. Airborne wind shear warning and escape guidance system

A device or system which uses various sensor inputs to identify the presence of wind shear once the phenomenon is encountered, and provides the pilot with a timely warning and adequate flight guidance to improve the probability of recovery from the wind shear encounter. This system may include both wind shear warning and wind shear caution alerts.

c. Airborne wind shear auto recovery system

A device or system which integrates or couples autopilot and/or autothrottle systems of the aeroplanes with an airborne wind shear flight guidance system.

d. Airborne wind shear escape guidance system

A system which provides the crew with flight guidance information to improve the probability of recovery once a wind shear phenomenon is encountered.

e. Failure

The inability of a system, subsystem, unit, or part to perform within the previously specified limits.

f. False warning or caution

A warning or caution which occurs when the wind shear warning or caution threshold of the system is not exceeded.

g. Nuisance warning or caution

A warning or caution which occurs when a phenomenon is encountered, such as turbulence, which does not, in fact, endanger the aeroplane because of the duration of the subsequent change in the magnitude of the wind shear.

h. Recovery procedure

A vertical flight path control technique that is used to maximise the potential for a recovery from an inadvertent encounter with wind shear.

i. Severe wind shear

A wind shear of sufficient intensity and duration that it exceeds the performance capability of a particular aeroplane type. This would be likely to cause an inadvertent loss of control or ground contact if the pilot did not have information available from an airborne wind shear warning and escape guidance system which meets the criteria of this ETSO.

j. Wind shear caution alert

An alert that is triggered by increasing performance conditions, which is set at a wind shear level that requires immediate crew awareness and probably subsequent corrective action by the pilot.

k. Wind shear warning alert

An alert that is triggered by decreasing performance conditions, which is set at a wind shear level that requires immediate corrective action by the pilot.

4. GENERAL REQUIREMENTS

In addition to the performance requirements provided in the main text of this Performance Standard and in the Appendices to ETSO-C117b, the following general requirements and equipment characteristics are defined below:

a. General standards

The following general requirements shall be met by all wind shear warning and escape guidance systems:

(1) Airworthiness

The design and manufacture of the airborne equipment shall provide for installation so as not to impair the airworthiness of the aeroplane. The material shall be of a quality which experience and/or tests have demonstrated to be suitable and dependable for use in aeroplane systems. The workmanship shall be consistent with high-quality aeroplane electromechanical and electronic component manufacturing practices.

(2) General performance

The equipment shall perform its intended function, as defined by the manufacturer.

(3) Fire resistance

Except for small parts (such as knobs, fasteners, seals, grommets and small electrical parts) that would not significantly contribute to the propagation of fire, all the materials that are used shall be self-extinguishing. One means to show compliance with this requirement is contained in Part 25, Appendix F.

(4) Operation of controls

Controls that are intended for use during flight shall be designed to minimise errors, and when operated in any possible combinations and sequences, shall not result in a condition whose presence or continuation would be detrimental to the continued performance of the equipment.

(5) Accessibility of controls

Controls that are not normally adjusted in flight shall not be readily accessible to the operator.

(6) Interfaces

The interfaces with other aeroplane equipment shall be designed such that the normal or abnormal operation of the wind shear warning and escape guidance equipment does not adversely affect the operation of other equipment.

(7) Compatibility of components

If a system component is individually acceptable but requires calibration adjustments or matching to other components in the aeroplane for its proper operation, it shall be identified in a manner that will ensure its performance to the requirements specified in this ETSO.

(8) Interchangeability

System components which are identified with the same manufactured part number shall be completely interchangeable.

(9) Control/display capability

A suitable interface shall be provided to allow data input, data output, and control of the operation of the equipment. The control/display shall be operable by one person with the use of only one hand.

(10) Control/display readability

The equipment shall be designed so that all the displays and controls are readable under all cockpit ambient light conditions, ranging from total darkness to reflected sunlight, and are arranged to facilitate the use of the equipment. If limitations are necessary on equipment installations to ensure that the displays are readable, they shall be included in the installation instructions.

(11) Effects of test procedures

The design of the equipment shall be such that the application of the specified test procedures does not produce a condition that is detrimental to the performance of the equipment, except as specifically allowed.

(12) Equipment computational response time

The equipment shall employ suitable update rates for the computation and display of detection and guidance information.

(13) Supplemental heating or cooling

If supplemental heating or cooling is required by system components to ensure that the requirements of this ETSO are met, they shall be specified by the equipment manufacturer in the installation instructions.

(14) Self-test capability

The equipment shall employ a self-test capability to verify the proper operation of the system.

- (i) Any manually initiated self-test mode of operation shall automatically return the system to the normal operating mode upon completion of a successful test.
- (ii) Any automatically activated self-test feature shall annunciate this mode of operation to the pilot if this feature activates annunciation lights, aural messages, or displaces the guidance commands in any way.
- (iii) Use of the system self-test feature shall not adversely affect the performance of operation of other aeroplane systems.
- (iv) A failure of the system to successfully pass the self-test shall be annunciated.

(15) Independence of warning and escape guidance functions

Irrespective of whether the warning and escape guidance functions are in a combined system or are separate systems, they should be sufficiently independent such that a failure of either system does not necessarily preclude or inhibit the presentation of information from the other. A warning system failure shall not result in any ambiguous or erroneous guidance system mode annunciations.

(16) System reliability

- (i) The probability of a false warning being generated within the wind shear warning system or the wind shear warning and escape guidance system shall be $1E-4$ or less per flight hour.
- (ii) The probability of an unannunciated failure of the wind shear warning system or the wind shear warning and escape guidance system shall be $1E-5$ or less per flight hour (reserved).

b. Equipment functional requirements — standard conditions

The equipment shall meet the following functional requirements:

(1) Mode annunciation

The mode of operation of the wind shear escape guidance display shall be annunciated to the pilot upon activation of the escape guidance during a wind shear encounter, and upon reversion to a different flight guidance mode.

(2) Malfunction/failure indications

The equipment shall indicate:

- (i) any inadequacy or absence of primary power;
- (ii) equipment failures;
- (iii) inadequate or invalid warning or guidance displays or output signals; and
- (iv) inadequate or invalid sensor signals or sources.

These malfunction/failure indications shall occur independently of any operator actions. The lack of adequate warning displays, escape guidance information, or sensor signals or sources shall be annunciated when compliance with the requirements of this ETSO cannot be assured.

(3) Wind shear caution alert

If the equipment includes a wind shear caution:

- (i) it shall provide an annunciation of increasing performance shear (updraft, increasing headwind, or decreasing tailwind) in accordance with the shear intensity curve shown in Figure 1;
- (ii) this caution alert shall display or provide an appropriate output for display of an amber caution annunciation dedicated for this purpose. An aural alert may be provided as an option. The caution display (or output) should remain until the threshold wind shear condition no longer exists (not less than 3 seconds) or a wind shear warning alert occurs; and
- (iii) gust conditions shall not cause a nuisance caution alert. Turbulence shall not cause more than one nuisance caution alert per 250 hours (or 3 000 flight cycles based on 1 hour/flight cycle) of system operation.

(4) Wind shear warning alert

- (i) A wind shear warning alert shall provide an annunciation of decreasing performance shear (downdraft, decreasing headwind, or increasing tailwind) with a magnitude that is greater than or equal to that shown in the shear intensity curve shown in Figure 1.
- (ii) This warning alert shall display or provide an appropriate output for display of a red warning annunciation labelled 'wind shear' dedicated for this purpose. The visual alert should remain at least until the threshold wind shear condition no longer exists, or for a minimum of 3 seconds, whichever is greater. An aural alert shall be provided that annunciates 'wind shear' for 3 aural cycles. The aural alert need not be repeated for subsequent wind shear warning alerts within the same mode of operation.
- (iii) Gust conditions shall not cause a nuisance warning alert. Turbulence shall not cause more than 1 nuisance warning alert per 250 hours (or 3 000 flight cycles based on 1 hour/flight cycle) of system operation.

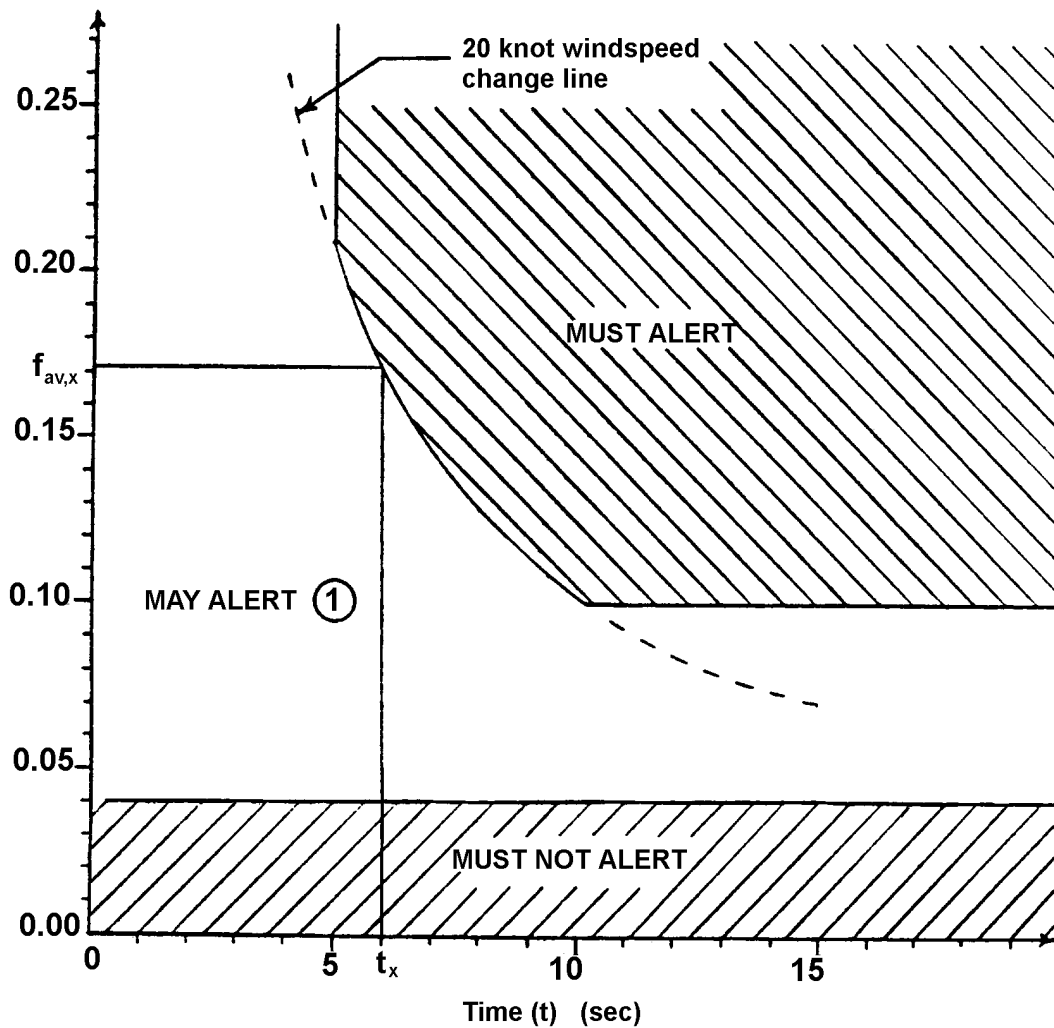
- (5) Wind shear alert with increased approach sensitivity and reduced take-off sensitivity modes
- (i) Increased approach sensitivity mode. If the system separates the approach and take-off scenarios, the crew may reduce the shear intensity level in the approach mode to increase the probability of providing timely wind shear alerts. They may lower the floor of the shear intensity curve 'must alert' curve in Figure 1 from 0.105 to 0.090. If they lower the floor, they may also modify the turbulence rejection tests in paragraph 4(d)(7)(ii) such that an alert in this region is not a failure of the turbulence rejection test.
 - (ii) Reduced take-off sensitivity mode. If the system separates the approach and take-off scenarios, the crew may desensitise the take-off mode to reduce the probability of unwanted alerts. They may raise the floor of the shear intensity 'must alert' curve in Figure 1 from 0.105 to 0.120.
 - (iii) Additional reduced take-off sensitivity mode. Some high performance jet aeroplanes receive unwanted wind shear alerts after take-off when climbing at high rates through atmospheric wind gradients. If these unwanted alerts risk desensitising pilots to wind shear alerting, the crew may tailor the floor of the shear intensity 'must alert' curve in Figure 1 to reduce these unwanted alerts under the following conditions:
 - (a) The airborne wind shear warning and escape guidance system can determine that the aeroplane is in the take-off versus approach phase.
 - (b) The aeroplane is climbing at a high rate of climb, the aeroplane continues to climb at a high rate, and the rate of climb is known to create unwanted wind shear alerts.
 - (c) The aeroplane power setting is at or near a level that is representative of the maximum for the segment of the take-off; for example, maximum take-off thrust.
 - (d) The Figure 1 shear intensity 'must alert' curve shall be complied with after take-off.
- (6) Alerting prioritisation
- If alerting is prioritised in the presentation for a wind shear warning and escape guidance system (reactive wind shear), forward-looking wind shear system, terrain awareness and warning system, ground proximity warning system, traffic collision avoidance system, or when a simultaneous aural annunciation could occur, sequencing shall be implemented that ensures that reactive wind shear warning alerts are presented or annunciated first. Reactive wind shear alerts that are cautions have a lower priority than all terrain awareness and warning or ground proximity warning system alerts.
- (7) The reactive wind shear systems caution alert should be disabled if a forward looking wind shear system is in operation. It is acceptable to issue reactive wind shear caution alerts if the forward-looking wind shear system is inoperative.
- (8) Operating altitude range
- The system shall be designed to function from at least 50 feet above ground level (AGL) to at least 1 000 feet AGL.

(9) Wind shear escape guidance

Flight guidance algorithms shall incorporate the following design considerations:

- (i) At the point of the system warning threshold, the available energy of the aeroplane shall be properly managed through a representative number of wind field conditions. These conditions shall take into account significant shear components in both the horizontal and vertical axes, individually and in combination.
- (ii) The flight path guidance commands shall be suitable for the dynamic response of aeroplane of the type on which the system is intended for installation. The applicant shall demonstrate that the flight guidance commands during a dynamic wind shear encounter can be followed without resulting in pilot induced oscillations.
- (iii) If the magnitude of the shear components is such as to overcome the performance capability of the aeroplane, guidance commands shall be such that a ground impact will occur in the absence of the ability to produce additional lift, an absence of excessive kinetic energy, and without putting the aeroplane into a stalled condition.
- (iv) Flight guidance command information shall be provided for presentation on the primary flight display/attitude direction indicator (PFD/ADI) and any available head-up display (HUD).
- (v) Flight guidance displays which command the flight path and pitch attitude should be limited to an angle of attack that is equivalent to the onset of a stall warning or a maximum pitch command of 27°, whichever is less.
- (vi) Flight guidance commands and any auto recovery mode (if included) may be automatically activated concurrently with or after the wind shear warning alert occurs, or may be manually selected. If manual selection is utilised, it shall only be via the take-off/go-around (TOGA) switch or equivalent means (i.e. a function of the throttle position, other engine parameters, etc.).
- (vii) Manual deselection of wind shear flight guidance and any auto recovery mode (if included) shall be possible by means other than the TOGA switches.
- (viii) Systems that incorporate the automatic reversion of flight guidance commands from wind shear escape guidance to another flight guidance mode should provide a smooth transition between the modes. Flight guidance commands shall not be removed from the flight guidance display until either they are manually deselected or until the aeroplane, following the end of the warning conditions, has maintained a positive rate of climb and speed above 1.3 Vs1 for at least 30 seconds.

FIGURE 1 — SHEAR INTENSITY CURVE



$f_{av,x}$ = average shear intensity to cause a warning at time t_x (resulting in a 20-knot wind speed change, bounded as shown; applies to horizontal, vertical, and combination shear intensities),

$$= \frac{\int_0^{t_x} f(t) dt}{t_x},$$

whereby $f(t)$ = instantaneous shear intensity at time t .

- ① A nuisance warning test that utilises the Dryden turbulence model and discrete gust model is conducted independently from the alert threshold tests to verify the acceptability of potential nuisance warnings due to turbulence or gusts.

- c. Equipment performance — environmental conditions
- (1) The environmental tests and performance requirements described in this subsection are intended to provide a laboratory means to determine the overall performance characteristics of the equipment under conditions that are representative of those that may be encountered in actual operations. Table 1 defines the environmental tests that are required for the equipment. It shows the section numbers in ED-14G that describe the individual environmental tests. Some of the environmental tests contained in this subsection do not need to be performed unless the manufacturer wishes to qualify the equipment for that particular environmental condition. These tests are identified by the phrase ‘When required’ in Table 1. If the manufacturer wishes to qualify the equipment to these additional environmental conditions, then these ‘When required’ tests shall be performed.
 - (2) Environmental requirements. The following subset of performance requirements shall be met under the environmental conditions required by paragraph 3.1.2 of this ETSO. Additionally, all the system controls, displays, inputs and outputs shall perform their intended functions when subjected to the ED-14G environmental conditions.
 - (i) Section 4.b(1) — Mode Annunciation
 - (ii) Section 4.b(2) — Malfunction/Failure Indications
 - (iii) Section 4.b(3) — Wind Shear Caution Alert, except paragraph 4.b(3)(iii)
 - (iv) Section 4.b(4) — Wind Shear Warning Alert, except paragraph 4.b(4)(iii)
 - (v) Section 4.b(5) — Wind Shear Alert with Increased Approach Sensitivity and Reduced Take-off Sensitivity Modes
 - (vi) Section 4.b(9) — Wind Shear Escape Guidance
 - (3) The applicant shall conduct environmental qualification tests for the following shear intensity ($f_{av,x}$) and exposure time (s) in Figure 1: 0.1050, 10; 0.1748, 6; and 0.2100, 5; and ensure that the system generates and displays alerts when required. A single representative wind shear waveform may be used for all the environmental tests if the system design is such that different waveforms will not affect the performance under environmental conditions. Gust and turbulence rejection tests are not required under environmental conditions.

Table 1 — Required EUROCAE ED-14G Testing by Category

Environmental Test	ED-14G Section	Required Test
Temperature and Altitude	4	
Ground Survival Low Temperature and Short-Time Operating Low Temperature		√
Low Operating Temperature		√
Ground Survival High Temperature and Short-Time Operating High Temperature		√
High Operating Temperature		√
In-Flight Loss of Cooling		When required
Altitude		√
Decompression		When required
Overpressure		When required
Temperature Variation	5	√
Humidity	6	√
Operational Shocks and Crash Safety	7	
Operational Shocks		√
Crash Safety		√
Vibration	8	√
Explosion Proofness	9	When required
Waterproofness	10	
Condensing Water Proof		When required
Drip Proof		When required
Spray Proof		When required
Continuous Stream Proof		When required
Fluids Susceptibility	11	
Spray		When required
Immersion		When required
Sand and Dust	12	When required
Fungus Resistance	13	When required
Salt Spray	14	When required
Magnetic Effect	15	√
Power Input	16	

Normal Operating Conditions (AC/DC)		√
Abnormal Operating Conditions (AC/DC)		√
Load Equipment Influence on Aeroplane Electrical Power System (AC/DC)		When required
Voltage spike	17	
Category A Requirements (If applicable)		√
Category B Requirements (If applicable)		√
Audio frequency conducted susceptibility	18	√
Induced Signal Susceptibility	19	√
RF Susceptibility	20	√
Emission of RF Energy	21	√
Lightning-induced Transient Susceptibility	22	√
Lightning Direct Effects	23	When required
Icing	24	When required
Electrostatic Discharge	25	When required
Fire, Flammability	26	√

d. Equipment test procedures

- (1) Definitions of terms and conditions of tests. The following definitions of terms and conditions of tests are applicable to the equipment tests specified herein:
 - (i) Power input voltage. Unless otherwise specified, all the tests shall be conducted with the power input voltage adjusted to the design voltage ± 2 per cent. The input voltage shall be measured at the input terminals of the equipment under test.
 - (ii) Power input frequency
 - (a) In the case of equipment that is designed for operation from an AC power source of essentially constant frequency (e.g. 400 Hz), the input frequency shall be adjusted to the design frequency ± 2 per cent.
 - (b) In the case of equipment designed for operation from an AC power source of variable frequency (e.g. 300 to 1 000 Hz), unless otherwise specified, the test shall be conducted with the input frequency adjusted to within 5 % of a selected frequency and within the range for which the equipment is designed.
 - (iii) Wind field models. Unless otherwise specified, the wind field models used for the tests shall be those specified in Appendix 2 to ETSO-C117b.
 - (iv) Adjustment of equipment. The circuits of the equipment under test shall be aligned and adjusted in accordance with the manufacturer's recommended practices prior to the application of the specified tests.

- (v) Test instrument precautions. Due precautions shall be taken during the execution of the tests to prevent the introduction of errors that result from the connection of voltmeters, oscilloscopes, and other test instruments across the input and output impedances of the equipment under test.
 - (vi) Ambient conditions. Unless otherwise specified, all the tests shall be made within the following ambient conditions:
 - Temperature: + 15 to + 35 °C (+ 59 to + 95 °F)
 - Relative humidity: Not greater than 85 %
 - Ambient pressure: 84–107 kPa (equivalent to + 5 000 to – 1 500 ft) (+ 1 525 to – 460 m)
 - (vii) Warm-up period. Unless otherwise specified, all the tests shall be conducted after the manufacturer's specified warm-up period.
 - (viii) Connected loads. Unless otherwise specified, all the tests shall be performed with the equipment connected to loads which have the impedance values for which it is designed.
- (2) Test procedures. The equipment shall be tested in all the modes of operation that allow different combinations of sensor inputs to show that it meets both the functional and accuracy criteria.

Dynamic testing provides quantitative data regarding the performance of wind shear warning and escape guidance equipment using a simplified simulation of flight conditions. This testing, when properly performed and documented, may serve to minimise the flight test requirements.

It shall be the responsibility of the equipment manufacturer to determine that the sensor inputs, when presented to the wind shear warning and escape guidance equipment, will produce performance that is commensurate with the requirements of this standard. Additional sensor inputs may be optionally provided to enhance the capability and/or performance of the equipment.

The equipment required to perform these tests shall be defined by the equipment manufacturer as a function of the specific sensor configuration of the equipment. Since these tests may be accomplished in more than one way, alternative test equipment set ups may be used where equivalent test functions can be accomplished. Combinations of tests may be used wherever appropriate.

The signal sources of the test equipment shall provide the appropriate signal formats for input to the specific system under test without contributing to the error values that are being measured. Tests need only be performed once, unless it is otherwise indicated.

The scenarios that are established for testing wind shear warning and escape guidance systems represent realistic operating environments to properly evaluate such systems. The wind field models contained in Appendix 2 to ETSO C117b should be used to evaluate the performance of the wind shear warning and escape guidance systems. The manufacturer may propose different wind field models provided that it is shown that they represent conditions that are at least as severe as those contained in this ETSO.

Note: The test waveform parameters provided in this ETSO are sufficiently broad to cover the wind field parameters that were observed in the known accident cases. However, the manufacturer is encouraged to verify that the detection systems will actually detect these wind shears by subjecting them to the wind field conditions specified for use in evaluating guidance commands.

- (3) Test set-up. Simulator tests shall be used to demonstrate the performance capability of the wind shear warning and escape guidance equipment. A suitable equipment interface shall be provided for recording the relevant parameters that are necessary to evaluate the particular system under test. The aeroplane simulator shall be capable of appropriate dynamic modelling of a representative aeroplane and of the wind field and turbulence conditions contained in Appendices 2 and 3 to this ETSO, or other wind field/turbulence models that are found to be acceptable by the administrator.

Note: This section requires testing in a single representative aeroplane simulator. Approval of the installation will require system testing in an aeroplane simulator that is representative of the aeroplane. Thus, we recommend you to accomplish the paragraph 4(d)(3) simulator testing in as many representative simulators as are necessary to cover all the intended installations.

- (4) Functional performance (paragraphs 4(b)(1) through 4(b)(5), 4(b)(8) and 4(b)(9)). Each of the functional capabilities identified in paragraphs 4(b)(1) through 4(b)(5), 4(b)(7) and 4(b)(8) shall be demonstrated with the wind shear warning and escape guidance equipment powered. These capabilities shall be evaluated either by inspection or in conjunction with the tests described in paragraphs 4(d)(5) through 4(d)(10).
- (5) Mode annunciation (paragraph 4(b)(1)). With the equipment operating, verify that the wind shear escape guidance display mode of operation is annunciated to the pilot upon activation of the escape guidance and upon reversion to a different flight guidance mode.
- (6) Malfunction/failure indications (paragraph 4(b)(2)). Configure the equipment for simulation tests as defined in paragraph 4(d)(3).
 - (i) With the system active (within the operating altitude range) and inactive (outside the operating altitude range), remove one at a time each required electrical power input to the equipment. There shall be a failure indication by the equipment of each simulated failure condition.
 - (ii) With the system active (within the operating altitude range) and inactive (outside the operating altitude range), cause each sensor or other signal input to become inadequate or invalid. There shall be a failure indication by the equipment of each simulated failure condition.
- (7) Wind shear caution alert (paragraphs 4(b)(3) and 4(b)(5)(i)). For equipment that incorporates a wind shear caution alert function, accomplish the following tests:
 - (i) Configure the equipment for a simulation test as defined in paragraph 4(d)(3). Subject the equipment to acceleration waveform values that meet the following conditions (reference Figure 2). The system shall generate an appropriate caution alert (or no alert) within the time intervals specified when subjected to the following average shear intensity ($f_{av,x}$) values:

$f_{av,x}$ (1)	Time of Exposure (t) (s)	Alert within (s) (3)
0.0200	20	no alert
0.0400	20	no alert
0.1050	10	10
0.1166	9	9
0.1311	8	8
0.1499	7	7
0.1748	6	6.2
0.2100	5	5.7
0.2700 (2)	5	5

Notes:

- (1) The average shear intensity which shall result in a caution alert after a time t_x or less meets the definition of $f_{av,x}$ in Figure 1. The maximum instantaneous shear intensity of the test waveform is restricted to 0.075 or 100 % of $f_{av,x}$ above the average shear value $f_{av,x}$, whichever is less. The minimum instantaneous shear intensity of the test waveform is zero. The test waveform rise and fall rates shall be limited to a maximum of 0.1 per second. The shear intensity before time 0 is zero for a sufficiently long time to allow the system to settle to stable conditions.
- (2) In order to achieve the test condition with the shear intensity $f_{av,x}$ equal to or greater than 0.270, it is necessary to have an initial rise of sufficient rate to achieve a shear intensity f value that will allow subsequent rise and fall rates that are limited to 0.1 per second to achieve the required $f_{av,x}$ value.
- (3) Account for latency due to the alert calculation and alert annunciation display functionality when measuring the alert time

The test conditions specified above shall be repeated 5 times for each axis (horizontal and vertical). A total of 90 runs are required for verification of the detection (9 conditions $\times$ 5 for each axis) for both performance increasing and performance decreasing wind shears. A different waveform for $f_{av,x}$ will be utilised for each of the 5 runs. An appropriate alert (or no alert) shall be generated for each test condition.

Verify that the system displays or provides an appropriate output for display of an amber caution annunciation that is dedicated for this purpose. Verify that the visual caution display (or output) remains at least until the threshold wind shear condition no longer exists, or a minimum of 3 seconds (whichever is greater), or until a wind shear warning occurs.

- (ii) Subject the equipment to wind speeds that are defined by the Dryden turbulence model contained in Appendix 4 to ETSO C117b. The system shall be exposed to these conditions for a minimum of 50 hours (or 600 flight cycles) at each altitude specified in Appendix 4 to ETSO C117b for a minimum total test duration of 250 hours (or 3 000 flight cycles based on 1 hour/flight cycle).

No more than 1 nuisance caution shall be generated during this test.

An alternative test equipment set-up may be used to accomplish the equivalent test function for the turbulence testing. A combination of analysis, simulation and testing may be used to demonstrate the performance of the equipment.

- (iii) Subject the equipment to the wind speeds that are defined by the discrete gust rejection model contained in Appendix 4 to ETSO C-117b. No alert shall be generated as a result of this test.

- (8) Wind shear warning alert (paragraphs 4(b)(4) and 4(b)(5)(ii)).

- (i) Configure the equipment for simulation tests as defined in paragraph 4(d)(3). Subject the equipment to acceleration waveform values that meet the following conditions (reference Figure 2). The system shall generate an appropriate warning alert (or no alert) within the time intervals that are specified when it is subjected to the following average shear intensity ($f_{av,x}$) values:

$f_{av,x}$ (1)	Time of Exposure (t) (s)	Alert within (s) (3)
0.0200	20	no alert
0.0400	20	no alert
0.1050	10	10
0.1166	9	9
0.1311	8	8
0.1499	7	7
0.1748	6	6.6
0.2100	5	6.2
0.2700 (2)	5	5.7

Notes:

- (1) The average shear intensity which shall result in a warning alert after a time t_x or less meets the definition of $f_{av,x}$ in Figure 1. The maximum instantaneous shear intensity of the test waveform is restricted to 0.075 or 100 % of $f_{av,x}$ above the average shear value $f_{av,x}$, whichever is less. The minimum instantaneous shear intensity of the test waveform is zero. The test waveform rise and fall rates shall be limited to a maximum of 0.1 per second. The shear intensity before time 0 is zero for a sufficiently long time to allow the system to settle to stable conditions.
- (2) In order to achieve the test condition with the shear intensity $f_{av,x}$ equal to or greater than 0.270, it is necessary to have an initial rise of a sufficient rate to achieve a shear intensity f value that will allow the subsequent rise and fall rates that are limited to 0.1 per second to achieve the required $f_{av,x}$ value.
- (3) Account for any latency due to the alert calculation and alert annunciation display functionality when measuring the alert time.

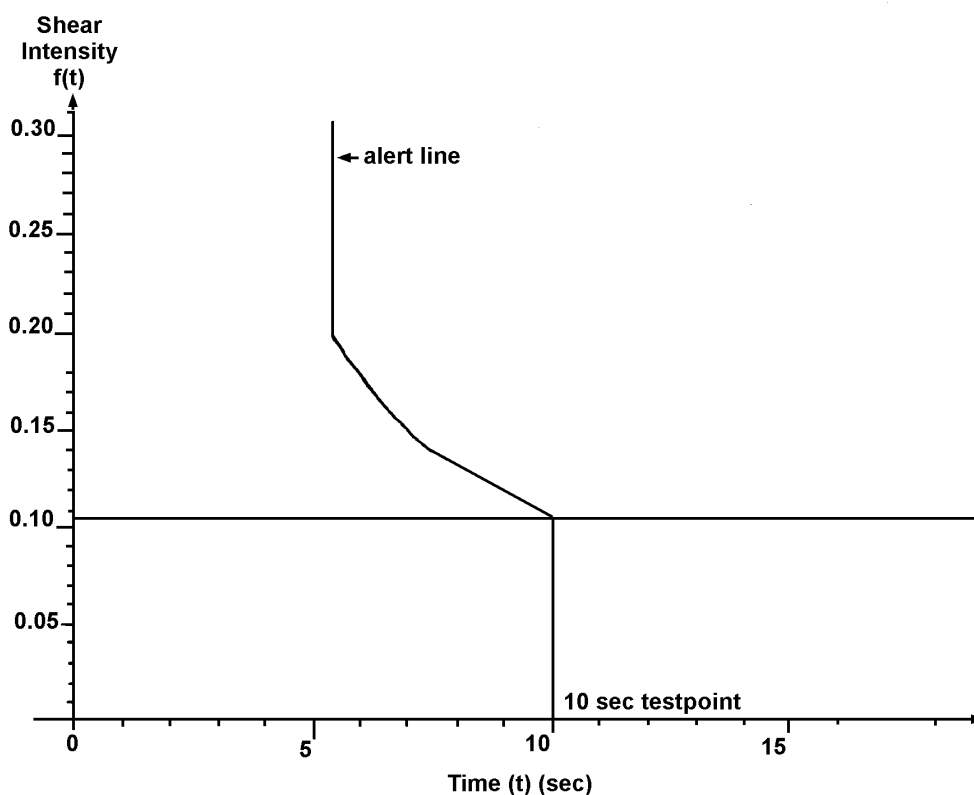
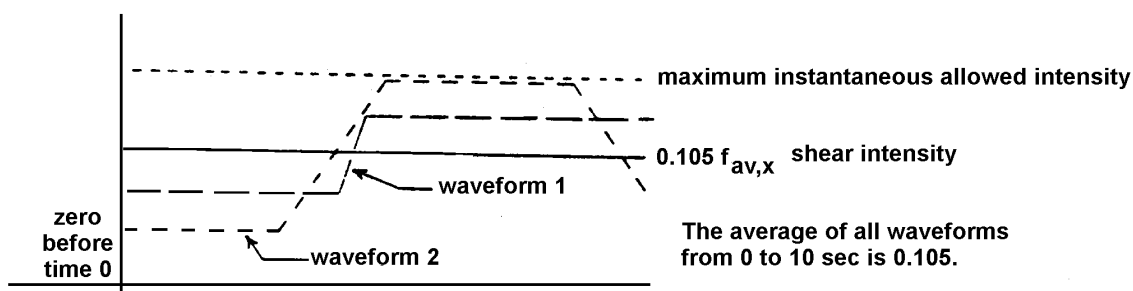
The test conditions specified above shall be repeated 5 times for each axis (horizontal and vertical). A total of 90 runs are required for verification of the detection (9 conditions $\times$ 5 for each axis) for both performance increasing and performance decreasing wind shears. A different waveform for $f_{av,x}$ will be utilised for each of the 5 runs. An appropriate alert (or no alert) shall be generated for each test condition.

Verify that the system displays or provides an appropriate output for display of a red warning annunciation labelled 'wind shear' that is dedicated for this purpose. Verify that the visual warning display (or output) remains until the threshold wind shear condition no longer exists, or a minimum of 3 seconds, whichever is greater. Verify that an aural alert is provided that annunciates 'wind shear' for 3 aural cycles.

- (ii) Subject the equipment to the wind speeds that are defined by the Dryden turbulence model contained in Appendix 4 to ETSO C117b. The system shall be exposed to these conditions for a minimum of 50 hours (or 600 flight cycles) at each altitude specified in Appendix 4 to ETSO C117b for a minimum total test duration of 250 hours (or 3 000 flight cycles based on 1 hour/flight cycle). No more than 1 nuisance warning shall be generated during this test.

An alternative test equipment set-up may be used to accomplish the equivalent test function for the turbulence testing. A combination of analysis, simulation, and testing may be used to demonstrate the performance of the equipment specified in this paragraph 4(d)(8)(ii).

- (iii) Subject the equipment to the wind speeds that are defined by the discrete gust rejection model contained in Appendix 4 to ETSO-C117b. No alerts shall be generated as a result of this test.

FIGURE 2 — WIND SHEAR ALERT TEST

Sample waveforms for 10 sec test point


- (9) Operating altitude range (paragraph 4.b(8)). Configure the equipment for the simulation tests as defined in paragraph 4(d)(3). Simulate a take-off to an altitude of at least 1 500 feet AGL. Verify the wind shear warning and escape guidance system is operational from at least 50 feet AGL to at least 1 000 feet AGL. Simulate an approach to landing from 1 500 feet AGL to touchdown. Verify the wind shear warning and escape guidance system is operational from at least 1 000 feet AGL to at least 50 feet AGL.

- (10) Wind shear escape guidance (paragraph 4.b(9)). Configure the equipment for simulation tests as defined in paragraph 4(d)(3). Subject the equipment to each of the wind field conditions contained in Appendix 2 to ETSO C117b for each operating mode (take-off, approach, landing, etc.) that is available. Each test condition shall be repeated 5 times. Recovery actions for the fixed pitch method comparison shall be initiated immediately upon entering the shear condition.

Notes:

- (1) Evaluate wind shear escape guidance commands using a simulation that incorporates the necessary dynamic modelling of the representative aeroplane (more than 1 representative aeroplane model may be necessary) in which installation of the equipment is intended. Dynamic modelling of the representative aeroplane should include consideration of all the relevant effects, including but not limited to pitch and roll rates, control authority, delays between control inputs and aeroplane responses, display system leads and lags, etc.
 - (2) The simulator should provide for a pilot in the loop evaluation of guidance flyability during simulated wind shear encounters. The guidance command gains should be consistent with those incorporated in the flight guidance system. While ‘fine-tuning’ of the guidance commands to obtain the optimum performance for a specific aeroplane may be accomplished, the use of unique tailoring for a specific aeroplane may not be necessary. Evaluation through means of a suitable engineering simulation may be acceptable to demonstrate the suitability of the guidance commands for a representative aeroplane. However, the equipment manufacturer should demonstrate that the flight guidance commands during a dynamic wind shear encounter can be followed without resulting in pilot-induced oscillations.
- (i) Verify that the flight path guidance commands manage the available energy of the aeroplane to achieve the desired trajectory through the shear encounter. These tests shall be performed with vertical only, horizontal only, and a combination of vertical and horizontal shear conditions. You may reduce the number of times you repeat each of these tests conditions to less than 5. To reduce the number of repetitions to less than 5, you shall have gathered sufficient data to demonstrate that the flight path guidance commands meet these requirements. You should also include aeroplane weight and centre of gravity variations if applicable.

- a. For the take-off case, verify that the flight guidance commands produce a trajectory that provides a resultant flight path that is at least as good (when considered over the entire spectrum of test cases) as that obtained by establishing a 15° pitch attitude (at an approximate rate of 1.5° per second) until the onset of a stall warning, and then reducing the pitch attitude to remain at the onset of a stall warning until the shear condition is exited. Evidence of a significant decrement (considered over the entire spectrum of test cases) below the flight path that is provided by the fixed pitch method that results from the use of the guidance commands provided by the system shall be adequately substantiated.
- b. For the approach/landing case, verify that the flight guidance commands produce a trajectory that provides a resultant flight path that is at least as good (when considered over the entire spectrum of test cases) as that obtained by establishing the maximum available thrust and a 15° pitch attitude (at an approximate rate of 1.5° per second) until the onset of stall warning, and then reducing the pitch attitude to remain at the onset of stall warning until the shear condition is exited. Evidence of a significant decrement (considered over the entire spectrum of test cases) below the flight path that is provided by the fixed pitch method that results from the use of the guidance commands that are provided by the system shall be adequately substantiated.
- c. For shear conditions that exceed the available performance capability of the aeroplane, verify that the flight guidance commands result in a ground impact in the absence of the ability to produce additional lift, an absence of excessive kinetic energy, and without putting the aeroplane into a stalled condition.

Note: There is no requirement to perform the tests described in paragraphs 4(d)(10)(ii) through (vii) with horizontal only, vertical only, and a combination of vertical and horizontal shear conditions. You may perform the tests described in paragraphs 4(d)(10)(ii) through (vii) with only the combination vertical and horizontal shear conditions.

- (ii) Verify that the flight guidance command outputs are capable of display on the associated flight displays. The interface specifications shall be verified and determined to be appropriate for the systems that are identified in the equipment installation instructions.
- (iii) Verify that the pitch attitude commands do not result in an angle of attack that exceeds the onset of a stall warning or a maximum pitch command of 27°, whichever is less.

- (iv) For systems that incorporate manual activation of recovery flight guidance commands, verify that the system is activated only by the TOGA switches (or equivalent means). For systems that provide automatic activation of recovery guidance, verify that the system is activated concurrently with the wind shear warning alert.
- (v) Verify that the wind shear recovery guidance commands and any automatic recovery mode can be deselected by a means other than the TOGA switches.
- (vi) For systems that incorporate automatic reversion of flight guidance commands from wind shear escape guidance to another flight guidance mode, verify that the transition between the flight guidance modes provides smooth guidance information.
- (vii) Verify that flight guidance commands are not removed from the flight guidance display until either they are manually deselected or until the aeroplane, following the exit of the warning conditions, has maintained a positive rate of climb and speed above 1.3 Vs1 for at least 30 seconds.

[Amdt ETSO/16]

APPENDIX 2 TO ETSO-C117B – WIND FIELD MODELS AND DATA

ED Decision 2020/011/R

This Appendix contains data that defines the wind field models to be used in conducting the tests specified in paragraph 4(d)(10) of this ETSO. This material was developed by the National Aeronautics And Space Administration (NASA), reference NASA Technical Memorandum 100632 [ref. 1].

The downburst model parameters below provide the variables to be used to obtain the representative test conditions: (1) and (2)

Radius of Downdraft (ft)	Maximum Outflow (ft/s)	Altitude of Max. Outflow (ft)	Distance from Starting Point (3) (ft)
920	37	98	20000 (-9000)
1180	47.6	98	15000 (-14000)
2070	58.4	131	25000 (-4000)
4430	68.9	164	30000 (1000)
9010	72.2	262	30000 (1000)
3450	88.2	197	25000 (-4000)
3180	53.1	262	30000 (1000)
1640	46	164	25000 (-4000)
5250	81.3	197	30000 (1000)
1250	67.6	100	25000 (-4000)

- (1) From analytic microburst model documented in NASA TM-100632. These parameters are based on data from Proctor's Terminal Area Simulation System (TASS) model.
- (2) For the takeoff case, the downburst centre is positioned at the point the aeroplane lifts off the runway for all test cases.
- (3) For the approach/landing case, the downburst centre is positioned as stated. The test is begun with the aeroplane at an initial altitude of 1 500 feet on a 3° glideslope (touchdown point approximately 29 000 feet away). The distance from the starting point indicates where the centre of the downburst shaft is located relative to the starting point. The number in parentheses next to it indicates the relative distance of the microburst centre from the touchdown point (not the end of the runway). A negative number indicates that the microburst centre is located before the touchdown point, positive indicates it is past the touchdown point.

SUMMARY

A simple downburst model has been developed for use in batch and real-time piloted simulation studies of guidance strategies for terminal area transport aeroplane operations in wind shear conditions. The model represents an axisymmetric stagnation point flow, based on velocity profiles from the Terminal Area Simulation System (TASS) model developed by Proctor [ref. 3,4] and satisfies the mass continuity equation in cylindrical coordinates. Altitude dependence, including boundary layer effects near the ground, closely matches real-world measurements, as do the increase, peak, and decay of outflow and downflow with increasing distance from the downburst centre. Equations for horizontal and vertical winds were derived, and found to be infinitely differentiable, with no singular points existent in the flow field. In addition, a simple relationship exists among the ratio of maximum horizontal to vertical velocities, the downdraft radius, depth of outflow, and altitude of maximum outflow. In use, a microburst can be modelled by specifying four characteristic parameters. Velocity components in the x, y, and z directions, and the corresponding nine partial derivatives are obtained easily from the velocity equations.

INTRODUCTION

Terminal area operation of transport aircraft in a wind shear environment has been recognised as a serious problem. Studies of aeroplanes trajectories through downbursts show that specific guidance strategies are needed for aeroplanes to survive inadvertent downburst encounters. In order for guidance strategies to perform in simulations as in actual encounters, a realistic set of conditions must be present during development of the strategies. Thus, aeroplane and wind models that closely simulate real-world conditions are essential in obtaining useful information from the studies.

Wind models for use on personal computers, or for simulators with limited memory space availability, have been difficult to obtain because variability of downburst characteristics makes analytical models unrealistic, and large memory requirements make the use of numerical models impossible on any except very large capacity computers.

Bray [ref. 2] developed a method for analytic modelling of wind shear conditions in flight simulators, and applied his method in modelling a multiple downburst scenario from Joint Airport Weather Studies (JAWS) data. However, the altitude dependence of his model is not consistent with observed data and, although flexibility in sizing the downbursts is built into the model, it does not maintain the physical relationships which are seen in real-world data among the sizing parameters. In particular, boundary layer effects should cause the radial velocity to decay vertically to zero at the ground, as does the vertical velocity.

In a study conducted at NASA Langley Research Center, three different guidance strategies for a Boeing 737-100 aeroplane encountering a microburst on take-off were developed [ref. 3-4]. These strategies were first developed using a personal computer, and then implemented in a pilot-in-the-loop simulation using a very simple wind model in both efforts. The wind velocities used are depicted in Figure 1. This model consisted of a constant outflow outside of the downburst radius and a constant slope headwind to tailwind shear across the diameter of the downburst.

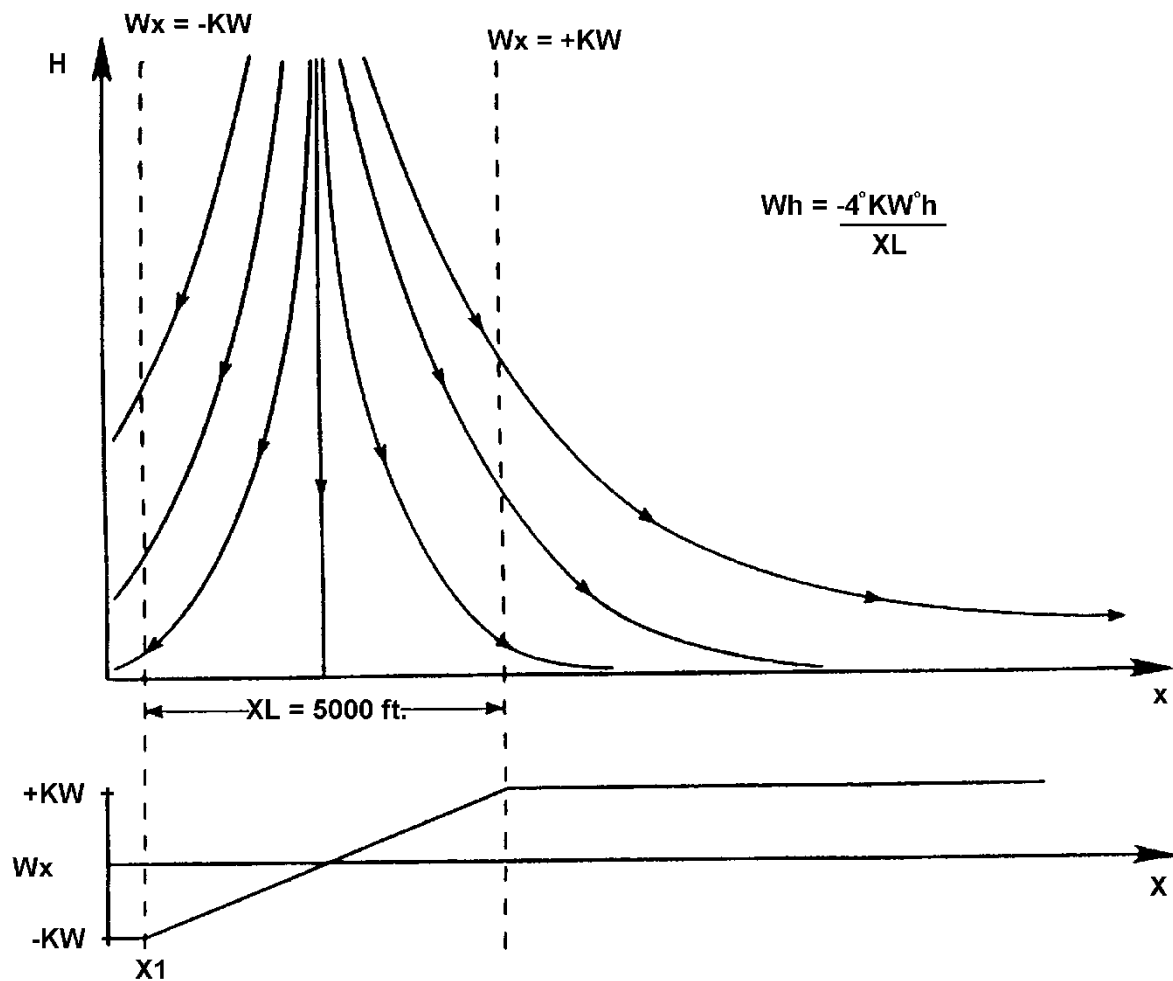


Figure 1 — Wind Model Used in Guidance Studies

It was recognised that a more realistic wind model could significantly alter the outcome of the trajectory. For the subsequent part of this study, which involves altering the aeroplane model to simulate approach to landing and escape manoeuvres and additional take-off cases, a more realistic wind model was preferred. The simple analytical model outlined in this report was developed for this purpose.

SYMBOLS

JAWS	Joint Airport Weather Studies
NIMROD	Northern Illinois Meteorological Research on Downbursts
R	radius of downburst shaft (ft)
r	radial coordinate (distance from downburst centre) (ft)
TASS	Terminal Area Simulation System
u	velocity in r-direction (or x-direction) (knots)
v	velocity in y-direction (knots)
w	velocity in z-direction (knots)
$w_{\max}$	magnitude of maximum vertical velocity (knots)
$u_{\max}$	magnitude of maximum horizontal velocity (knots)
x	horizontal (runway) distance, aeroplane to downburst centre (ft)
y	horizontal (side) distance, aeroplane to downburst centre (ft)
z	aeroplane altitude above ground level (ft)
z_h	depth of outflow (ft)
z_m	height of maximum U-velocity (ft)
z_{m2}	height of half-maximum U-velocity (ft)
z^*	characteristic height, out of boundary layer (ft)
e	characteristic height, in boundary layer (ft)
λ	scaling factor (s-1)

DEVELOPMENT OF VELOCITY EQUATIONS

Beginning with the full set of Euler and mass continuity equations, some simplifying assumptions about the downburst flow conditions were made. Effects of viscosity were parameterised explicitly, and the flow was assumed to be invariant with time. The downburst is axisymmetric in cylindrical coordinates, and characterized by a stagnation point at the ground along the axis of the downflow column. The flow is incompressible, with no external forces or moments acting on it.

The resulting mass conservation equation is

$$\nabla \cdot v = 0. \quad (1)$$

Written out in full, equation 2 is

$$\frac{\partial u}{\partial r} + \frac{\partial w}{\partial z} + \frac{u}{r} = 0. \quad (2)$$

This equation is satisfied by solutions of the form

$$w = g(r^2)q(z) \quad (3a)$$

$$u = \frac{f(r^2)}{r}p(z) \quad (3b)$$

provided that

$$f'(r^2) = \frac{\lambda}{2}g(r^2) \quad (4a)$$

$$q'(z) = \lambda p(z). \quad (4b)$$

Note that $f'(r^2) = \frac{\partial f(r^2)}{\partial r^2}$. To solve this system of equations, solutions were assumed for two of the functions and the other two were obtained from equations 4a and 4b.

It was desired that the velocity profiles of this analytic model exhibit the altitude and radial dependence shown in the large-scale numerical TASS (Terminal Area Simulation System) weather model [ref. 6-9]. The TASS model is based on data from the Joint Airport Weather Studies (JAWS) [ref. 10], and provides a three-dimensional velocity field, frozen in time, for given locations of an aeroplane within the shear [ref. 11-12].

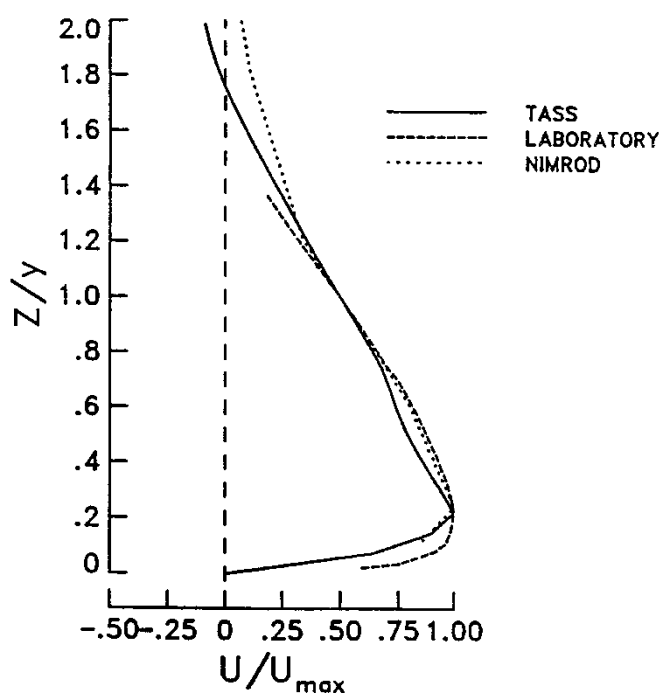


Figure 2 — Vertical Profile of Microburst Outflow (Non-dimensional)

Figure 2 shows dimensionless vertical profiles of horizontal velocity, u , for TASS data, laboratory data obtained by impingement of a jet on a flat plate, and data from NIMROD (Northern Illinois Meteorological Research on Downbursts) [ref. 13-21]. Specific points of interest are the maximum horizontal velocity (located 100-200 metres above the ground), below which is a decay region due to boundary layer effects, zero velocity at the stagnation point on the ground, and an exponential decay with altitude above the maximum velocity altitude. Vertical velocity profiles from TASS data are shown in Figure 3, also exhibiting a decay to zero at the stagnation point.

VERTICAL PROFILES OF VERTICAL VELOCITY FOR 30 JUN 82 CASE:
SENSITIVITY TO RADIUS OF PRECIPITATION SHAFT

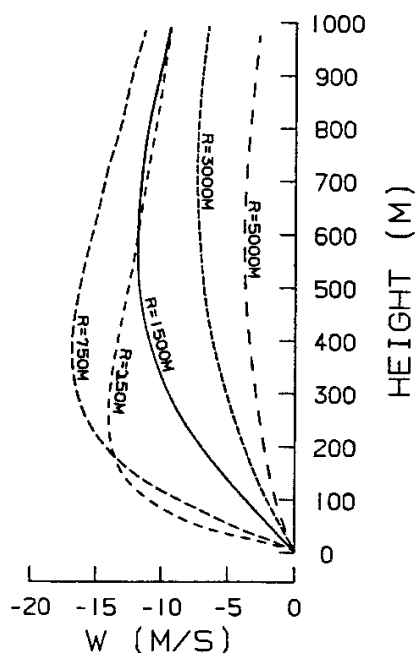


Figure 3 — Vertical Profile of Microburst Downflow

The radially varying characteristics desired for the horizontal wind were two peaks of equal magnitude and opposite direction located at a given radius, with a smooth, nearly linear transition between the two. Beyond the peaks, the velocity should show an exponential decay to zero. The vertical velocity was required to have a peak along the axis of symmetry ($r = 0$), and to decay exponentially as the radius increases.

A pair of shaping functions that gave velocity profiles matching the TASS data as required are given below.

$$g(r^2) = e^{-(r/R)^2}$$

$$p(z) = e^{-z/z^*} - e^{-z/\varepsilon}$$

The remaining solutions were found by integrating equations 4a and 4b, yielding:

$$f'(r^2) = \frac{\lambda R^2}{2} [1 - e^{-(r/R)^2}]$$

$$q(z) = -\lambda \{ \varepsilon (e^{-z/\varepsilon} - 1) - z * (e^{-z/z^*} - 1) \}$$

Figures 4 and 5 show plots of these shaping functions.

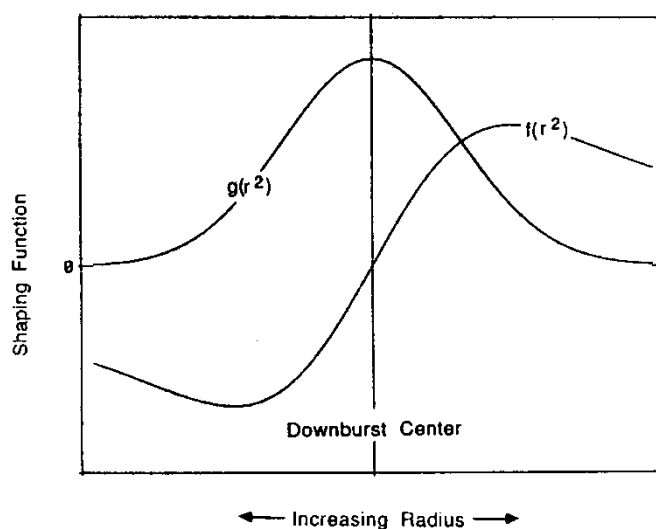


Figure 4 — Characteristic Variation of Horizontal Shaping Functions

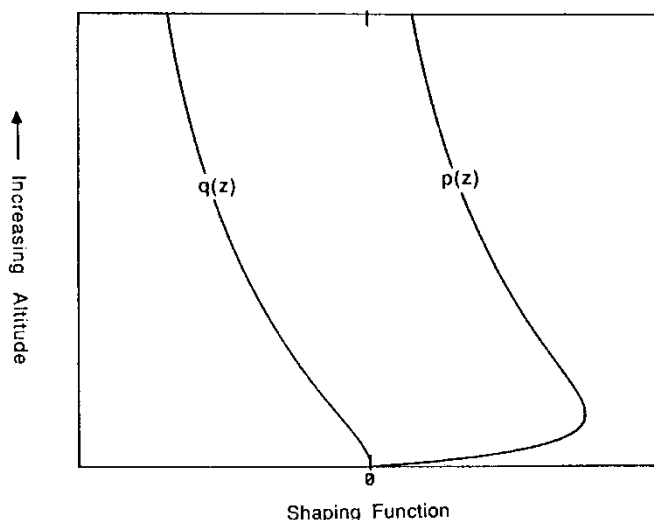


Figure 5 — Characteristic Variation of Vertical Shaping Functions

Combining the functions as in equation 3, the horizontal and vertical velocities are expressed as

$$u = \frac{\lambda R^2}{2r} [1 - e^{-(r/R)^2}] (e^{-z/z^*} - e^{-z/\varepsilon}) \quad (5)$$

$$w = -\lambda e^{-(r/R)^2} [\varepsilon (e^{-z/\varepsilon} - 1) - z^* (e^{-z/z^*} - 1)] \quad (6)$$

By taking derivatives of equations 5 and 6 with respect to r and z , respectively, and substituting in equation 2, it can be shown that the velocity distributions satisfy continuity.

The parameters z^* and ε were defined as characteristic scale lengths associated with ‘out of boundary layer’ and ‘in boundary layer’ behaviour, respectively. Analysis of TASS data indicated that $z^* = z_{m2}$, the altitude at which the magnitude of the horizontal velocity is half the maximum value.

It was also noted that the ratio

$$\frac{z_m}{z^*} = 0.22$$

To determine the location of the maximum horizontal velocity, the partial derivatives of u with respect to r and z were set equal to zero. The resulting equation for the r -derivative is

$$2 \left(\frac{r}{R} \right)^2 = e^{-(r/R)^2} - 1$$

The resulting equation for the z -derivative is

$$\frac{z_m}{z^*} = \frac{1}{(z^*/\varepsilon) - 1} \ln(z^*/\varepsilon)$$

Recalling that $z_m/z^* = 0.22$, the values 1.1212 and 12.5 were obtained from iteration for the ratios r/R and z^*/ε , respectively.

Using these values, the maximum horizontal velocity can be expressed as $u_{\max} = 0.2357 \lambda R$. The maximum vertical wind is located at $r = 0$ and $z = z_h$, by definition, and is given by

$$W_{\max} = \lambda z * (e^{-(z_h/z*)} - 0.92)$$

A ratio of maximum outflow and downflow velocities can be formed

$$\frac{u_m}{w_m} = \frac{0.2357R}{z * (e^{-(z_h/z*)} - 0.92)}$$

The Scaling factor, λ , was determined by using either of equations 5 or 6 for horizontal or vertical velocity, and setting it equal to the maximum velocity, $u_{\max}$ or $w_{\max}$, respectively. Solving for λ results in:

$$\lambda = \frac{w_m}{z * (e^{-(z_h/z*)} - 0.92)} = \frac{u_m}{0.2357R}$$

The velocity equations were easily converted to rectangular coordinates, as shown in the Appendix. Partial derivatives with respect to x , y , and z were obtained by differentiating the velocity equations, and are also listed in this Appendix.

DISCUSSION AND RESULTS

Vertical and horizontal velocity profiles for u and w are shown in Figures 6 and 7.

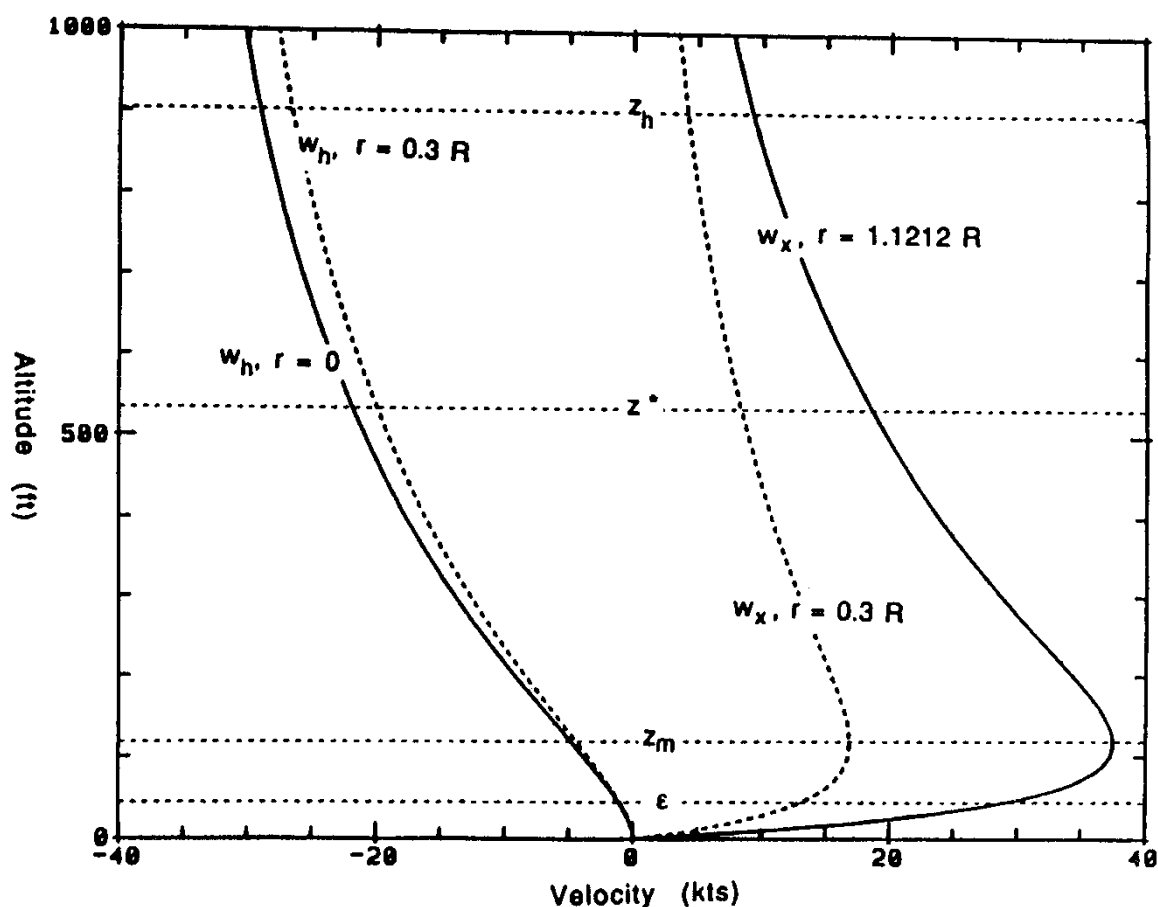


Figure 6 — Vertical Velocity Profiles for the Analytical Model

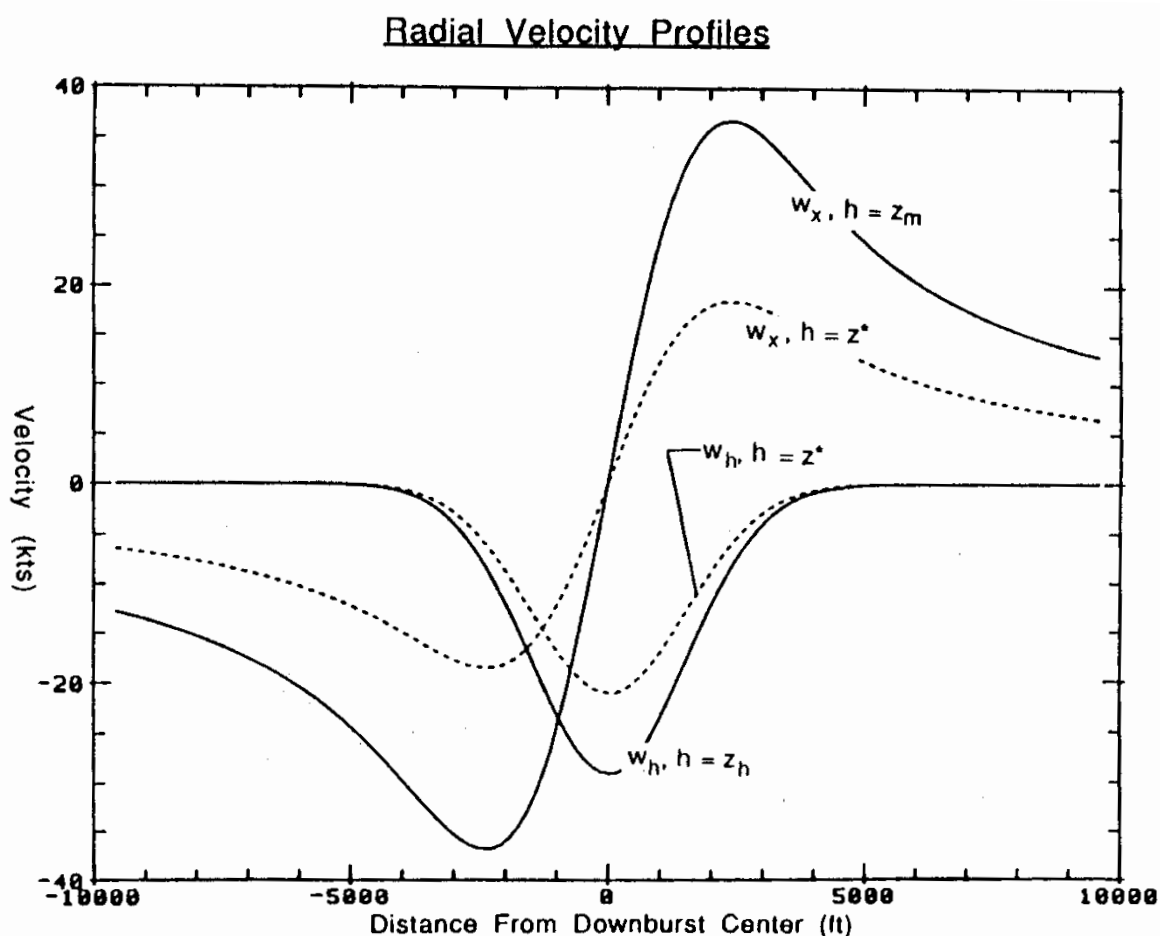


Figure 7 — Radial Velocity Profiles for the Analytical Model

Four profiles are shown for each component. The horizontal wind profiles in figure 6 were taken at the radius of peak outflow ($r = 1.1212 R$) and at about one-fourth that radius ($r = 0.3 R$), where the maximum outflow is approximately half the value at the peak outflow radius. The vertical wind profiles were taken at the radius of peak downflow ($r = 0$) and at $r = 0.3 R$. Horizontal wind and vertical wind profiles in figure 7 were taken at altitudes of $h = z_m$ (maximum outflow), $h = z^*$ (half-maximum outflow), and $h = z_h$ (depth of outflow).

This analytical model is compared with TASS, laboratory, and NIMROD data in figure 8. The figure shows that, when non-dimensionalised by the altitude of half-maximum outflow (z^*) and by the maximum outflow ($u = u_{max}$), the analytical model agrees closely with the other data.

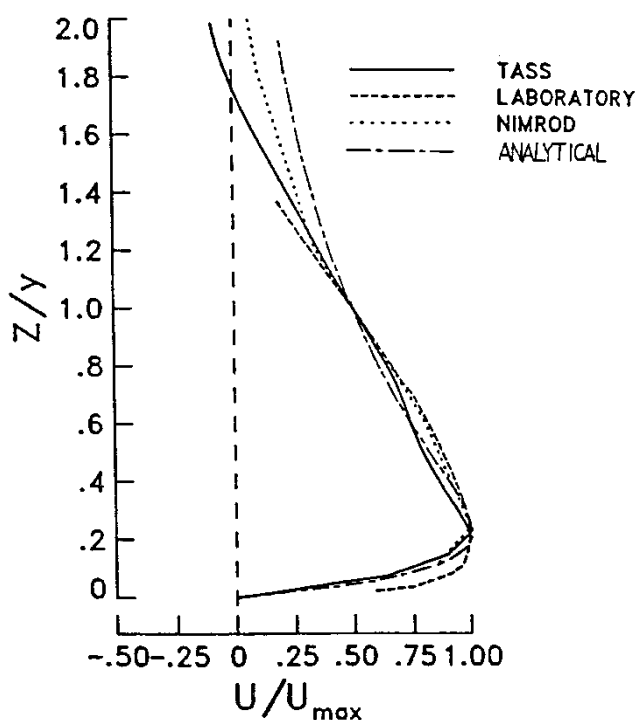


Figure 8 — Comparison of Wind Model Vertical Profiles

Different shears can be modelled by specifying four parameters, and the location of the downburst centre relative to the aeroplane flying through it. The four parameters are: 1) a characteristic horizontal dimension; 2) the maximum wind velocity; 3) the altitude of maximum outflow; and 4) the depth of outflow. The characteristic horizontal dimension specified is the radius of the downdraft column, noting that this is about 89 % of the radius of the peak outflow. The maximum wind velocity can be either horizontal or vertical.

CONCLUDING REMARKS

The analytic microburst model developed for use in real-time and batch simulation studies was shown to agree well with real-world measurements for the cases studied. The functions chosen for the model showed boundary-layer effects near the ground, as well as the peak and decay of outflow at increasing altitudes, and increasing downflow with altitude. The exponential increase and decay of the downflow and outflow (in the radial direction) are also characterised by the model. Equations for horizontal and vertical winds are simple and continuously differentiable, and partial derivatives in rectangular or cylindrical coordinates can be easily obtained by direct differentiation of the velocity equations. The governing equation for this system is the mass conservation law, and the analytic velocity functions developed here satisfied this condition. The model is sustained by a strong physical basis and yields high fidelity results, within the limitations of maintaining simplicity in the model, and variability of the microburst phenomenon. Parameterization of some of the characteristic dimensions allows flexibility in selecting the size and intensity of the microburst.

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[Amdt ETSO/16]

APPENDIX 3 TO ETSO-C117B – WIND FIELD MODEL COORDINATE SYSTEM TRANSFORMATION

ED Decision 2020/011/R

This Appendix describes the conversion of the velocity equations in Appendix 2 to rectangular coordinates.

Define intermediate variables to simplify written equations:

$$\begin{aligned} e_r &= e^{-(r/R)^2} & e_d &= e_z - e_e \\ e_e &= e^{-(h/\varepsilon)} & e_c &= z^*(1 - e_z) - \varepsilon(1 - e_e) \\ e_z &= e^{-(h/z^*)} \end{aligned}$$

Horizontal and Vertical Velocities

$$\begin{aligned} W_x &= \frac{\lambda R^2}{2r^2} (1 - e_r) e_d x_{ad} \\ W_y &= \frac{\lambda R^2}{2r^2} (1 - e_r) e_d y_{ad} \\ W_h &= -\lambda e_r e_c \end{aligned}$$

Partial Derivatives

$$\begin{aligned} \frac{\partial w_x}{\partial x} &= \frac{\lambda R^2 e_d}{2r^2} \left[e_r \left(\frac{2x_{ad}^2}{R^2} + \frac{2x_{ad}^2}{r^2} - 1 \right) - \frac{2x_{ad}^2}{r^2} + 1 \right] \\ \frac{\partial w_x}{\partial y} &= \frac{\lambda R^2 x_{ad} y_{ad} e_d}{r^2} \left[e_r \left(\frac{1}{R^2} + \frac{1}{r^2} \right) - \frac{1}{r^2} \right] \\ \frac{\partial w_x}{\partial h} &= \frac{\lambda R^2 x_{ad}}{2r^2} (1 - e_r) \left[\frac{e_e}{\varepsilon} - \frac{e_z}{z^*} \right] \\ \frac{\partial w_y}{\partial x} &= \frac{\lambda R^2 x_{ad} y_{ad} e_d}{r^2} \left[e_r \left(\frac{1}{R^2} + \frac{1}{r^2} \right) - \frac{1}{r^2} \right] \\ \frac{\partial w_y}{\partial y} &= \frac{\lambda R^2 e_d}{2r^2} \left[e_r \left(\frac{2y_{ad}^2}{R^2} + \frac{2y_{ad}^2}{r^2} - 1 \right) - \frac{2y_{ad}^2}{r^2} + 1 \right] \\ \frac{\partial w_y}{\partial h} &= \frac{\lambda R^2 y_{ad}}{2r^2} (1 - e_r) \left[\frac{e_e}{\varepsilon} - \frac{e_z}{z^*} \right] \\ \frac{\partial w_h}{\partial x} &= \frac{2\lambda x_{ad} e_r e_c}{R^2} \\ \frac{\partial w_h}{\partial y} &= \frac{2\lambda y_{ad} e_r e_c}{R^2} \\ \frac{\partial w_h}{\partial h} &= -\lambda e_r e_d \end{aligned}$$

Other Relationships

From TASS $\frac{z_m}{z^*} = 0.22$ $\frac{z^*}{\varepsilon} = 12.5$

Maximums $W_{x_{max}} = 0.2357\lambda R$

$$W_{y_{max}} = W_{x_{max}}$$

$$W_{h_{max}} = \lambda z^* (e^{-(z_h/z^*)} - 0.92)$$

(λ is determined from the above relationships)

$$\frac{W_{x_{max}}}{W_{h_{max}}} = \frac{0.2357R}{z^* (e^{-(z_h/z^*)} - 0.92)}$$

Variable List

z^* = altitude where w_x is half the value of $w_{x \max}$ (ft)

ε = characteristic height of boundary layer effects (ft)

z_h = depth of outflow (ft)

z_m = altitude of maximum outflow (ft)

λ = scaling parameter (s^{-1})

r = radial distance from aeroplane to downburst (ft)

h = altitude of aeroplane (ft)

R = radius of downdraft (ft)

x_{ad}, y_{ad} = x, y coordinates, aeroplane to microburst (ft)

$w_{x \max}, w_{y \max}, w_{h \max}$ maximum winds, x, y, and h directions

[Amdt ETSO/16]

APPENDIX 4 TO ETSO-C117B – DRYDEN TURBULENCE AND DISCRETE GUST MODEL

ED Decision 2020/011/R

This Appendix contains data that defines the Dryden turbulence and discrete gust model to be used in conducting the tests specified in paragraphs 4(d)(7)(ii), 4(d)(7)(iii), 4(d)(8)(ii), and 4(d)(8)(iii) of Appendix 1 to this ETSO.

Dryden Turbulence Model

$$F_u(S) = \text{SIGMA}_u * \text{SQRT}(\text{TAU}_u/\text{PI}) * 1/(1 + \text{TAU}_u*S)$$

$$F_v(S) = \text{SIGMA}_v * \text{SQRT}\left(\frac{\text{TAU}_v}{\text{PI}^2}\right) * \frac{(1 + \text{SQRT}3*\text{TAU}_v*S)}{(1 + \text{TAU}_v*S)*(1 + \text{TAU}_v*S)}$$

$$F_w(S) = \text{SIGMA}_w * \text{SQRT}\left(\frac{\text{TAU}_w}{\text{PI}^2}\right) * \frac{(1 + \text{SQRT}3*\text{TAU}_w*S)}{(1 + \text{TAU}_w*S)*(1 + \text{TAU}_w*S)}$$

where:

SIGMA_u, SIGMA_v, SIGMA_w are the RMS intensities;

TAU_u = L_u/V_A;

TAU_v = L_v/V_A;

TAU_w = L_w/V_A;

L_u, L_v, L_w are the turbulence scale lengths; V_A is the aircraft's true airspeed (ft/sec);

PI = 3.1415926535;

PI² = 6.2831853070 (2 times PI);

SQRT3 = 1.732050808 (square root of 3); and

S is the Laplace transform variable.

The following table lists SIGMA_u, SIGMA_v, SIGMA_w, L_u, L_v, and L_w versus altitude. Extrapolation will not be used, and simulator altitudes outside the bounds of the turbulence list will use the data at the boundary.

Altitude (feet)	RMS Intensities (ft/sec)			Scale Lengths (feet)		
	Long	Lat	Vert	Long	Lat	Vert
100	5.6	5.6	3.5	260	260	100
300	5.15	5.15	3.85	540	540	300
700	5.0	5.0	4.3	950	950	700
900	5.0	5.0	4.45	1123	1123	900
1500	4.85	4.85	4.7	1579	1579	1500

The applicant shall demonstrate that the variance of their turbulence implementation is adequate.

Discrete Gust Rejection

Discrete gusts (in the horizontal axis) with ranges of amplitude and frequency (A and OMEGA) of the form $A(1 - \cos \text{OMEGAt})$ shall be used.

The following table lists the values of A and OMEGA to be used (this simulates an approximate 15-knot gust condition):

A	OMEGA (rad/sec)	Approx. Gust Duration (sec)
7.5	2.10	3
7.5	1.26	5
7.5	0.78	8
7.5	0.63	10
7.5	0.52	12
7.5	0.42	15
7.5	0.31	20

[Amdt ETSO/16]

APPENDIX 5 TO ETSO-C117B – SHEAR INTENSITY

ED Decision 2020/011/R

$$f(t) = \frac{\dot{W}_x}{g} - \frac{W_h}{V}$$

where

$\dot{W}_x$ = Horizontal component of the wind rate of change expressed in g units (1.91 kt/s = 0.1 g)
(positive for increasing headwind).

W_h = Vertical component of the wind vector w (ft/s) (positive for downdraft).

V = True airspeed (ft/s).

g = Gravitational acceleration (ft/sec²).

[Amdt ETSO/16]

APPENDIX 6 TO ETSO-C117B – WIND SHEAR SIMULATION MODEL

ED Decision 2020/011/R

The following computer listing (written in QuickBasic) provides a simplified aircraft simulation model for evaluating the effectiveness of various guidance schemes. This simulation runs on a personal computer, and the results obtained using it have been found to be comparable to those obtained on a full six-degrees-of-freedom simulator. This model was developed by J. Rene Barrios of the Honeywell Company.

The Wind Shear Simulation Model (WSSM) is a point mass three-degrees-of-freedom mathematical model which simulates the motion of an aeroplane in a vertical plane. The equations of motion, which are described in the wind axes, include the wind components of velocity and acceleration so that the aeroplane dynamics during a wind shear encounter are accurately modelled. This model has been used by several investigators to study the behaviour of an aeroplane during wind shear encounters.

Note: The Wind Shear Simulation Model provided at the end of this Appendix is an example written in Microsoft QuickBasic. Other programming languages such as Microsoft FORTRAN, C, or assembly language are also acceptable.

The Equations of Motion

The motion of a constant mass point in the vertical plane may be described by four equations of state and a control variable. For an aeroplane, it is convenient to use an orthogonal reference frame which is attached to the frame of the aeroplane, and its x-direction points in the direction of motion. Such a reference frame is the relative wind reference frame.

The following equations model the states of the aeroplane in the wind axes:

$$Vdt = g[(T.csalf) - D]/W - sngam] - Wxdt.csgam - Wzdt.sngam \quad (1)$$

$$Gdt = \{g[(T.snalf + L)/W - csgam] + Wxdt.sngam - Wzdt.csgam\}/V \quad (2)$$

$$Hdt = V.sngam + Wz \quad (3)$$

$$Xdt = V.csgam + Wx \quad (4)$$

where:

Vdt	Rate of change of true airspeed in knots/second
G	Gravitational constant in knots/second
T	Total engine thrust in lb
csalf	cos (alpha)
alpha	Angle of attack in radians
D	Total drag in lb.
W	Gross weight in lb
sngam	sin (gamma)
gamma	Flight path angle in radians
Wxdt	Inertial wind shear x-component in knots/second

Gdt	Rate of change of gamma in rad/second
snalf	sin (alpha)
L	Total lift in lb
V	True airspeed in knots
Hdt	Altitude rate in knots
Wz	Inertial wind z-component in knots
Xdt	Ground speed in knots

In the above equations, the positive directions are upwards and forwards. This implies that tailwinds and updrafts are positive, while headwinds and downdrafts are negative. All the states can be determined from a given alpha; therefore, alpha is the control variable.

Since the model is that of a point mass, it is necessary to introduce the concept of alpha_command and actual alpha to account for the effect of the horizontal tail/elevator. This is done by introducing a lag between the alpha_command and the actual alpha. Therefore, any command that is given to the elevator or stabiliser can be interpreted as an alpha_command, which will cause a change in the angle of attack.

From equations 1, 2, 3 and 4, it can be seen that any change in alpha will produce a change in the longitudinal and normal accelerations, which in turn will change the states of the aeroplane.

The Path Control Function

The different segments of the trajectory flown by the WSSM are described by a series of alpha_commands, which are generated by the procedure explained below.

1. The aeroplane is trimmed for the initial conditions specified by the user. The initial conditions are usually specified as the altitude, gross weight, flaps, speed, flight path angle, and wind characteristics. The trimming operation consists in finding the angle of attack that satisfies the equations of state and will result in an unaccelerated motion.
2. After the initial trim, alpha_command must be specified for each segment of the trajectory, which usually consists of a climb or descent segment at constant speed or constant path angle, and guidance through wind disturbances. The wind disturbance is provided by wind models that can be selected at initialisation time.
3. In order to specify an alpha_command, the user must supply a subroutine where a quadratic function is defined in such a way that when minimised with respect to alpha, and constrained by the equations of state, the minimising alpha will produce the desired path in an optimal manner. For example, if we want to fly initially at a constant path angle, say 8 degrees, then the quadratic function may be defined by the expression:

$$- \text{cst} = \left(\text{gamma} + \text{Gdt} * \text{dt} - \frac{8}{57.3} \right)^2 \quad (5)$$

where:

cst	Function to be minimised w.r.t alpha
dt	Time increment used in simulation in sec.
Gdt*dt	A predictive term which anticipates the change in gamma

Other expressions follow:

$$cst = (V + V_{dt} * dt - V_{cmd})^2 \text{ Constant speed}$$

$$cst = (\alpha + \gamma + G_{dt} * dt - pitch_{cmd})^2 \text{ Constant Pitch}$$

The minimisation of the function cst is performed by a subroutine at each time frame and is totally transparent to the user, who has to supply only the objective function cst.

4. Each expression defining a different value of the objective function cst is called a 'LAW'. The user selects the guidance law to be used during the wind shear encounter at the time the menu is displayed. This method allows the user to compare different guidance laws under the exact same conditions.

The Wind Models

The WSSM has two types of wind models: the Dallas-Ft Worth accident wind field, simulated by a quad_vortex model, and the constant shear model, which is user defined via the initial conditions menu.

Plotting Capabilities

The WSSM can plot up to 3 runs with 10 parameters per run. The length of each run should be kept under 60 seconds. This feature allows the user to compare different trajectories by overlaying the results.

The Programme

The WSSM is written in Microsoft QuickBasic, which is a highly structured language with a very friendly full-page editor. QuickBasic is very convenient for development, since it allows the user to stop execution, change the programme and continue executing. It also interfaces with Microsoft FORTRAN, C, or assembly language.

The procedure suggested for this application is that the WSSM be compiled without subroutines DETECT and GUIDE. DETECT and GUIDE can be separately compiled and put in a library called WNDSHR.QLB. These external subroutines may be written in Microsoft FORTRAN, C, or assembly language.

Listing of Programme

'***** AIRCRAFT FLIGHT PROFILE SIMULATION *****'

DECLARE SUB PLOT ()

DECLARE SUB TAKEOFF ()

DECLARE SUB EULER ()

DECLARE SUB MCRBRST ()

DECLARE SUB WINDS ()

DECLARE SUB OPT ()

DECLARE SUB MIN (DM, M2, C1, C2, C3, M)

DECLARE SUB BEGIN ()

DECLARE SUB VSHAKER ()

DECLARE SUB COST ()

DECLARE SUB LIMIT ()

DECLARE SUB RATES ()

DECLARE SUB THRUST ()

DECLARE SUB ATMOS ()

DECLARE SUB PRINTS ()

DECLARE SUB DRAGS ()

COMMON SHARED FLPS%, GEAR%, GEAR\$, CL, CD, LIFT, DRAG, ALPHA

COMMON SHARED SEC, ALT, DST, HDOT, ALF, GAM, GAMREF, GREF, G

COMMON SHARED WSALERT%, WXO, WL, WX, WXDT, WZ, WZDT, DFW

COMMON SHARED WV, LC%, GM, GREFF, NOSAVE, GMO

COMMON SHARED DELTA, ISA, TO, SPDSND, VT, VC, MACH, A0, TAT, TAMF

COMMON SHARED THRST, EPR, TFCT, APPFLG%

COMMON SHARED SNGM, CSGM, CSAL, SNAL, VDOT, WG, GDOT, XDOT

COMMON SHARED AWX, AWZ, AU, AZ, VG, GRND, KF1, GMIN, KF2

COMMON SHARED ACMD, OLDALF, DT, HP, LP, ALFLIM

COMMON SHARED LAW%, GMR, ASS, CST, VTO, GCMD

COMMON SHARED OUTFILE\$, DM, ALT1, PL\$, TTT, WXDTO, TDY, TSH, WZO, TDZ, TSV

COMMON SHARED GM1, VTP, THETA

COMMON SHARED ALFRTE, PLMFLG%

'*****'

' MAIN PROGRAM *'

'*****'

START: '< -----<< RE-RUNS START HERE

```
CLOSE : CLEAR
COLOR 15, 1: CLS : VIEW PRINT
LOCATE 8, 23: PRINT "WINDSHEAR SIMULATION"
LOCATE 10, 23: PRINT "FOR "
LOCATE 12, 23: PRINT "BOEING 737/200 "
LOCATE 23, 23: PRINT "TYPE " + CHR$(&H22) + "I" + CHR$(&H22) + " FOR INFORMATION"
DO WHILE a$ = ""
a$ = INKEY$
LOOP
IF a$ = "I" OR a$ = "i" THEN
a$ = "": CLS
'----- INFORMATION PAGE-----
LOCATE 2, 2: PRINT "BOEING 737/200 INFORMATON"
LOCATE 3, 2: PRINT "JT8D-17 ENGINES"
LOCATE 5, 2: PRINT "-----"
LOCATE 7, 2: PRINT "ALLOWABLE WEIGHT RANGES.....: 75,000 TO 120,000 POUNDS"
LOCATE 9, 2: PRINT "ALLOWABLE TAKEOFF FLAP SETTINGS.....: 1, 2, 5, 15, 20, 25 DEGREES"
LOCATE 11, 2: PRINT "ALLOWABLE LANDING FLAP SETTINGS.....: 30, 40 DEGREES"
LOCATE 13, 2: PRINT "TAKEOFF EPR AT SEA LEVEL, STD. DAY...: 2.1 "
LOCATE 15, 2: PRINT "REFERENCE WING AREA.....: 980 SQUARE FEET"
LOCATE 17, 2: PRINT "REFERENCE TAKEOFF SPEED.....: V2 + 10"
LOCATE 19, 2: PRINT "REFERENCE LANDING SPEED.....: 1.3 Vs"
LOCATE 23, 2: PRINT "Press Any Key to Continue..."
DO: LOOP WHILE INKEY$ = ""
END IF
ANS$ = "2"
CLS
WHILE (ANS$ = "2")
LOCATE 10, 30: PRINT "Fly ..... 1"
LOCATE 12, 30: PRINT "Plot ..... 2"
LOCATE 14, 30: PRINT "Exit ..... 3"
LOCATE 18, 30: INPUT "Selection ....."; ANS$
IF ANS$ = "2" THEN
CALL PLOT
COLOR 15, 1
```

```
CLS
END IF
WEND
IF ANS$ = "3" THEN END
CALL BEGIN 'GET DATA/INITIALIZE VARIABLES
CALL THRUST 'INITIALIZE THRUST
CALL TAKEOFF 'INITIALIZE TAKEOFF
CALL COST 'SUBROUTINE COST
CALL PRINTS 'SUBROUTINE PRINT
FOR ICL% = 1 TO TTT ' TTT IS THE RUN TIME IN SECONDS
CALL THRUST ' SUBROUTINE EPR/THRUST
CALL WINDS ' SUBROUTINE WINDS
' CALL DETECT ' SUBROUTINE WINDSHEAR DETECTION
' SUPPLIED BY USER
' MUST RESIDE IN LIBRARY WNDshr.qlb
CALL OPT ' SUBROUTINE OPTIMIZE
CALL LIMIT ' SUBROUTINE ALPHA RATE
CALL EULER ' SUBROUTINE INTEGRATE
CALL ATMOS ' SUBROUTINE ATMOSPHERE
CALL PRINTS ' SUBROUTINE PRINT
IF ALT < 0 THEN EXIT FOR
NEXT ICL%
PRINT "RUN IS COMPLETE"
PRINT "TYPE " + CHR$(&H22) + "D" + CHR$(&H22) + " FOR RUN DATA"
a$ = ""
DO WHILE a$ = "" ' Wait for key to be pressed
a$ = INKEY$
LOOP
VIEW PRINT: COLOR 15, 4: CLS
IF a$ = "D" OR a$ = "d" THEN
a$ = ""
LOCATE 2, 2: PRINT "DATA FROM CURRENT RUN"
LOCATE 4, 2: PRINT "-----"
LOCATE 6, 2: PRINT "GROSS WEIGHT: "; WG; " POUNDS"
LOCATE 7, 2: PRINT "ISA DEVIATION: "; ISA; " DEG C"
```

```
LOCATE 8, 2: PRINT "FLAP POSITION: "; FLPS%; " DEGREES"
LOCATE 9, 2: PRINT "GEAR POSITION: "; GEAR$
LOCATE 11, 2: PRINT "CONTROL LAW: "; LAW%
LOCATE 12, 2: PRINT "GAMMA REFERENCE: "; GAMREF
LOCATE 13, 2: PRINT "PITCH LIMITING: "; PL$
IF PL$ = "YES" THEN
LOCATE 14, 2: PRINT "MAXIMUM PITCH: "; HP * 57.3; " DEGREES"
LOCATE 15, 2: PRINT "MINIMUM PITCH: "; LP * 57.3; " DEGREES"
END IF
LOCATE 16, 2: PRINT "TIME OF RUN: "; TTT * DT; " SECONDS"
IF DFW = 1 THEN
LOCATE 17, 2: PRINT "DALLAS/FW Wind Model"
ELSE
LOCATE 17, 2: PRINT "HORIZ. WIND MAGNITUDE "; WXO; " KNOTS"
LOCATE 18, 2: PRINT "HORIZ. SHEAR MAGNITUDE: "; WXDTO; " KNOTS/SECOND"
LOCATE 19, 2: PRINT "HORIZ. SHEAR DURATION: "; TDX; " SECONDS"
LOCATE 20, 2: PRINT "VERT. WIND MAGNITUDE: "; WZO * 1.689; " FT/SECOND"
LOCATE 21, 2: PRINT "VERT. WIND DURATION: "; TDZ; " SECONDS"
LOCATE 22, 2: PRINT "-----"
END IF
IF LEN(OUTFILE$) = 0 THEN OUTFILE$ = "NONE"
LOCATE 23, 2: PRINT "OUTPUT FILE: "; OUTFILE$
LOCATE 24, 2: PRINT "Press Any Key to Continue...."
DO: LOOP WHILE INKEY$ = "" 'Wait for key to be pressed
END IF
GOTO START
END
SUB ATMOS STATIC
'*****
' SUBROUTINE ATMOSPHERE *
'*****
STATIC THETA
L% = ALT > 36089!
FISA = 1.8 * ISA
IF ALT > 36089 THEN
```

```
TMP = .7519 * T0
DELTA = .2234 * EXP((36089! - ALT) / 20806)
ELSE
TMP = T0 - .0035662 * ALT
DELTA = (TMP / T0) ^ 5.256
END IF
TAMB = TMP + FISA 'TAMBient in deg. R
TAMF = TAMB - 459.7 ' " " F
THETA = TAMB / T0
SQRTH = SQR(THETA)
SPDSND = A0 * SQRTH
IF VT > 0 THEN MACH = VT / SPDSND
VC = A0 * SQR(5 * (((1 + MACH * MACH / 5) ^ 3.5 - 1) * DELTA + 1) ^ .28571 - 5)
TAX = (TMP + FISA) * (1 + .2 * MACH * MACH) 'Deg. R
TAT = 5 * (TAX - 459.7 - 32) / 9 'Deg. C
IF INKEY$ < > "" THEN PRINT : INPUT "Press ENTER to continue...."; XXX
END SUB
SUB BEGIN STATIC
CLS : VIEW PRINT
'<----- DATA_INPUT ----->
PRINT
INPUT "OUTPUT FILE (DEFAULT IS NO FILE) "; OUTFILE$
IF OUTFILE$ = " " THEN
NOSAVE = 1
ELSE
NOSAVE = 0
END IF
' CONSTANTS USED IN CALCULATIONS:
A0 = 661.478599# 'Speed of sound at sea level in knots
G = 19.07583 'Gravitational constant in knots/sec
T0 = 518.67 'Standard temperature at SL in deg Rankine
DT = .25 'Simulation time step in seconds
' ----- INITIALIZATION OF VARIABLES-----
GMIN = 0
VDOT = 0
```

```
ALT1 = 0
INPUT "TAKEOFF OR APPROACH (T/A) (Default is T)....."; ANS$
IF ANS$ = "a" OR ANS$ = "A" THEN
INPUT "ENTER ALTITUDE IN FEET (Default is 1000' . "; ALT1
IF ALT1 = 0 THEN ALT1 = 1000
APPFLG% = 1
TFCT = 1
END IF
ALT = ALT1
' ----- CONFIGURATION CONSTANTS-----
ASS = 16.5 'Stick Shaker alpha in degrees
ASS = ASS / 57.3 ' " " "radians
' ----- GROSS WEIGHT ENTRY-----
PRINT : INPUT "ENTER GROSS WEIGHT IN POUNDS (Default is 110000) "; WG
IF WG = 0 THEN WG = 110000! ' DEFAULT SETTING
FL% = 0
WHILE (NOT FL%)
INPUT "ENTER FLAPS SETTING (Default is 0)....."; FLPS%
SELECT CASE FLPS%
CASE 0, 1, 2, 5, 15, 20, 25, 30, 40
FL% = -1
CASE ELSE
FL% = 0
PRINT "Invalid flaps setting"
PRINT "Only 0, 1, 2, 5, 15, 20, 25, 30, & 40 are supported"
PRINT
END SELECT
WEND
IF FLPS% < 15 THEN GEAR% = 1
IF FLPS% = 15 THEN INPUT "GEAR UP OR DOWN (1/0) (Default is Down)....."; GEAR%
IF GEAR% = 1 THEN
GEAR$ = " UP"
ELSE
GEAR$ = " DOWN"
END IF
```

```
INPUT "ENTER ISA DEV. IN DEGREES C (Default is 0)....."; ISA
PRINT
CALL VSHAKER ' COMPUTE V2+10 FOR FLAPS<33 OR 1.3Vs FOR FLAPS>32
PRINT " CONTROL LAW SELECTION:"
PRINT
PRINT " Speed = 1.1* V_stall = 1"
PRINT " Alpha = Stick Shaker Alpha = 2"
PRINT " Horizontal Acceleration = 0 = 3"
PRINT " 15_Degree Pitch = 4"
PRINT " Theoretical HONEYWELL/SPERRY = 5"
PRINT " User Defined = 6"
PRINT
INPUT " SELECT CONTROL LAW ..... "; LAW%
IF LAW% = 0 THEN LAW% = 5
PRINT : PRINT
' ----- GAMMA REFERENCE INPUT-----
IF LAW% > 4 THEN
INPUT "ENTER GAMMA REFERENCE IN DEGREES (Default is 0)....."; GMR
PRINT
GAMREF = GMR
GMR = GMR / 57.3: GMIN = GMR
END IF
' ----- PITCH LIMITING SELECTION-----
INPUT "PITCH LIMITING DESIRED (y/n) (Default is NO)....."; PL$
IF PL$ = "Y" OR PL$ = "y" THEN
PL$ = "YES"
INPUT " MAXIMUM PITCH ALLOWED IN DEGREES "; HP
INPUT " MINIMUM PITCH ALLOWED IN DEGREES "; LP
HP = HP / 57.3: LP = LP / 57.3: PL% = 1
ELSE
HP = 100
LP = -100
PL% = 0
PL$ = "NO"
END IF
```

CLS

'----- TIME FOR RUN-----

PRINT

INPUT "ENTER TIME OF RUN IN SECONDS (Default is 45)....."; TTT

TTT = TTT / DT

IF TTT = 0 THEN TTT = 45 / DT ' DEFAULT SETTING

'----- WINDSHEAR SET UP-----

INPUT "DALLAS/FW Wind Model (y/n)...(Default is constant Shear)....."; ANS\$

IF ANS\$ = "Y" OR ANS\$ = "y" THEN

DFW = 1

ELSE

DFW = 0

PRINT

INPUT "MAGNITUDE OF HORZ. WIND IN KNOTS.....(Head wind < 0)....."; WXO

INPUT "MAGNITUDE OF HORZ. SHEAR IN KT/SEC. (Dec. Perf. > 0)....."; WXDTO

INPUT "DURATION OF HORZ. SHEAR IN SEC.....(Default is 0)....."; TDX

INPUT "TIME FOR SHEAR TO START IN SEC.....(Default is 0)....."; TSH

PRINT

INPUT "MAGNITUDE OF VERT. WIND IN FT/SEC. (Down Draft < 0)....."; WZO

WZO = WZO / 1.689 'Convert to knots

INPUT "DURATION OF VERT. WIND IN SEC.....(Default is 0)....."; TDZ

INPUT "TIME FOR SHEAR TO START IN SEC.....(Default is 0)....."; TSV

PRINT

END IF

'----- OTHER SET UPS-----

VT = VTO

WX = WXO

CALL ATMOS ' SUBROUTINE ATMOSPHERE

'----- HEADERS FOR SCREEN DISPLAY-----

CLS : PRINT

PRINT "TIME ALT HDOT VT ALPHA GAMMA PITCH GREF WXDT WZ VDOT ALRT"

PRINT "(SEC) (FT) (FPM) (KTS) (DEG) (DEG) (DEG) (DEG) (KT/S) (FPS) (KT/S)"

PRINT STRING\$(75, "-"): VIEW PRINT 5 TO 25

' SUBROUTINE INIT_OUTPUT FILE *

IF NOSAVE THEN ' CREATE OUTPUT FILE

ELSE

OPEN "O", 2, OUTFILE\$

FMT\$ = " ###.## ##### ##### ##### ## ###.## ###.## ###.##"

FMT\$ = FMT\$ + " ###.## ###.## ###.## ##.## "

END IF

END SUB

SUB COST STATIC

' SUBROUTINE COST *

CALL DRAGS ' SUBROUTINE DRAG & LIFT

CALL RATES ' SUBROUTINE RATES

IF LC% = 0 THEN 'Constant gamma segment

$FCT = (GM + GDOT * DT - GMO) ^ 2$

GREFF = 57.3 * GMO

ELSE 'All guidance laws

SELECT CASE LAW%

CASE 1 ' ----- 1.1*Vstall-----

$CST = (VT + VDOT * DT - 1.1 * 135) ^ 2$

CASE 2 ' ----- Alpha = Ass-----

$CST = (ALPHA - ASS) ^ 2$

CASE 3 ' ----- Ax = 0-----

$CST = (VDOT - VT * GDOT * GM + WXDT) ^ 2$

CASE 4 ' ----- 15 Degrees-----

$CST = (GM + 3 * GDOT * DT + ALPHA - 15 / 57.3) ^ 2$

CASE 5 ' ----- User Defined-----

PRINT "Not defined"

STOP

CASE 6 ' ----- User Supplied-----

'User must supply a subroutine called GUIDE

'which must reside in the WND SHR.QLB Library

'GUIDE can have a list of arguments

'As an example

```
'ALF = 57.3*ALPHA
'PTH = 57.3 * (ALPHA + GM)
' units : ft fpm kt deg g's *
'CALL GUIDE(ALT, HDOT, VC, ALF, PTH, AU, AZ, CST)
END SELECT
END IF
' CST is the Cost Function to be minimized
END SUB
SUB DRAGS STATIC
*****
' SUBROUTINE DRAG FOR B737/200 *
*****

X = 57.3 * ALPHA + 1
CF5 = 0: CF4 = 0: CF3 = 0: CF2 = 0
SELECT CASE FLPS%
CASE 0
CF1 = .091
CF0 = .0156
CASE 1
CF3 = -1.164058E-04
CF2 = 2.48561E-03
CF1 = .0905781
CF0 = .062114
CASE 2
CF0 = .101198
CF1 = .110993
CF2 = -.0015162
CF3 = 1.8931E-04
CF4 = -7.1427E-06
CF5 = -4.2776E-09
CASE 5
CF0 = .192638
CF1 = .123509
CF2 = -.0051477
CF3 = 6.4968E-04
```

CF4 = -3.0891E-05

CF5 = 4.1291E-07

CASE 10

CF0 = .249855

CF1 = .114005

CF2 = 7.1207E-04

CF3 = -9.9541E-05

CF4 = 7.0431E-06

CF5 = -2.3773E-07

CASE 15

CF0 = .40149

CF1 = .118723

CF2 = -6.4877E-04

CF3 = 6.6281E-05

CF4 = -1.6113E-07

CF5 = -1.4278E-07

CASE 25

CF0 = .592655

CF1 = .122433

CF2 = -.0026365

CF3 = 3.5963E-04

CF4 = -1.5579E-05

CF5 = 1.0894E-07

CASE 30

IF X < 4 THEN

CF1 = .12

CF0 = .72

ELSE

CF3 = -1.651192E-04

CF2 = 4.16461E-03

CF1 = 8.337061E-02

CF0 = .8350316

END IF

CASE 40

IF X < 4 THEN

```
CF1 = .12
CF0 = 1.08
ELSE
CF3 = -1.689903E-04
CF2 = 3.733285E-03
CF1 = 8.483822E-02
CF0 = 1.201596
END IF
CASE ELSE
PRINT "Flaps "; FLPS%; " not available....."
END
END SELECT 'For CL computation
CL = (((CF5 * X + CF4) * X + CF3) * X + CF2) * X + CF1) * X + CF0
SELECT CASE FLPS% 'Low Speed Drag Polars
CASE 0
D0 = .013285: D1 = .052868: D2 = -.07182: D3 = .071561
CASE 1
D0 = .026143: D1 = .022358: D2 = -.00083: D3 = .016338
CASE 2
D0 = .070346: D1 = -.0852: D2 = .097453: D3 = -.01207
CASE 5
D0 = .045214: D1 = -.0178: D2 = .04373: D3 = .002101
CASE 10
D0 = -.04266: D1 = .19643: D2 = -.1152: D3 = .03966
CASE 15
IF GEAR% = 0 THEN
D0 = .034954: D1 = .098892: D2 = -.04187: D3 = .020496
ELSE
D0 = -.02822: D1 = .174631: D2 = -.0874: D3 = .029566
END IF
CASE 25
D0 = -.10416: D1 = .327506: D2 = -.17059: D3 = .043313
CASE 30
D0 = .124697: D1 = -.03348: D2 = .055295: D3 = -.00311
CASE 40
```

D0 = .124925: D1 = .052537: D2 = .006912: D3 = .0058

CASE ELSE

PRINT "Flaps "; FLPS% " not available...."

END

END SELECT

CD = ((D3 * CL + D2) * CL + D1) * CL + D0

Q = 1451770 * MACH * MACH * DELTA 'B737/200

LIFT = Q * CL

DRAG = Q * CD

END SUB

SUB EULER STATIC

!*****

' SUBROUTINE EULER'S PREDICTOR/CORRECTOR *

' (INTEGRATION SUBROUTINE) *

!*****

DTH = DT / 3600: DTM = DT / 60: SEC = SEC + DT: VTP = VT

CALL RATES ' SUBROUTINE RATES <<PREDICTOR>>

ALT1 = ALT: HDOT1 = HDOT: ALT = ALT + HDOT * DTM

GM1 = GM: GDOT1 = GDOT: GM = GM + GDOT * DT

DST1 = DST: XDOT1 = XDOT: DST = DST + XDOT * DTH

VT1 = VT: VDOT1 = VDOT: VT = VT + VDOT * DT

CALL RATES ' SUBROUTINE RATES <<CORRECTOR>>

ALT = ALT1 + (HDOT1 + HDOT) * DTM / 2

GM = GM1 + (GDOT1 + GDOT) * DT / 2

DST = DST1 + (XDOT1 + XDOT) * DTH / 2

VT = VT1 + (VDOT1 + VDOT) * DT / 2

END SUB

SUB LIMIT STATIC

!*****

' SUBROUTINE ALPHA DOT AND PITCH LIMIT *

!*****

ALPHA = OLDALF + .25 * (ACMD - OLDALF) 'Pitch dynamics

CALL DRAGS ' SUBROUTINE DRAG (REQ'D FOR RATE SUB CALL)

IF PLMFLG% = 0 THEN EXIT SUB

OLDGM = GM

```
PLIM% = 0
DO WHILE (PLIM% = 0)
CALL RATES ' SUBROUTINE RATES
X = ALPHA + OLG*GDOT * DT
IF X > HP THEN ALPHA = .9 * ALPHA
IF X < LP THEN ALPHA = 1.1 * ALPHA
IF ALPHA > ALFLIM THEN
ALPHA = ALFLIM
PLIM% = 1
END IF
LOOP
END SUB
SUB MCRBRST STATIC
IF MU1 = 0 THEN
MU1 = -37141!
AV = 5500: H1 = 2500: G3 = 3: J1 = -700: J2 = 800: J3 = 6.5
MU2 = -20000
BV = 12000: H2 = 2000: N1 = 200: N2 = 2500: N3 = 4
WX = 5
IF ALT > 1000 THEN
PRINT
PRINT " DFW data not available above 1000'"
PRINT " Please start at or below 1000'"
END
END IF
END IF
X = 6078 * DST: Y = ALT: A1 = AV: A2 = BV
NX1 = Y - H1: DENX1 = (Y - H1) ^ 2 + (X - A1) ^ 2
NY1 = X + J2 - A1: DENY1 = (Y + J1 - H1) ^ 2 + (X + J2 - A1) ^ 2
NX2 = Y - H2: DENX2 = (Y - H2) ^ 2 + (X - A2) ^ 2
NY2 = X + N2 - A2: DENY2 = (Y + N1 - H2) ^ 2 + (X + N2 - A2) ^ 2
NX3 = Y + H1: DENX3 = (Y + H1) ^ 2 + (X - A1) ^ 2
NY3 = X + J2 - A1: DENY3 = (Y + J1 + H1) ^ 2 + (X + J2 - A1) ^ 2
NX4 = Y + H2: DENX4 = (Y + H2) ^ 2 + (X - A2) ^ 2
NY4 = X + N2 - A2: DENY4 = (Y + N1 + H2) ^ 2 + (X + N2 - A2) ^ 2
```

```
XX = MU1 * (-NX1 / DENX1 + NX3 / DENX3) + MU2 * (NX2 / DENX2 - NX4 / DENX4)
WX = WX + .65 * (XX - WX) + 2 * G3
IF DST = 0 THEN WXP = WX
ZZ = MU1 * (NY1 / DENY1 - NY3 / DENY3) * J3 + MU2 * (-NY2 / DENY2 + NY4 / DENY4) * N3
WZ = WZ + .65 * (ZZ - WZ)
IF DST = 0 THEN WZP = WZ
WX5 = WX4: WX4 = WX3: WX3 = WX2: WX2 = WX1: WX1 = WX
WZ5 = WZ4: WZ4 = WZ3: WZ3 = WZ2: WZ2 = WZ1: WZ1 = WZ
IF WCNT% < 4 THEN WXDT = (WX - WXP) / DT: WXP = WX
IF WCNT% < 4 THEN WZDT = (WZ - WZP) / DT: WZP = WZ
IF WCNT% > 3 THEN WXDT = (26 * WX5 - 27 * WX4 - 40 * WX3 - 13 * WX2 + 54 * WX1) / (70 * DT)
IF WCNT% > 3 THEN WZDT = (26 * WZ5 - 27 * WZ4 - 40 * WZ3 - 13 * WZ2 + 54 * WZ1) / (70 * DT)
IF ABS(WXDT) > 15 THEN WXDT = 15 * SGN(WXDT)
IF ABS(WZDT) > 15 THEN WZDT = 15 * SGN(WZDT)
WCNT% = WCNT% + 1
END SUB
SUB MIN (DM, M2, C1, C2, C3, M) STATIC
'*****
'SUBROUTINE MIN_CST BY LEAST SQUARES PARABOLA *
'*****
ALPHA = M2 + DM 'INCREMENT ALPHA
CALL COST 'SUBROUTINE COST
IF DM < 0 THEN
C4 = CST
ELSE
SWAP C1, C3
C5 = CST
END IF
ALPHA = M2 - DM 'DECREMENT ALPHA
CALL COST 'SUBROUTINE COST
IF DM < 0 THEN
C5 = CST
ELSE
C4 = CST
END IF
```

$M = \text{ABS}(\text{DM}) * (14 * C1 + 7 * C4 - 7 * C5 - 14 * C3) / (20 * C1 - 10 * C4 - 20 * C2 - 10 * C5 + 20 * C3)$

END SUB

SUB OPT STATIC

'SUBROUTINE OPTALF - DETERMINES THE ALPHA REQD FOR CMD GAMMA '

OLDALF = ALPHA: GM1 = GM

CALL ATMOS ' SUBROUTINE ATMOSPHERE

CALL RATES ' SUBROUTINE RATES

DM = 1 / 57.3 ' SET ALPHA INCREMENT TO 1 DEGREE

C1 = 1E+20

C2 = 1E+20

C3 = 1E+20

OPTFLG% = 0

WHILE (OPTFLG% = 0)

CALL COST ' SUBROUTINE COST

C3 = C2: C2 = C1: C1 = CST

M3 = M2: M2 = M1: M1 = ALPHA

LGC% = C1 > C2 AND C3 = 1E+20

IF LGC% THEN

DM = -DM ' Reverse search direction

C1 = C2: C2 = CST: M1 = M2: M2 = ALPHA

ALPHA = ALPHA + 2 * DM

ELSE

IF C1 < C2 THEN

L% = ABS(OLDALF - ALPHA) / DT > ALFRTE OR ALPHA > ALFLIM OR ALPHA < -.08

IF L% THEN OPTFLG% = 1

ALPHA = ALPHA + DM

ELSE

DM = DM / 2

CALL MIN(DM, M2, C1, C2, C3, M)'Fit parabola & find minimum

ALPHA = M2 + M 'This is the optimum alpha

OPTFLG% = 1 'Set flag to terminate

END IF

END IF

WEND

ALFLIM = ASS 'SET ALPHA LIMIT TO ALPHA STICK SHAKER

SELECT CASE LAW%

CASE 4

ALFLIM = ASS - .035 'LIMIT TO SS MINUS 2 DEG

CASE 5, 6

ALFLIM = ASS - KF2

CASE ELSE

END SELECT

IF ALPHA < -.08 THEN ALPHA = -.08

IF ALPHA > ALFLIM THEN ALPHA = ALFLIM

ACMD = ALPHA 'SET ALPHA COMMAND TO COMPUTED ALPHA

END SUB

SUB PLOT

'* PLOT ROUTINE *

REM \$DYNAMIC

' TWO DIMENSIONAL PLOTTER

DEFINT I-L, N

DIM F\$(3) ' file name array

DIM DTA(3, 250, 15) ' data array

DIM TY\$(14) ' title array (dependant variable)

TITLE\$ = "HONEYWELL WINDSHEAR SIMULATION" ' main title

TX\$ = "Time (s)" ' X title

TY\$(1) = "Altitude ft "

TY\$(2) = "Alt Rate fpm "

TY\$(3) = "T A S kts "

TY\$(4) = "Alpha deg "

TY\$(5) = "Gamma deg "

TY\$(6) = "Pitch deg "

TY\$(7) = "G_ref deg "

TY\$(8) = "Hz Shear kps "

```
TY$(9) = "Vt Wind fps "  
TY$(10) = "Vt rate kps "  
TY$(11) = "W/S Flag "  
NV = 12  
CLS  
LOCATE 3, 15: PRINT "Enter the names of the data files you wish to plot."  
FOR NC = 1 TO 3  
LOCATE 6 + 2 * NC, 25 ' input  
PRINT "FILENAME "; NC; " "; ' filenames  
INPUT ; F$(NC) ' containing  
IF F$(NC) = " " THEN EXIT FOR ' data  
NEXT NC  
NC = NC - 1 ' number of curves to plot  
LOCATE 20, 15: PRINT "Reading from disk....."  
FOR I = 1 TO NC  
CLOSE  
OPEN "I", #1, F$(I) ' open file for input  
NP = 0  
DO  
NP = NP + 1 ' number of points  
FOR J = 1 TO NV  
INPUT #1, DTA(I, NP, J) ' read data  
NEXT J  
LOOP UNTIL EOF(1)  
CLOSE  
NEXT I  
DO ' display all selected parameters  
DO ' prompt user until a valid parameter is selected  
100 CLS  
LOCATE 3, 20: PRINT "Select the parameter you wish to plot."  
FOR I = 1 TO NV - 1  
LOCATE 4 + I, 30: PRINT TY$(I); " = "; I  
NEXT I  
LOCATE 21, 30: INPUT "parameter number (0 to exit)"; PARAM%  
IF PARAM% = 0 THEN
```

```
CLS
EXIT SUB ' return to calling program
END IF
LOOP UNTIL 1 <= PARAM% AND PARAM% <= 14 'end of select loop
PARAM% = PARAM% + 1
DX = 5 ' x axis grid increment
GOSUB 400 ' find maximum x and y values
IF PLTFLG% = 1 THEN
PRINT "No information to plot...."
PRINT "Press any key to continue..."
DO: LOOP WHILE INKEY$ = ""
GOTO 100
END IF
GOSUB 600 ' grid and titles
FOR I = 1 TO NC
GOSUB 1110 ' plot graph
NEXT I
DO
LOOP WHILE INKEY$ = ""
CLS : SCREEN 0
LOOP
'*****
'*****
400 '* MAX SUBROUTINE *
'*****
'*****
'
MAXX = DTA(1, 1, 1)
MAXY = DTA(1, 1, PARAM%)
MINY = DTA(1, 1, PARAM%)
FOR I = 1 TO NC
FOR J = 1 TO NP
IF DTA(I, J, 1) > MAXX THEN MAXX = DTA(I, J, 1)
IF DTA(I, J, PARAM%) > MAXY THEN MAXY = DTA(I, J, PARAM%)
IF DTA(I, J, PARAM%) < MINY THEN MINY = DTA(I, J, PARAM%)
```

```
NEXT J
NEXT I
PLTFLG% = 0
DY = (MAXY - MINY) / 15
IF DY = 0 THEN
PLTFLG% = 1
DY = 5
END IF
MAG = 10 ^ (INT(LOG(DY) / LOG(10))): DY = DY / MAG
IF DY <= 5 THEN
DY = 5
ELSE
DY = 10
END IF
DY = DY * MAG
IF INT(MAXX / DX) <> MAXX / DX THEN MAXX = INT(MAXX / DX + 1) * DX
IF INT(MAXY / DY) <> MAXY / DY THEN MAXY = INT(MAXY / DY + 1) * DY
IF INT(MINY / DY) <> MINY / DY THEN MINY = INT(MINY / DY) * DY
NUMX = MAXX / DX
NUMY = (MAXY - MINY) / DY
RETURN
600
'*****
*****
'* GRID AND TITLES *
'*****
*****
'
CLS
SCREEN 2 ' 640*200 monochrome graphics
KEY OFF
'
FOR J = 0 TO NUMX
Z = J * 580 / NUMX + 59
LINE (Z, 10) - (Z, 170) ' vertical grid line
```

```
Z = J * 71 / NUMX + 7
a = DX * J
IF a < > 0 THEN ' adjustment for
D = INT(LOG(a) / LOG(10)) + 1 ' large numbers
IF D > 1 THEN Z = Z - D + 1
END IF
LOCATE 23, Z
PRINT a;
NEXT J
FOR J = 0 TO NUMY
Z = J * 160 / NUMY + 10
LINE (60, Z) - (640, Z) ' horizontal grid line
Z = 22 - J * 20 / NUMY
LOCATE Z, 2
Z = DY * J + MINY
AZ = ABS(Z)
IF INT(Z) = Z THEN
G$ = "#####"
ELSEIF AZ < .1 THEN
G$ = "#.####"
ELSEIF AZ >= .1 AND AZ < 1 THEN
G$ = "##.###"
ELSEIF AZ >= 1 AND AZ < 10 THEN
G$ = "###.##"
ELSEIF AZ >= 10 AND AZ < 100 THEN
G$ = "####.#"
ELSE
G$ = "#####"
END IF
PRINT USING G$; Z;
NEXT J
Z = (80 - LEN(TITLE$)) / 2 + 2
LOCATE 1, Z: PRINT TITLE$ ' print main title
LOCATE 24, 36: PRINT TX$; ' X axis title
LOCATE 8, 1 ' Y
```

```
FOR J = 1 TO LEN(TY$(PARAM% - 1)) ' axis
PRINT MID$(TY$(PARAM% - 1), J, 1) ' title
NEXT J
LOCATE 25, 10: PRINT "1"; ' curve
LINE (90, 195) - (130, 195)
LOCATE 25, 20: PRINT "2"; ' labels
FOR J = 0 TO 40 STEP 8
XX = 170 + J
PSET (XX, 195)
CIRCLE (XX + 80, 195), 2
NEXT J
LOCATE 25, 30: PRINT "3";
RETURN

'*****
'*****

'* PLOTTING ROUTINE *

'*****
'*****

'
1110 FOR J = 1 TO NP
XX = 580 * DTA(I, J, 1) / MAXX + 60 ' calculate pixel X position
YY = 170 - 160 * (DTA(I, J, PARAM%) - MINY) / (MAXY - MINY)
IF J = 1 THEN GOTO 1170
IF I = 1 THEN LINE (XXOLD, YYOLD) - (XX, YY) ' line 1170
1170 XXOLD = XX: YYOLD = YY
IF I = 2 THEN PSET (XX, YY) ' point
IF I = 3 THEN CIRCLE (XX, YY), 2 ' circle
NEXT J
RETURN
END SUB
REM $STATIC
DEFSNG I-L, N
SUB PRINTS

'*****

' SUBROUTINE PRINT TO SCREEN AND FILE *
```

ACMDG = 57.3 * ACMD

ALF = 57.3 * ALPHA

GAM = 57.3 * GM

PITCH = ALF + GAM

WZX = 1.689 * WZ

IF NOSAVE = 0 THEN PRINT #2, SEC, ALT, HDOT, VT, ALF, GAM, PITCH, GREFF, WXDT, WZX, VDOT,
WSALERT%

FMT1\$ = "###.## ##### ##### ###.## ###.## ###.## ###.## ###.## ###.## #"

PRINT USING FMT1\$; SEC, ALT, HDOT, VT, ALF, GAM, PITCH, GREFF, WXDT, WZX, VDOT, WSALERT%

END SUB

SUB RATES STATIC

' SUBROUTINE RATES *

SNGM = SIN(GM): CSGM = COS(GM): SNAL = SIN(ALPHA): CSAL = COS(ALPHA)

VDOT = G * ((THRST * CSAL - DRAG) / WG - SNGM) - WXDT * CSGM - WZDT * SNGM

GDOT = G * ((LIFT + THRST * SNAL) / WG - CSGM) + WXDT * SNGM - WZDT * CSGM

GDOT = GDOT / VT

HDOT = 101.28 * (VT * SNGM + WZ)

XDOT = VT * CSGM + WX

AWX = VDOT + WXDT * CSGM + WZDT * SNGM 'Inertial Acc. along Wind_x axis

AWZ = VT * GDOT - WXDT * SNGM + WZDT * CSGM 'Inertial Acc. along Wind_z axis

AU = (AWX * CSAL + AWZ * SNAL) / G 'LONG. ACCEL. ->=?

AZ = (AWX * SNGM + AWZ * CSGM) / G 'VERT. ACCEL. UP=?

VG = XDOT

GRND = (VT * GM + WZ) / (VT + WX) 'Gamma w/r ground

KF1 = 1

GHAT = GMIN * (1 + WX / VT)

IF WZ > -30 AND WZ < -20 THEN KF1 = 1 + .025 * (WZ + 20)

IF WZ <= -30 THEN KF1 = .75

DGAM = 57.3 * (20 * GDOT - (GHAT - GRND + (1 - KF1) * WZ / 152 + 20 * GDOT))

IF DGAM < 0 THEN

KF2 = (2 + .4 * DGAM)

ELSE

```
KF2 = 2
END IF
IF KF2 < 0 THEN KF2 = 0
KF2 = KF2 / 57.3
END SUB
SUB TAKEOFF STATIC
'*****
' SUBROUTINE INTIALIZE TAKEOFF *
'*****
IF APPFLG% = 0 THEN
ALPHA = .12
WHILE (LIFT <= WG)
CALL DRAGS
ALPHA = ALPHA + .01
WEND
GM = (THRST - DRAG) / WG 'COMPUTE POTENTIAL GAMMA
ELSE
GM = -3 / 57.3
ALPHA = 2 / 57.3
CALL DRAGS
TFCT = 1
CALL THRUST
T = DRAG - .052 * WG
IF T < 0 THEN T = .2 * THRST
TFCT = T / THRST
THRST = T
END IF
GMO = GM
CALL RATES
END SUB
SUB THRUST STATIC
'*****
' SUBROUTINE EPR/THRUST *
'*****
' TAKE-OFF THRUST FOR JT8D-17 ENGINES
```

```
VE = 1.668 * VT
R00 = 14688.74: R01 = -.65187546#: R02 = 6.7371E-05
R10 = -13.9295: R11 = .000751143#: R12 = -1.5405E-07
R20 = .014643: R21 = 5.3444E-07: R22 = -4.8907E-10
AA0 = (R02 * ALT + R01) * ALT + R00
AA1 = (R12 * ALT + R11) * ALT + R10
AA2 = (R22 * ALT + R21) * ALT + R20
THRST = 2 * ((AA2 * VT + AA1) * VT + AA0) 'Temp. = 100 F
IF APPFLG% = 1 THEN
IF LC% = 1 AND TFCT < 1 THEN
GMO = .136
TSPL = 5.5
'Engine Spool Up Time
TFCT = TFCT + DT / TSPL
END IF
IF TFCT > 1 THEN TFCT = 1
ELSE
TFCT = 1
END IF
THRST = TFCT * THRST
" THRST = 2 * (((2.64159E-05 * VT + 5.110896E-03) * VT - 12.56476) * VT + 15550)
END SUB
SUB VSHAKER STATIC
'----- COMPUTATION OF Vss AND V2-----
V2 = 145
VTO = V2 + 10 ' SETS INITIAL SPEED EQUAL TO V2 + 10
SELECT CASE FLPS%
CASE 10
IF VTO < 150 THEN VTO = 150 ' TAKEOFF
CASE 18
IF VTO < 148 THEN VTO = 148 ' FLAP
CASE 22
IF VTO < 147 THEN VTO = 147 ' SETTINGS
CASE 33
VTO = 63.11225 + .222468 * WG / 1000 ' APPROACH
```


CASE 42 ' FLAP

VTO = 62.67386 + .21744 * WG / 1000 ' SETTINGS

CASE ELSE

END SELECT

END SUB

SUB WINDS STATIC

!*****

' SUBROUTINE WINDS *

!*****

,

IF TDX > 0 THEN

T1 = 4

T2 = TSH

T3 = T1 + T2

T4 = -4

T5 = T3 + TDX

T6 = T5 - T4

B1 = 3 * WXDTO / T1 ^ 2

A1 = -2 * B1 / (3 * T1)

B2 = 3 * WXDTO / T4 ^ 2

A2 = -2 * B2 / (3 * T4)

IF SEC > T2 AND SEC <= T3 THEN

X = SEC - T2

WXDT = (A1 * X + B1) * X * X

END IF

IF SEC > T5 AND SEC <= T6 THEN

X = SEC - T6

WXDT = (A2 * X + B2) * X * X

END IF

IF SEC > T6 THEN WXDT = 0

WX = WX + WXDT * DT

END IF

IF TDZ > 0 THEN

T1 = 4

T2 = TSV

```
T3 = T1 + T2
T4 = - 4
T5 = T3 + TDZ
T6 = T5 - T4
B1 = 3 * WZO / T1 ^ 2
A1 = -2 * B1 / (3 * T1)
B2 = 3 * WZO / T4 ^ 2
A2 = -2 * B2 / (3 * T4)
IF SEC > T2 AND SEC <= T3 THEN
X = SEC - T2
WZ = (A1 * X + B1) * X * X
WZC = WZ
END IF
IF SEC > T5 AND SEC <= T6 THEN
X = SEC - T6
WZ = (A2 * X + B2) * X * X
WZC = WZ
END IF
KALT = (-.0000011 * ALT + .00212) * ALT - .0251
IF KALT < 0 OR ALT <= 0 THEN KALT = 0
KALT = 1
WZ = KALT * WZC
IF SEC > T6 THEN WZ = 0
WZDT = (WZ - WZ1) / DT
WZ1 = WZ
END IF
IF DFW = 1 THEN CALL MCRBRST 'DALLAS Model
END SUB
[Amdt ETSO/16]
```

ETSO-C118a

ED Decision 2018/002/R

TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS) AIRBORNE EQUIPMENT, TCAS I

1 Applicability

This ETSO provides the requirements which active traffic alert and collision avoidance system airborne equipment that are designed and 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 Radio Technical Commission for Aeronautics (RTCA) Document DO-197A, Minimum Operational Performance Standards for An Active Traffic Alert and Collision Avoidance System I (Active TCAS 1) Section 2.1 and 2.2, dated September 12, 1994, as modified by Change 1 dated July 29, 1997.

Equipment test procedures set forth in Radio Technical Commission for Aeronautics (RTCA) Document DO-197A, Minimum Operational Performance Standards for An Active Traffic Alert and Collision Avoidance System I (Active TCAS 1) Section 2.4, dated September 12, 1994, as modified by Change 1 dated July 29, 1997.

3.1.2 Environmental Standard

See CS-ETSO [Subpart A](#) paragraph 2.1

3.1.3 Software

See CS-ETSO [Subpart A](#) paragraph 2.2

3.1.4 Electronic Hardware

See CS-ETSO [Subpart A](#) paragraph 2.3.

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 is a major failure condition for malfunctions causing the display or annunciation of hazardously misleading information in airborne aircraft.

Loss of the function defined in paragraph 3.1.1 is a minor failure condition.

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.

[Amdt ETSO/13]

ETSO-C119d

ED Decision 2016/013/R

**AIRBORNE COLLISION AVOIDANCE SYSTEM II (ACAS II) VERSION 7.1 WITH
HYBRID SURVEILLANCE****1 Applicability**

This ETSO provides the requirements which Airborne Collision Avoidance System II (ACAS II) Version 7.1 equipment that are designed and 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-143, Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance System II (TCAS II), dated September 2008, as modified by Change 1 dated April 2009, Change 2 (Version 7.1) dated April 2013, and by [Appendix 1](#) to this ETSO and EUROCAE Document ED-221, Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance System II (TCAS II) Hybrid Surveillance, dated April 2013, Sections 2 and 3, as modified by [Appendix 2](#) to this ETSO

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.

3.1.4 Electronic Hardware Qualification

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific resulting in misleading information

None.

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 of this ETSO resulting in misleading information is a hazardous failure condition.

Failure of the function defined in paragraph 3.1.1 of this ETSO resulting in loss of function is a minor failure condition.

4 Marking**4.1 General**

Marking as 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.

[Amdt ETSO/11]

APPENDIX 1 TO ETSO-C119D – TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM II (TCAS II) VERSION 7.1 AMENDMENT TO EUROCAE ED-143 CHANGE 2 REQUIREMENTS

ED Decision 2016/013/R

This Appendix lists EASA modification to MPS for Traffic Alert And Collision Avoidance System (TCAS) Airborne Equipment, TCAS II Change 2, dated April 2013.

When own ship is on the ground, clarification is required to allow the system to limit the output of TCAS intruders to the display to those within 3 000 feet of own altitude. In lieu of section '2.2.2 System Performance' of EUROCAE ED-143 Change 2, substitute the following:

2.2.2 System Performance

Note: *When operating within the maximum aircraft transponder population and electromagnetic interference levels defined in subparagraph 2.2.1.2, TCAS II will provide a level of performance for active surveillance of targets-of-interest that will support the requirements for generation of collision advisory information.*

Specifically, TCAS II will generate a surveillance track in range and altitude on a target-of-interest at the range and with the track probability and range accuracy specified below. This is to ensure that a correct resolution advisory can be issued in time for the pilot to maintain adequate vertical separation at closest-point-of-approach.

TCAS II will also generate, whenever possible, a surveillance track in range and altitude on a target-of-interest at the range and with the track probability and range accuracy specified below such that a correct traffic advisory can be issued as a precursor to the resolution advisory.

In addition to the surveillance requirements to support generation of resolution and traffic advisories, TCAS II will display the range and, if available, the altitude and bearing position information on targets that generate advisories. The bearing position information will be generated according to the accuracy requirement specified below.

TCAS II will also generate for display, whenever possible, surveillance range, altitude and bearing position information on Mode C and Mode S aircraft that are within the range specified below and within $\pm 10\,000$ ft altitude relative to TCAS II when airborne, and within $\pm 3\,000$ ft altitude relative to TCAS II when on the ground.

It is acceptable to limit the output of TCAS intruders to the display to those within 3 000 feet of own altitude when own aircraft is on the ground. This is permitted (but not required) so that the altitude surveillance volume for TCAS Mode C intruders can be consistent with the Mode S surveillance altitude limits modified in EUROCAE ED-143 Change 2 (section 2.2.4.6.2.2.1). This allowance to limit the display to $\pm 3\,000$ feet does not modify surveillance altitude volumes which are defined in EUROCAE ED-143, section 2.2.4.6.

The system shall use the definition of on-ground as defined in EUROCAE ED-143, Volume II, 2.1.14. Alternatively, the system may use the definition of 'operating on Surface' in EUROCAE ED-221, section 2.2.8, for on-ground.

[Amdt ETSO/11]

APPENDIX 2 TO ETSO-C119D – TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM II (TCAS II) VERSION 7.1 HYBRID SURVEILLANCE AMENDMENT TO EUROCAE ED-221 REQUIREMENTS

ED Decision 2016/013/R

This Appendix lists EASA modification to MPS for Traffic Alert and Collision Avoidance System II (TCAS II) Hybrid Surveillance, dated April 2013.

Text from EUROCAE ED-221 is provided here as needed to provide context. Text to be added is underlined. Text to be removed is lined through.

- 1 To ensure proper revalidation when own aircraft is operating on the surface, in the first paragraph of EUROCAE ED-221, section 2.2.7.5 'Revalidation', insert the following new underlined text:

An established track that is under hybrid surveillance (per §2.2.7.1) **shall** be subject to revalidation. If a track under hybrid surveillance does not satisfy the first (altitude) condition of §2.2.6.1.4, it shall be subject to revalidation every 60th surveillance update interval; if it satisfies the first and second (altitude and range) conditions of §2.2.6.1.4 but not the third (airborne) condition, it shall be subject to revalidation every 10th surveillance update interval; if it satisfies the first condition of §2.2.6.1.4 but not the second (range) condition, it **shall** be subject to revalidation at intervals calculated according to the following procedure. The revalidation interval *t* **shall** be calculated at the time of the initial successful validation and at the time of each successful revalidation. It **shall** be used as the number of surveillance update intervals until the next revalidation attempt.

- 1.2 Because there is a requirement specifying creation of information which is never used, in EUROCAE ED-221, section 2.2.11 'Interface to the CAS Logic', delete existing lined through text from the first paragraph as follows:

Position data for tracks under passive surveillance may be provided to the CAS logic via the interface specified in Ref. A, §2.2.4.8.1. ~~If this is done, information shall be provided in addition to that required in Ref. A, §2.2.4.8.1(a) to distinguish a position report that resulted from a passive reception of an Airborne Position Message from one that resulted from an active interrogation.~~

- 1.3 Tests 2, 3a and 3b specified in EUROCAE ED-221, section 2.4.2.5 'Verification of Acquisition and Maintenance of Established Tracks Using Active Surveillance' (§2.2.6), do not need to be performed as their expected results are incorrect. Test coverage of the input conditions associated with those tests is provided, in aggregate, by other existing tests in EUROCAE ED-221.
- 1.4 A new Test 11a is required in addition to the existing Test 11 specified in EUROCAE ED-221, section 2.4.2.6 'Verification of Maintenance of Established Tracks using Passive Surveillance' (§2.2.7). This new test is to verify the revalidation rate when own aircraft is operating on the surface. Perform this new test in addition to the existing Test 11; the new test does not replace Test 11. Insert the following new underlined text after existing Test 11:

Test 11a (Intruder Revalidation Rate when own aircraft is operating on the surface §2.2.7.5)

This test verifies the revalidation rate when own aircraft is operating on the surface based on the altitude and range criteria for active tracking (§2.2.7.5).

(The following tests may be performed using ADS-B reports or directly decoded ADS-B messages. TIS-B and ADS-R data is not permitted.)

Scenario Description

- Intruder 1 shows that when own aircraft is operating on the airport surface and an intruder is within the altitude and range criteria for active surveillance it will be tracked using hybrid surveillance with a 10-second revalidation rate (§2.2.7.5).
- Intruder 2 shows that when own aircraft is operating on the airport surface and an intruder is within the altitude but not the range criteria for active surveillance it will be tracked using hybrid surveillance with a variable revalidation rate according to the requirements in (§2.2.7.5).

TCAS Aircraft

Altitude = 0 ft (Ground Level)

Altitude Rate = 0 FPM

Position = Sydney

Radio altitude input = 0 ft

Ground Speed is valid and at 0 knots and TCAS Air/Ground (OOGROUN) indicates on-ground.

Intruder Aircraft #1

Altitude = 2 000 ft

Altitude Rate = 0 FPM

Range = 2 NM

Relative Speed = 0 kt

At T = 100 the intruder is terminated.

Intruder Aircraft #2

Altitude = 2 000 ft

Altitude Rate = 0 FPM

Range = 8 NM

Relative Speed = 0 kt

At T = 100 the intruder is terminated.

Success Criteria

For the tests in this section, the revalidation rate for each applicable success criteria was identified using the table in §2.2.7.5. If the implementation uses the equation method, then the revalidation interval can be longer by 10 to 20 seconds. Care should be taken to verify that the success criteria matches the value expected based on the implementation.

For each intruder:

The surveillance reports to the CAS logic are present for the duration of the track. Verify that the track is under passive surveillance.

Intruder 1

Verify that revalidation interrogations are transmitted every 10 seconds.

Intruder 2

Verify that revalidation interrogations are transmitted every 30 seconds.

The revalidation rate for each applicable success criteria was identified using the table in §2.2.7.5. If the implementation uses the equation method, then the revalidation interval can be longer by up to 10 to 20 seconds. Care should be taken to verify that the success criteria matches the value expected based on the implementation.

- 1.5 EUROCAE ED-221 removes a provision which allowed for larger range calculation errors above ± 60 degrees latitude from RTCA/DO-300, Section 2.2.7.6 (from which ED-221 is derived), but the associated tests were not updated accordingly. To account for the removal of that provision, delete the following lined through text from EUROCAE ED-221, sections 2.4.2.8 ‘Verification of Error Budget in Computing Slant Range from Passive Data’ and 2.4.2.10 ‘Verification of DF17 Decoding’, and insert as underlined below a clarifying note in Appendix A ‘Conversion of Reported Positions to Slant Range’, section A.1 ‘Overview’.

2.4.2.8 Verification of Error Budget in Computing Slant Range from Passive Data

(...)

If the test method is used to demonstrate compliance with the requirement, then this paragraph describes one potential scenario. Own aircraft and intruder aircraft are travelling towards each other at 600 kt at high latitude (~~near 60 degrees~~). If the error between the passive range estimate and active range measurement is less than 145 meters then the intent of the requirement is met. The error in range computation of tests at slower closure rates can be used to extrapolate or predict errors at the 1 200 kt closure rate.

(...)

2.4.2.10 Verification of DF17 Decoding

(...)

Success Criteria

All Intruders.

For all of the Intruders ~~with Latitudes within ± 60 degrees~~, verify that the range for each intruder is within 145 m of the calculated range identified in Table 3.

For all of the Intruders ~~with Latitudes within ± 60 degrees~~, verify that the bearing for each intruder is within 3 degrees of the calculated bearing identified in Table 3.

Verify that the error in range from the calculated range does not use more of the error budget allowed for range based on the completion of Test §2.4.2.8 (Verification of Error Budget in Computing Slant Range from Passive Data) Test 1.

(...)

A.1 OVERVIEW

This Appendix provides useful guidance on computing range from own and reported position data. This Appendix does not recommend a particular implementation and should be used for reference only.

Firstly, the exact conversion equations from position to slant range are given. The computational requirements for the exact conversion equations are reasonable and could be used as is for modern processors and typical TCAS traffic loads.

Secondly, several approximate conversion equations from position to slant range are presented. For circumstances where hybrid surveillance is implemented as a software upgrade to existing processors, it may be desirable to use approximations to the conversion equations to reduce the computational requirements. The errors in the approximate equations are presented and compared to the computational accuracy requirements of §2.2.7.6, which requires a maximum 145 m processing error when calculating slant range.

Note: The equations in A.2 provide an example of conversion equations which meet the accuracy requirements. The approximation equations provided in the Appendix may not provide the required accuracy.

[Amdt ETSO/11]

ETSO-C121b

ED Decision 2013/012/R

UNDERWATER LOCATING DEVICE (ACOUSTIC) (SELF-POWERED)**1 Applicability**

This ETSO gives the requirements which Underwater Locating Device (Acoustic) (Self-Powered) 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 AS8045A, Minimum Performance Standard for Underwater Locating Devices (Acoustic) (Self-Powered), dated August 2011.

3.1.2 Environmental standard

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 Airborne electronic hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 Specific

The battery used in the underwater locating device authorized under this ETSO must be appropriate for the intended operational environment, not pose a hazard to the aircraft and meet the requirements of acceptable battery standards. If non-rechargeable lithium batteries are used to power the underwater locating device, [ETSO-C142a](#) "Lithium Batteries" provides MPS for such lithium batteries.

Demonstrate the saltwater immersion tests in SAE Document AS8045A, section 5.13, using a seawater solution meeting the requirements of ASTM D1141-98, Standard Practice for the Preparation of Substitute Ocean Water, dated 2008.

3.2.1 Failure condition classification

See CS-ETSO, Subpart A, paragraph 2.4.

Failure or loss of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a minor failure condition.

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.

[Amdt ETSO/3]

[Amdt ETSO/8]

ETSO-C126c

ED Decision 2020/011/R

LOCATOR TRANSMITTER**1 Applicability**

This ETSO provides the requirements which Emergency Locator Transmitters that are designed and manufactured on or after the applicability date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 Procedures**2.1 General**

The 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**

The applicable standards are those provided in EUROCAE ED-62B, MOPS for Aircraft Emergency Locator Transmitters 406 MHz, dated December 2018 as amended by EUROCAE ED-62B Change 1, dated 16 June 2020.

3.1.2 Environmental Standard

Refer to EUROCAE ED-62B as amended by EUROCAE ED-62B Change 1 and, for categories not addressed in EUROCAE ED-62B, see CS-ETSO, [Subpart A](#), paragraph 2.1.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific

None

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

A failure of the function defined in paragraph 3.1 that results in signal outputs that do not meet the requirements of paragraph 3 is a minor failure condition. A loss of the function defined in paragraph 3.1 is a minor failure condition.

A transmission of an erroneous encoded location for an ELT(DT) is a minor failure condition.

An unintended deployment of an ELT(AD) is a major failure condition.

3.2.2 Documentation

The declaration of design and performance (DDP) shall list the type, class, categories and capabilities of the ELT, as well as the applicable version of the COSPAS-SARSAT beacon standards.

A copy of the COSPAS-SARSAT approval shall be provided to EASA.

4 Marking

4.1 General

See CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

As per EUROCAE ED-62B Sections 3.10, 3.3.3, 2.9.3.2 and 3.8.2.

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/11]

[Amdt ETSO/16]

ETSO-C127b

ED Decision 2016/013/R

ROTORCRAFT, TRANSPORT AEROPLANE, AND SMALL AEROPLANE SEATING SYSTEMS

1 Applicability

This ETSO provides the Minimum Performance Standards (MPS) that rotorcraft, transport aeroplane, and small aeroplane seating systems of the following designated types that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

This ETSO's standards apply to equipment intended to be utilised as aircraft seating systems of the following classifications:

- (1) Seat Type and applicable Aircraft Category:
 - (a) Type A Airplane. Aircraft Category: Transport
 - (b) Type B Rotorcraft. Aircraft Category: Transport or Normal
 - (c) Type C Small Airplane. Aircraft Category: Normal, Utility, Acrobatic, or Commuter
- (2) Seat Subtype:
 - (a) Subtype 1 Passenger
 - (b) Subtype 2 Flight Attendant
 - (c) Subtype 3 Observer
 - (d) Subtype 4 Pilot/Co-pilot
- (3) Seat Orientation:
 - (a) Forward-Facing
 - (b) Rearward-Facing

Note: Seats with installation limitations of angles more than 18 degrees from the aircraft centre line are not addressed by this standard. See [Appendix 1](#) to this ETSO amending SAE AS8049B, subsection 5.3.3.5.i.

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

New models of rotorcraft, transport airplane, and small airplane seating systems identified and manufactured on or after the effective date of this ETSO must meet the requirements in the following: SAE International's Aerospace Standard (AS) 8049B, Performance Standard for Seats in Civil Rotorcraft, Transport Aircraft, and General Aviation Aircraft, dated January 2005, as modified by [Appendix 1](#) to this ETSO; SAE Aerospace Recommended Practice (ARP) 5526C, Aircraft Seat Design Guidance and Clarifications, dated May 2011, as modified by [Appendix 1](#) to this ETSO; and [Appendix 2](#) to this ETSO (for specific elective requirements).

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. In addition, each seating system shall be legibly and permanently marked with the following:

- (i) The specific seat MPS complied with as abbreviated by paragraphs 4.a.(1).(a) through 4.a.(1).(e) below. Separate each applicable identifier with a dash. For example, a transport airplane passenger seat that is forward facing, rearward facing, meets the step load on the baggage bar standard, and meets higher static loads shall be marked as: Type A-T-1-FF-RF-a-c.
 - (a) The seat type, use: 'Type A' for Airplane, 'Type B' for Rotorcraft, or 'Type C' for Small Airplane.
 - (b) The seat type shall be followed by the aircraft category, use: 'T' for Transport, 'N' for Normal, 'U' for Utility, 'A' for Acrobatic, or 'C' for Commuter.
 - (c) The aircraft category shall be followed by the appropriate seat subtype, use: '1' for Passenger, '2' for Flight Attendant, '3' for Observer, or '4' for Pilot/Copilot.
 - (d) The subtype shall be followed by the appropriate seat facing designation, use: 'FF' for Forward Facing, or 'RF' for Rearward Facing.
 - (e) The seat facing designations shall be followed by the applicable paragraph letter of the elective criteria defined in appendix 2 of this ETSO, use: 'a' for Step Load on Baggage Bars, 'b' for Flight Attendant Step Load, 'c' for Testing to Higher Static Loads, 'd' for Hand Holds, 'e' for Flammability –Large Exposed Non-metallic Parts.

- (ii) The seating system, safety belt restraint system, and seat cushion part numbers.
- (iii) The document reference that contains installation instructions and limitations.
- (iv) For Type A and Type B-Transport passenger, flight attendant and observer seating systems, mark each seat cushion to be qualified with 'Complies with CS 25.853(c)', or 'Complies with CS 29.853(b)', as applicable when tested in accordance with the requirements of Section 3.4.2 of SAE AS8049A, as revised by subparagraph 2.2.3 of [Appendix 1](#) of this ETSO.
- (v) Each separate component that is easily removable (without hand tools, except those components that are ETSO articles), each interchangeable element, and each separate sub-assembly of the article that the manufacturer determines may be interchangeable with other seating systems must be permanently and legibly marked with at least the name of the manufacturer, manufacturer's sub-assembly part number, and the ETSO number.

4.2 Specific

None.

5 Availability of Referenced Document

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/11]

APPENDIX 1 TO ETSO-C127B – MPS FOR ROTOCRAFT, TRANSPORT AEROPLANE, AND SMALL AEROPLANE SEATING SYSTEMS

ED Decision 2016/013/R

- 1.0. This Appendix prescribes MPS for SAE International's Aerospace Standard (AS) 8049B, *Performance Standard for Seats in Civil Rotorcraft, Transport Aircraft, and General Aviation Aircraft*, dated January 2005. When the SAE section *recommends* (or *suggests*, *advises*, etc.) something, and it is part of the MPS, the recommendation becomes a *requirement*. In addition, modify AS8049B as follows:

Table 1 — SAE AS8049B

When reading AS8049B...	Do the following:
Section 1	Disregard
Section 2	Disregard
Section 3	Apply all subsections unless disregarded or modified below: ----- Page 5, disregard subsection 3.1. ----- Page 6, replace subsection 3.2.7 to read as follows: 3.2.7 When an under-seat baggage restraint is incorporated in a passenger seat, it shall be designed to restrain at least 9.1 kg (20 lb) or its placarded weight of stowed items per passenger place under the <i>dynamic and static (forward and sideward directions only)</i> test conditions of this document in a manner that will not significantly impede rapid egress from the seat. ----- Page 6, replace subsection 3.2.15 to read as follows: 3.2.15 Except for rearward facing seats and seats equipped with multiple anchorage point pelvic restraints (e.g. Y-belts), the pelvic restraint system shall be designed such that the vertical angle between the pelvic restraint centerline and the seat reference point (SRP) waterline shall range from 35° to 55°. The SRP water line is a line/plane passing through the SRP parallel to the floor waterline. The pelvic restraint centerline is formed by a line from the pelvic restraint anchorage to a point located 250 mm (9.75 in) forward of the SRP and 180 mm (7.0 in) above the SRP water line. In addition, the pelvic restraint anchorage point(s) must be located no further than 2.0 inches forward of the SRP (ref Figure 1A). See the FAA AC 21-34 for additional guidance for acceptable seat belt geometry. ----- Page 6, add subsection 3.2.16 to read as follows: 3.2.16 All hinged armrest caps installed along an aisle must close as a result of normal movement along the aisle. Caps must not snag clothing or present any other impediment to egress when contacted by a person moving in either direction along the aisle. ----- Page 6, add subsection 3.2.17, to read as follows: 3.2.17 Safety belt restraint systems must be equipped with a metal-to-metal latching device. -----

Page 6, add subsection 3.2.18 to read as follows:

3.2.18 Design seat stowage compartments to prevent the contents becoming a hazard by shifting under the load conditions identified in Table 4 and subsection 5.3.1. Specify the maximum weight of the contents allowed in each stowage compartment.

Page 6, add subsection 3.2.19 to read as follows:

3.2.19 The seat reference point (SRP) must be determined using only one of the methods described in Figure 1B. The selected method shall be documented, and must be used consistently when evaluating all variations of the seat ETSOA model or future changes to the seat ETSOA model design.

Page 10, replace subsection 3.4.1 to read as follows:

3.4.1 Test the materials in Type A Transport and Type B Transport seating systems, ensuring they meet the fire protection properties specified in CS-25, Appendix F, Part I, paragraph (a)(1). The material's fire protection properties may be demonstrated using the methods provided in the FAA policy statement, PS-ANM-25.853-01-R2, Flammability Testing of Interior Materials, which may permit substantiation based on previously tested materials. The definition and use of parts that are considered small parts that would not contribute significantly to the propagation of a fire must be approved in advance by EASA. When inflatable restraints are included, the airbag material shall meet the flammability requirements of CS-25, Appendix F, Part I(a)(iv). Note: Inflatable restraints are a new and novel technology that may be subject to significant additional special conditions and certification requirements for installation approval.

Materials in Normal, Utility and Acrobatic category Type C seating systems must have flame-resistant properties as defined in 14 CFR Part 1. Test the materials to meet the requirements of paragraph 8.b of the FAA Advisory Circular (AC) 23-2A, Change 1, Flammability Tests. Commuter category Type C seating systems shall meet the flammability performance requirements defined in CS 23.853(d)(3), and tested as prescribed in CS-23, Appendix F, Part I.

*Materials in Type B Normal Rotorcraft seating systems must have flame-resistant properties as defined in **14 CFR Part 1**. Test the materials to meet the requirements of paragraph 8.b of the FAA Advisory Circular 23-2A 'Flammability Test', dated May 11, 2007. The material's fire protection properties may also be demonstrated by analysis (similarity) to provide equivalent protection.*

Type A — Transport airplane insulation on electrical wire and electrical cable, and materials used to provide additional protection for the wire and cable, must be self-extinguishing when tested in accordance with the applicable portions of Appendix F, Part I of CS-25.

Type B — Rotorcraft insulation on electrical wire and cable must be self-extinguishing when tested in accordance with Appendix F, Part I(a)(3), to CS-25.

Type C seats with insulation on electrical wire and electrical cable must be self-extinguishing when tested at an angle of 60 degrees in accordance with the applicable portions of Appendix F to CS-23. The average burn length must not

exceed 3 inches (76 mm) and the average flame time after removal of the flame source must not exceed 30 seconds. Drippings from the test specimen must not continue to flame for more than an average of 3 seconds after falling.

Page 10, replace subsection 3.4.2 to read as follows:

Type A Transport and Type B Transport — passenger, flight attendant, and observer seat cushion systems shall be tested to and shall meet the fire protection provisions of CS-25 Appendix F, Part II. *The material's fire protection may also be demonstrated by following the FAA AC 25.853-1 'Flammability Requirements for Aircraft Seat Cushions' and, where applicable, the FAA Policy Statement ANM-115-07-002 on certification for flammability of lightweight seat cushions.*

Page 12, replace subsection 3.5.7 to read as follows:

3.5.7 Deployable Items: Certain items on the seat, such as food trays, legrests, arm caps over in-arm tray tables, etc., are used by passengers in flight and are required to be stowed for taxi, takeoff and landing. Deployment of such items should be treated as 'permanent deformation' if the item deploys into an area that must be used by multiple passengers (in addition to the occupant of the seat) for egress. The location of the measuring point used for determining the deformation of the deployed item shall be either at the point of full deployment or at the point of the actual deployment if a partially deployed item resists further deployment upon application of a static load of 45 N (10 lb) along the direction of the inertial load path. Such deployments can be considered acceptable, even if they exceed the provisions of 3.5 and its subparagraphs, if they are readily pushed out of the way by normal passenger movement, and remain in a position that does not affect egress (i.e., when pushed out of the way it remains in that position). Normal passenger movement is the act of the seated occupant getting up out of the seat and moving to egress the airplane (i.e., unbuckling their restraint, standing, turning towards the aisle and moving into the aisle). It does not include additional movements to lift or stow items, or latching an item in place. Any items that remain in a position that would affect egress shall be reported as permanent deformation.

If the food tray table deploys as a result of being struck by the ATD head during a row-to-row HIC test and the food tray table is easily pushed out of the way, the deployment is acceptable and does not need to be considered as permanent deformation (except for seats installed where deployment may affect egress through a required exit path — see below). It is not required for the food tray table to remain in a position that does not affect egress. 'Easily pushed out of the way' is not required to be by normal passenger movement. Determination of the food tray deploying as a result of being struck by the ATD head during the test shall be made by evaluation of the high-speed film/video.

If the food tray table deploys as a result of being struck by the ATD head during the test and the food tray table is not easily pushed out of the way, the deployment shall be treated as permanent deformation.

Any food tray deployment on a seat that will be installed where deployment may affect egress through a required exit path, regardless of being struck by the ATD head, shall be treated as permanent deformation.

When reading AS8049B...	Do the following:
Section 4	Apply all subsections unless disregarded or modified below: ----- Page 16, replace note (1) in Table 4 to read as follows: <i>The 4.0 ultimate load factor applies to the seat assembly (except for the fittings). The highest special factor of safety (e.g. casting) applicable to any part (except for the fittings) shall be applied to the 4.0 ultimate load factor. Fittings (as defined in paragraph 4.1.3) must meet a minimum applied load factor of 4.0 g. The 4.0 applied load factor for the fittings includes the 1.33 fitting factor. If multiple special factors of safety are applicable to the fittings (e.g. fitting factor and casting factor), then as indicated in paragraph 4.1.4, the fitting shall be tested statically to the highest applicable special factor of safety. Since for the fittings the 4.0 g applied load factor already includes the 1.33 fitting factor, the 1.33 fitting factor is divided out before the highest special factor of safety is applied.</i> ----- Page 16, replace note (2) in Table 4 to read as follows: <i>(2) Elective: Increase these load factors as necessary for reduced weight gust/flight loads or landing requirements. Loads at angles other than those prescribed by Table 4 may be tested. All seat adjustment positions and occupancy variations, including those used in flight, must be evaluated when using these increased load factors. Document the increased load factors. They must also be marked on the ETSO placard (see Appendix 2).</i> ----- Page 16, replace note (4) in Table 4 to read as follows: <i>(4) Normal, Utility, Acrobatic and Commuter Category.</i> ----- Page 16, delete note (7) in Table 4. Explanation: The seating system's manufacturer doesn't control the CS-23 requirements applying to the seat installation. The manufacturer may test to load factors higher than required in Table 4 under the provisions of Appendix 2, paragraph c, to this ETSO. ----- Page 16, add a reference of note (8) to be applicable to the <i>Upward load direction for Type C Seat</i> in Table 4. Add note (8) to Table 4 to read as follows: <i>(8) Use a factor of 4.5 for Acrobatic Category seats.</i>
Section 5	Apply all subsections unless disregarded or modified below: ----- Page 21, replace subsection 5.1.9 to read as follows: 5.1.9 The load due to any item of mass, including the seat that is not restrained by the occupant restraint system, must be applied in a representative manner at the c.g. of the mass, <i>or with a corrective factor applied in a conservative manner relative to the c.g. of the item of mass.</i> <i>Note: If the retention of an item of mass attached to the seat is demonstrated (by the dynamic qualification tests of subsection 5.3), the static retention for the forward and down static conditions doesn't need to further be</i>

When reading AS8049B...	Do the following:
	<i>demonstrated. However, the retention of items of mass for the side, up and aft static conditions must still be demonstrated.</i> ----- Page 23, replace subsection 5.2.2 to read as follows: 5.2.2 The seat structure must be able to support ultimate loads without failure for at least 3 seconds. If it can be shown that failure of an armrest on a seat assembly does not reduce the degree of safety afforded the occupant(s) or become a hazard, such failure will not be cause for rejection. <i>Note: If the retention of an item of mass attached to the seat is demonstrated by the dynamic qualification tests of subsection 5.3, the static retention for the forward and down static conditions don't need to further be demonstrated. However, the retention of items of mass for the side, up and aft static conditions must still be demonstrated.</i> ----- Page 23, replace 5.3 to read as follows: 5.3 Dynamic Qualification Tests: This section specifies the dynamic tests to satisfy the requirements of this document. <i>For Type A Seats: it may be demonstrated the compliance with the dynamic test procedures and documentation of subsections 5.3.1 'Dynamic Impact Test Parameters' through subsection 5.3.9.2 'Impact Pulse Shape' of SAE AS 8049B by the equivalent procedures of the FAA AC 25.562-1B. The equivalent method shall be documented in the document that contains installation instructions and limitations, and must be used consistently when evaluating all variations of the seat or future changes to the seat design.</i> <i>For Type A Seats: the simplified procedures for head injury criteria (HIC) outlined in the FAA AC 25.562-1B can also be used instead of the test conditions in AS8049B subsection 5.3.6.2.</i> <i>Except for Hybrid III ATDs (49 CFR Part 572, Subpart E) modified in accordance with SAE Technical Paper 1999-01-1609, use of an equivalent ATD must be established by the applicant and accepted by EASA.</i> ----- Page 23, replace subsection 5.3.1.2 to read as follows: 5.3.1.2 Test 2 (Figures 6, 7A, and 7B), as a single row seat test, determines the performance of a system in a test condition where the predominant impact force component is along the aircraft longitudinal axis and is combined with a lateral impact force component. This test evaluates the structural adequacy of the seat, permanent deformation of the structure, the pelvic restraint and upper torso restraint (if applicable) behaviour and loads, and may yield data on ATD head displacement, velocity, and acceleration time histories and the seat leg loads imposed on the seat tracks or attachment fittings. <i>For seats intended to be installed at an angle relative to the longitudinal axis of the aircraft that is greater than 2° (but less than 18°), the test yaw angle for the test that substantiates those seats shall be 10° plus or minus the intended</i>

When reading AS8049B...	Do the following:
	<i>installation angle (if more critical) depending on which yaw angle results in the most critical attachment fitting resultant loads.</i> ----- Page 37, replace subsection 5.3.3.5.i to read as follows: Side-Facing Seats: <i>Seats with installation limitations of angles more than 18° from aircraft centerline are not addressed by this standard.</i> ----- Page 37, replace subsection 5.3.3.6 to read as follows: 5.3.3.6 Multiple Row Test Fixtures: In tests of passenger seats that are normally installed in repetitive rows in the aircraft, head and knee impact conditions are best evaluated through tests that use at least two rows of seats. These conditions are usually critical only in Test 2. This test allows direct measurements of the head and femur injury data. - The fixture shall be capable of setting the aircraft longitudinal axis at a yaw angle of – 10° and + 10°. The fixture should also allow adjustment of the seat pitch. - To allow direct measurement of head acceleration for head injury assessment for a seat installation where the head of the occupant is within striking distance of structure, a representative impact surface may be attached to the test fixture in front of the front row seat at the orientation and distance from the seat representing the aircraft installation. <i>Test 2 (Figures 6, 7A, & 7B) conducted solely to collect head/knee path data should be conducted with 0° yaw and without floor deformation. The test must be conducted on the seat with the greatest overhang among the seats selected for the applicable forward longitudinal dynamic structural test. It is acceptable to use the opposite-hand part for this seat. The occupancy used in the applicable forward longitudinal dynamic structural test must be used for this test. For consistency, a floor should be used for tests used to gather head path data. It is acceptable to collect ATD head path data in the applicable forward longitudinal dynamic structural test.</i> <i>Seats designed for seat tracks that are not in-line and parallel (track-break seats) typically require special floor attachment fittings. The installation of the seat tracks on the test fixture for these seats is unique, and depends on the intended seat location in the airplane. The test setup must represent the seat track orientation on the airplane (that is, angles, offsets, forward/aft distance, and so forth) of seat tracks under the aft attachments vs. the forward attachments).</i> ----- Page 43, replace subsection 5.3.5 to read as follows: 5.3.5 Selection of Test Articles: Many seat designs comprise a family of seats that have the same basic structural design but differ in detail. For example, a basic seat frame configuration can allow for several different seat leg locations to permit installation in different aircraft. If these differences are of a nature that their effect can be determined by rational analysis, then the analysis can determine the most critical configuration. As a minimum, the most critically stressed configuration shall be selected for the dynamic tests so that the other configurations could be accepted by comparison with that configuration.

When reading AS8049B...	Do the following:
	There are two factors that must be considered in selecting the critical structural test configurations. First, the seat to aircraft interface loads (undeformed seat) can be determined by rational analysis for the seat design and load configurations. The rational analysis can be based on static or dynamic seat/occupant analytical methods. The rational analysis can form the basis for selecting the most highly stressed critical configuration based on load. Additionally, the effects of seat deformation should be considered. As noted, a family of seats typically includes seat models with varied seat leg locations. The effects of floor deformation are more critical for narrowly spaced legs. Thus, a test or rational analysis of the seat model with the minimum seat leg spacing must be conducted to evaluate the most highly stressed critical configuration based on deformation. ----- Page 44, replace subsection 5.3.5.1 to read as follows: 5.3.5.1 In all cases, the test article must be representative of the final production article in all structural elements, and shall include the seat, seat cushions, restraints and armrests. It must also include a functioning position adjustment mechanism and correctly adjusted break over (if present). Weights simulating luggage carried by luggage restraint bars (9.1 kg (20 lb) per passenger place) need only be representative masses. Items 0.15 kg (0.33 lb) or greater that are part of the seat and affect the dynamic performance of the seat, including occupant injury and egress, must be representative of the production item and production means of attachment on the test article. Items 0.15 kg (0.33 lb) or greater that are part of the seat but do not affect the dynamic performance of the seat, including occupant injury and egress, may be representative masses, but the production means of attachment must be on the test article. Items less than 0.15 kg (0.33 lb) and their means of attachment are not required to be on the test article. However, the mass of the item must be included on the test article as ballast. Wiring harnesses, regardless of weight, may be represented on the test article by ballast weights. The production means of attachment need not be included in the test. Life vests must be installed on the test article, if provisions are provided, but are not required to be the production life vest. Any life vest of equivalent weight, or greater, may be included on the test article. <i>The life vest may be ballasted to substantiate heavier life vests. The life vest must represent the size and configuration of the production life vest if its size or configuration could affect retention of the life vest.</i> <i>For Type A seats, if an item of mass that does not affect the dynamic performance of the seat fails during a test that is otherwise acceptable, then the design may be validated by a 24g static test. The failed test article must be redesigned unless the failure is attributable to test setup or non-representative</i>

When reading AS8049B...	Do the following:
	<i>test article. The certified gross weight of the test article must be adjusted to account for any separation of mass due to failure. Apply the load for the 24g test in the same direction as the load vector in the dynamic test where the failure occurred. Any preload, such as due to floor warpage, of the failed article must be represented in the static 24g test.</i> In any case, the separation of an item of mass should not leave any sharp or injurious edges. Function of equipment or subsystems after the test is not required. Once it has been demonstrated that an item of mass can be retained in its critical loading case, subsequent tests may be conducted with the item secured for test purposes. ----- Page 45, replace subsection 5.3.6.3 to read as follows: 5.3.6.3 If a non-symmetrical upper torso restraint system (such as a single diagonal shoulder belt) is used in a system, it shall be installed on the test fixture in a position representative of that in the aircraft. For a forward-facing seat equipped with a single diagonal shoulder belt, the Test 2 yaw direction should be selected such that the belt passes over the <i>leading shoulder</i>. <i>Note: ~~For a Type A seat~~, additional tests may be required with the single diagonal shoulder belt passing over the trailing shoulder in order to evaluate retention of the harness on the occupant shoulder. As applicable, test per the FAA AC-25.562-1B, paragraph 3.b.(3).</i> ----- Page 50, replace subsection 5.3.9.2 to read as follows: 5.3.9.2 Impact Pulse Shape: Data for evaluating the impact pulse shape are obtained from an accelerometer that measures the acceleration in the direction parallel to the inertial response shown in Figures 6, 7A, and 7B. The impact pulses intended for the tests discussed in this document have an isosceles triangle shape. These ideal pulses are considered minimum test conditions. Since the actual acquired test pulses will differ from the ideal, it is necessary to evaluate the acquired test pulses to ensure the minimum requirements are satisfied. The five properties of the ideal pulse that must be satisfied by the acquired test pulse are (referring to Figures 6, 7A, and 7B, and as discussed in Appendix A): Pulse shape: isosceles triangle Greg: peak deceleration required by test condition Treq: rise time required by test condition V: total velocity change required by test condition Vtr: velocity change required during Treq ($V_{tr} = V/2$) A graphical technique can be used to evaluate pulse shapes that are not precise isosceles triangles. Appendix A presents the graphical method of evaluating the acquired pulse (the recorded test sled acceleration versus time). For the acquired pulse to be acceptable, <i>the requirements of Appendix A shall be met.</i> ----- Page 54, replace subsection 5.3.9.9 to read as follows:

When reading AS8049B...	Do the following:
	5.3.9.9 Femur Load (Type A Seats): Data for measuring femur loads can be collected in the tests discussed in this document if the ATD's legs contact seats or other structure. The maximum compressive load in the femur can be obtained directly from a plot or listing of each femur load transducer output. If the value of peak acceleration measured in the test exceeds the level given in Figure 6, 7A, or 7B, the femur load measured in the test may be adjusted by no more than 10 % by multiplying the measured values by the ratio of the peak acceleration given in Figure 6, 7A, or 7B, divided by the measured peak acceleration, if necessary. Data need not be recorded in each individual test if rational comparative analysis is available for showing compliance. For large clearance installations (distance from seat SRP to strike target is greater than 100 cm (40 in.) nominally), no data is necessary to substantiate femur loads. <i>However, appropriate limitations must be documented.</i> <i>Extensive seat testing has shown that the femur loading criterion is not usually exceeded therefore, recording femur loads may not be necessary during the test if it can be shown compliance by rational comparative analysis using data from previous tests. However, the rational analysis must show that the testing applies to the seat design, and must include appropriate limitations which must be documented.</i> ----- Page 54, replace subsection 5.3.9.11 to read as follows: 5.3.9.11 Seat Deformation: The permanent deformations affecting aircraft evacuation shall be evaluated and documented. The floor deformation fixture may be returned to the flat floor condition for documenting seat deformation. This documentation can take the form of dimensioned scale drawings that show the seat in its deformed condition relative to a reference origin, such as a floor track fitting which can be related to the aircraft interior. If the seat deformation is not critical, still photographs of the seat (with dimensional targets or grids in place so that measurements can be made) will provide adequate documentation. Any actions necessary for proper seat functions, such as stowage of the seat when the ATD is removed, shall be observed and documented. <i>Safety belt restraint systems must not yield to the extent they would impede rapid evacuation of the occupant.</i> ----- Page 56, replace subsections 5.3.10.1.1.e and 5.3.10.1.1.f to read as follows: e. A statement confirming that the data collection was done in accordance with the requirements of this document, or a detailed description of the actual procedure used and technical analysis showing equivalence to the requirements of this document. ~~f. Manufacturer, governing specification, serial number, and test weight of ATDs used in the tests, and a description of any modifications or repairs performed on the ATDs that could cause them to deviate from the specification.~~
Section 6	Disregard and refer to paragraph 4 of this ETSO.
Section 7	Disregard
Appendix A	No Changes

- 2.0 This paragraph prescribes the MPS for SAE International ARP5526C ‘Aircraft Seat Design Guidance and Clarifications’, dated May 2011. When the SAE section recommends (or suggests, advises, etc.) something, and it is part of the MPS, the recommendation becomes a requirement. In addition, modify ARP5526C as follows:

Table 2 — SAE ARP5526C

When reading ARP5526C...	Do the following:
Section 1	Disregard
Section 2	Disregard
Section 3	Disregard all subsections in Section 3 not listed below. The following subsections apply as modified: Page 5, replace subsection 3.2.2 to read as follows: 3.2.2 Definition and Criteria: Seatbelt misalignment is a condition where the seatbelt and/or shackle is positioned to give the impression that the belt has been properly tightened, when in fact there is slack in the system or the shackle is positioned so that it will not carry the force generated in an emergency landing or turbulence condition. <i>Restraint system anchorages should provide self-aligning features. If self-aligning features are not provided, the static and dynamic tests in this document should be conducted with the restraints and anchorages positioned in the most adverse configuration allowed by the design. The anchorage system shall minimise the possibility of incorrect installation or inadvertent disconnection of the restraints.</i> The seat belt installation should not appear to the belted occupant to be properly adjusted (snug) while there is significant (2.54 cm (one inch) or more) slack in the system which may pay out in an emergency landing situation. For example, the belt installation should not be able to be caught between seat features such that the occupant would not know there was slack in the belt which may allow the occupant to slide forward during emergency landing or turbulence. To test the installed seat belt for misalignment, the seat should be positioned in its taxi, take-off and landing condition. Installations on seats having bottom cushions that can be removed or incorrectly repositioned without tools should be evaluated with the cushions installed, removed and incorrectly repositioned. The belt and shackle combination should be manipulated with one hand in an attempt to place the restraint in a non-design configuration where it could carry the seatbelt adjustment forces. Particular effort should be made to place the restraint in a position that the restraint forces would not be applied to the hook of the shackle in the same manner as they would be applied in a straight tension pull on the belt. Attempts should be made with the restraint in its normal shape, a single twist of the webbing and/or a single fold of the webbing. Typical areas around the restraint shackle that should be checked are the plastic shrouding around the armrest, the hydraulic seat recline device, the seat pan, anti-rotation brackets/stops, seat pan supports and exposed fasteners. If a condition of potential misalignment is identified, the seatbelt and shackle, in that condition, should be loaded by a restorative force of 22.2 N (five pounds) applied through the belt in the direction that it would be loaded in the emergency landing or turbulence situation. If the load is carried in the

When reading ARP5526C...	Do the following:
	misaligned condition, the design is unacceptable. The examples in Section 3.2.3 illustrate various misalignment conditions that have been found to be unacceptable, as indicated. These examples are not intended to be all-inclusive. To test the belt for inadvertent disengagement, where disengagement is defined as the separation of the restraint's attachment fitting from the seat structure, the belt should be tested in all orientations with the seat in the taxi, take-off and landing conditions with the seat cushions installed. Interaction of belts in adjacent seats, where the belts could be inadvertently crossed and used by occupants in those adjacent seats, must be evaluated for the possibility of disengagement. ----- Page 9, replace subsection 3.3.2 to read as follows: <i>3.3.2 Definition and Criteria: The terms 'life preserver', 'life vest' and 'life jacket' may be used interchangeably. When life preserver stowage provisions are included as part of the seat design, the stowage provisions shall provide access to a life preserver for each seating position. The life preserver stowage shall be designed and located such that the requirements of this section are met. The installation, operating and maintenance instructions shall also reflect the requirements of this section. For example, installation instructions shall account for the allowable life preserver weight and size, marking requirements, as well as the required unobstructed area to remove the life preserver from the container. Furthermore, the operating instructions must report the detailed content of the simulated preflight briefing and any special instructions for unique aspects of the design operation that should be considered for operational use and continued performance.</i> <i>a. The life preserver shall be restrained under all applicable loading conditions, i.e. the retention device shall not allow the life preserver to come free during emergency landing static and dynamic conditions, taxi, take-off, landing, turbulence, and during stowage and removal of underseat baggage.</i> <i>b. Any life preserver locating placard installed on the seat shall accurately state the location of the life preserver and be adequately marked per 3.8.2 of this ARP5526 Revision C document (e.g. "Life preserver under center armrest"). For life preserver locations other than under the seat or under a console between the seats, mark "Life preserver" or "Life preserver inside" on the container or compartment, unless the location is identified with a pull strap. Pull straps shall be red or labelled "PULL" or "PULL FOR LIFE PRESERVER" in contrasting colour. A symbolic placard may be used in lieu of text. For seats intended to be installed in sequential rows, a placard may be on the seat back stating the location of the life preserver for the occupant seated behind.</i> <i>c. The retrieval path of the life preserver shall be free of obstructions due to life preserver container movement and/or seat or aircraft components (e.g. seat legs, cushions, baggage bars, shrouds, etc.) when the seat is in the configuration for taxi, take-off and landing.</i> <i>d. The life preserver stowage shall not present any sharp edges or points that could damage the life preserver or cause injury.</i> <i>e. For underseat pan storage on passenger seats (excluding center console storage):</i>

When reading ARP5526C...	Do the following:
	1) A pull strap shall be connected to the life preserver, or a pull strap or latch shall be on the compartment opening, such that when the strap or latch is pulled, the preserver is presented on the strap or the occupant can reach into the compartment to retrieve the preserver (i.e. one or two motions of the occupant result in retrieval of the life preserver). 2) The life preserver shall be located no more than 3 inches aft of the front edge of the seat bottom, i.e. the seat frame or cushion, whichever is further forward. 3) Unless limited by seat cushions or structure (e.g. seat leg, floor, etc.), designs utilising a pull strap shall permit life preserver retrieval when pulled from any angle between: a) 45 degrees up and 50 degrees down from the horizontal, b) 45 degrees left and 45 degrees right from the container centerline. 4) For designs utilising a pull strap, normal seat operation or underseat baggage storage activities shall not sweep the pull strap into an unreachable location. 5) The life preserver container, or compartment, as installed on the seat shall protect the life preserver from inadvertent damage from normal passenger movement such as the stowage and removal of underseat baggage. f. Demonstrate that the life preserver shall be within easy reach of, and shall be readily removed by a seated and belted occupant (shoulder strap(s) may be removed prior to demonstration), for all seat orientations and installations that are intended for use during taxi, take-off and landing. In lieu of an actual life preserver, a representative object (e.g. size and weight) may be utilised for testing. The evaluation to quickly retrieve the preserver is to begin with the occupant moving their hand(s) from the seated position to reach for the preserver and to end with the occupant having the preserver in their hand(s) and fully removed from the stowage container. It does not include the time for the occupant to return to the upright position, to remove a pull strap from the preserver (if used) or to open the preserver package provided by the preserver manufacturer. Test the critical configuration(s) to demonstrate retrieval in less than 10 seconds by a minimum of 5 test subjects with a success rate of no less than 75 %. The test shall evaluate three anticipated occupant test subject size categories: 5th, 50th and 95th percentile. At least one occupant from each size category shall demonstrate successful retrieval within 10 seconds. Test subjects for either the 5th or 95th percentile occupant category shall not exceed 40 % of the overall test subject population. 1) For passenger seats, the test subjects shall be naïve. For the purpose of this test, naïve test subjects shall be defined as: they shall have had no experience within the prior 24 months in retrieving a life preserver. Subjects must receive no retrieval information other than a typical preflight briefing. The occupant size categories to be evaluated shall be defined as: a. A 5th percentile is no more than 60 in. (1.5 m) tall. b. A 50th percentile is at least 63 in. (1.6 m) tall but no more than 70 in. (1.8 m) tall. c. A 95th percentile weighs at least 244 lb (110.7 kg). 2) For flight attendant and observer seats, the test subjects do not need to be naïve. The occupant size categories to be evaluated shall be defined as: a. A 5th percentile is no more than 60 in. (1.5 m) tall. b. A 50th percentile is at least 63 in. (1.6 m) tall but no more than 70 in. (1.8 m) tall.

When reading ARP5526C...	Do the following:
	<i>c. A 95th percentile weighs at least 244 lb (110.7 kg).</i> <i>3) For pilot/co-pilot seats, the test subjects do not need to be naïve. The occupant size categories to be evaluated shall be defined as:</i> <i>a. A 5th percentile is no more than 62 in. (1.57 m) tall.</i> <i>b. A 50th percentile is at least 63 in. (1.6m) tall but no more than 70 in. (1.8 m) tall.</i> <i>c. A 95th percentile weighs at least 244 lb (110.7 kg).</i> 3.6.2 For Type A seats, apply as written. 3.7.2 For Type A seats, apply as written. Page 13, replace subsection 3.8.2 to read as follows: 3.8.2 Definition and Criteria: Safety placards on occupant seats should be permanently affixed, located such that they cannot be easily obscured and of a type that cannot be easily erased. The lettering height and colour contrast should be sufficient to allow the placard to be read by the intended occupant (e.g. placards located on the back of the seat should be designed to allow the occupant seated behind to easily read it at the anticipated installed pitch.) 3.9.2 Apply as written. 3.10.2 Apply as written. 3.11.2 Apply as written. Page 20, replace subsection 3.12.2 to read as follows: 3.12.2 Definition and Criteria: Edges that could cut skin during normal use (including in edges on electrical equipment) should be eliminated and for maintenance should be minimised. <i>To be considered non-injurious, edges that are accessible (as defined in section 3.11.2.1) and could cut skin during normal use shall meet either of the standards listed below:</i> 1. NASA Standard 3000 Volume I (NASA–STD-3000 Vol. I), Man-Systems Integration Standards, Revision B, July 1995, Section 6.3.3, or 2. UL 1439, Standard for Tests for Sharpness of Edges on Equipment, Edition 4, February 26, 1998, with revisions through 6/1/2004. In addition, the seat should not have any feature whose edges or corners are exposed when deployed, that presents an impediment to an occupant’s egress (e.g. cocktail table, seat back and in-arm video, flip-out PCU, ashtray, etc.). 3.13.2 Apply as written. 3.14.2 Apply as written. 3.15.2 Apply as written. 3.17.2 For Type A passenger seats, apply as written. 3.20.2 Apply as written.
Appendix A	Apply Appendix A as necessary to comply with the requirements of this ETSO.

When reading ARP5526C...	Do the following:
Appendix B	Disregard all subsections in Appendix B not listed below. The following subsections apply as modified: ----- B.1.1.14 Apply as written. B.1.1.26 Apply as written. ----- Page 46, replace subsection B.1.1.28 to read as follows: B.1.1.28 Where seat recline could adversely affect emergency evacuation, passenger seat recline and control mechanisms should have an override feature so that the reclined seat back may be moved to the upright position without releasing the recline control button.

[Amdt ETSO/11]

APPENDIX 2 TO ETSO-C127B – ELECTIVE MPS FOR ROTOCRAFT, TRANSPORT AEROPLANE, AND SMALL AEROPLANE SEATING SYSTEMS

ED Decision 2016/013/R

Complying with the MPS in these paragraphs is elective. However, the MPS must be followed for the one(s) elected to comply.

Per ETSO paragraph **3.1.1**, elective MPS subparagraphs complied with must be documented and reported to receive credit under this ETSO.

In addition, see ETSO paragraph **4.1.(i).(e)** for marking requirements.

- a. Step Load on Baggage Bars: For seats where the baggage restraint allows application of a foot step load, apply the test criteria of ARP5526C, subsection 3.7.2. The testing must not degrade either the basic forward or side load carrying capabilities noted in AS8049B, Table 4, or result in deformation, posing a tripping hazard.
- b. Flight Attendant Step Load: For seats that include a built-in flight attendant step in the seat design, demonstrate that such a step design meets expected service loads. Apply ARP5526C, Appendix B, subsection B.1.1.29, Table B1, to qualify the design.
- c. Testing to Higher Static Loads: To substantiate the seat to load factors higher than those specified in Table 4 of AS8049B, or to combine load factors, the higher load factors must be reported. The higher load factors must be marked on the ETSO placard.
- d. Hand Holds: For seats designed to provide a handhold for passengers moving about the airplane, apply ARP5526C, Section 3.1.2.
- e. Flammability — Large Exposed Non-metallic Parts: For Type A seats incorporating large non-metallic panels in their design, test and meet the fire protection provisions of Appendix F, parts IV and part V (heat release and smoke emission) of CS-25. The material's fire protection properties may be demonstrated using the methods provided in the FAA policy statement, PS-ANM-25.853-01-R2 'Flammability Testing of Interior Materials', which may permit substantiation based on previously tested materials.

[Amdt ETSO/11]

ETSO-C132a

ED Decision 2016/029/R

GEOSYNCHRONOUS ORBIT AERONAUTICAL MOBILE SATELLITE SERVICES AIRCRAFT EARTH STATION EQUIPMENT

1 Applicability

This ETSO gives the requirements which Geosynchronous Orbit Aeronautical Mobile Satellite Services (AMSS) aircraft earth station equipment that is designed and 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 Federal Aviation Administration standard “Geosynchronous Orbit Aeronautical Mobile Satellite Services Aircraft Earth Station Equipment”.

This standard is based on RTCA document DO 210D “MOPS for Geosynchronous Orbit Aeronautical Mobile Satellite Services (AMSS) avionics” Section 2.0 dated April 19, 2000 including Change 1, dated December 14, 2000, Change 2, dated November 28, 2001, Change 3 dated September 19, 2006; and Change 4, dated March 24, 2015.

Functionality. This ETSO’s standards apply to AMSS AES equipment that provides direct worldwide communications between aircraft subnetworks and ground subnetworks using aeronautical mobile satellites in geosynchronous orbit and their ground earth stations. AMSS will support both data and voice communications between aircraft users and ground-based users, such as air route traffic control centers (ARTCC) and aircraft operators. Communication services with AMSS functions include four categories: air traffic services (ATS), aircraft operational control (AOC), aeronautical administrative communications (AAC), and aeronautical passenger communications (APC).

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

3.2.1 Failure Condition Classification

See CS-ETSO [Subpart A](#) paragraph 2.4.

- (1) Failure of the function defined in paragraph 3.1.1 is a minor failure condition.
- (2) Loss of the function defined in paragraph 3.1.1 of this ETSO is a minor failure condition. Satellite communication is a supplemental service operation, with high frequency (HF) radio required for primary communication. The loss of satellite communication is mitigated by availability of HF communications.
- (3) AMSS equipment is intended for procedural airspace area operations. FAA determined the failure condition specified in paragraph 3.2.1 of this ETSO based on AMSS equipment operating as an approved long-range communication system (LRCS) in oceanic airspace area environments. Use of AMSS equipment in other operating environments (for example, high-density terminal/en route domestic airspace) may impact equipment performance and safety considerations.

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.

[Amdt ETSO/3]

[Amdt ETSO/12]

ETSO-C135a

ED Decision 2010/010/R

LARGE AEROPLANE WHEELS AND WHEEL AND BRAKE ASSEMBLIES**1 Applicability**

This ETSO prescribes the minimum performance standard that large aeroplane wheels, and wheel and brake assemblies must meet to be identified with the applicable ETSO marking. Brakes and associated wheels are to be considered as an assembly for ETSO authorisation purposes.

2 Procedures**2.1 General**

Applicable procedures are detailed in CS-ETSO [Subpart A](#).

2.2 Specific**2.2.1 Data Requirements.**

2.2.1.1 In addition to the data specified in CS-ETSO Subpart A, the manufacturer must furnish one copy each of the following to the Agency:

2.2.1.2 The applicable limitations pertaining to installation of wheels or wheel and brake assemblies on aeroplane(s), including the data requirements of paragraph 4.1 of [Appendix 1](#) or [Appendix 2](#) of this ETSO.

2.2.1.3 The manufacturer's ETSO qualification test report.

2.2.2 Data to be Furnished with Manufactured Articles.

2.2.2.1 Prior to entry into service use, the manufacturer must make available to the Agency all applicable maintenance instructions and data necessary for continued airworthiness.

2.2.2.2 The manufacturer must provide the applicable maintenance instructions and data necessary for continued airworthiness to each organisation or person receiving one or more articles manufactured under this ETSO. In addition, a note with the following statement must be included:

"The existence of ETSO approval of the article displaying the required marking does not automatically constitute the authority to install and use the article on an aeroplane. The conditions and tests required for ETSO approval of this article are minimum performance standards. It is the responsibility of those desiring to install this article either on or within a specific type or class of aeroplane to determine that the aeroplane operating conditions are within the ETSO standards. The article may be installed only if further evaluation by the user/installer documents an acceptable installation and the installation is approved by the Agency.

Additional requirements may be imposed based on aeroplane specifications, wheel and brake design, and quality control specifications. In-service maintenance, modifications, and use of replacement components must be in compliance with the performance standards of this ETSO, as well as any additional specific aeroplane requirements."

3 Technical Conditions

3.1 Basic

3.1.1 Minimum Performance Standard

3.1.1.1 Hydraulically actuated brakes and wheels

Standards set forth in Appendix 1.

3.1.1.2 Electrically actuated brakes and wheels

Standards set forth in Appendix 2 for the brakes plus the applicable requirements of Appendix 1 for the wheels.

3.1.2 Environmental Standard

None.

3.1.3 Computer Software

None

3.2 Specific

None

4 Marking

4.1 General

In addition to the marking specified in CS-ETSO Subpart A paragraph 1.2; the following information shall be legibly and permanently marked on the major equipment components:

- (i) Size (this marking applies to wheels only).
- (ii) Hydraulic fluid type (this marking applies to hydraulic brakes only).
- (iii) Serial Number.

4.1.1 All stamped, etched, or embossed markings must be located in non-critical areas.

4.2 Specific

None.

5 Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.

[Amdt ETSO/6]

APPENDIX 1 TO ETSO-C135A – MINIMUM PERFORMANCE SPECIFICATION FOR LARGE AEROPLANE WHEELS, BRAKES, AND WHEEL AND BRAKE ASSEMBLIES

ED Decision 2010/010/R

CHAPTER 1

INTRODUCTION

1.1 PURPOSE AND SCOPE.

This Minimum Performance Specification defines the minimum performance standards for wheels, brakes, and wheel and brake assemblies to be used on aeroplanes certificated under CS-25. Compliance with this specification is not considered approval for installation on any large aeroplane.

1.2 APPLICATION.

Compliance with this minimum specification by the applicant is required as a means of assuring that the equipment will have the capability to satisfactorily perform its intended function(s).

Note: Certain performance capabilities may be affected by aeroplane operational characteristics and other external influences. Consequently, anticipated aeroplane braking performance should be verified by aeroplane testing.

1.3 COMPOSITION OF EQUIPMENT.

The words “equipment” or “brake assembly” or “wheel assembly,” as used in this document, include all components that form part of the particular unit.

For example, a wheel assembly typically includes a hub or hubs, bearings, flanges, drive bars, heat shields, and fuse plugs. A brake assembly typically includes a backing plate, torque tube, cylinder assemblies, pressure plate, heat sink, and temperature sensor.

It should not be inferred from these examples that each wheel assembly and brake assembly will necessarily include either all or any of the above example components; the actual assembly will depend on the specific design chosen by the applicant.

1.4 DEFINITIONS AND ABBREVIATIONS.

1.4.1 Brake Lining.

Brake lining is individual blocks of wearable material, discs that have wearable material integrally bonded to them, or discs in which the wearable material is an integral part of the disc structure.

1.4.2 $BROP_{MAX}$ - Brake Rated Maximum Operating Pressure.

$BROP_{MAX}$ is the maximum design metered pressure that is available to the brake to meet aeroplane stopping performance requirements.

1.4.3 BRP_{MAX} - Brake Rated Maximum Pressure.

BRP_{MAX} is the maximum pressure to which the brake is designed to be subjected (typically aeroplane nominal maximum system pressure).

1.4.4 BRP_{RET} - Brake Rated Retraction Pressure.

BRP_{RET} is the pressure to which the brake inlet pressure must be reduced to cause full piston retraction after a brake is sufficiently pressurised to extend all pistons.

1.4.5 BRPP_{MAX} - Brake Rated Maximum Parking Pressure.

BRPP_{MAX} is the maximum parking pressure available to the brake.

1.4.6 BRWL - Brake Rated Wear Limit.

BRWL is the brake maximum wear limit to ensure compliance with paragraph 3.3.3, and, if applicable, paragraph 3.3.4 of this Appendix 1.

1.4.7 D - Distance Averaged Deceleration.

$D = ((\text{Initial brakes-on speed})^2 - (\text{Final brakes-on speed})^2) / (2 (\text{braked flywheel distance}))$.

D is the distance averaged deceleration to be used in all deceleration calculations.

1.4.8 D_{DL} - Rated Design Landing Deceleration.

D_{DL} is the minimum of the distance averaged decelerations demonstrated by the wheel, brake and tyre assembly during the 100 KE_{DL} stops in paragraph 3.3.2 of this Appendix 1.

1.4.9 D_{RT} - Rated Accelerate-Stop Deceleration.

D_{RT} is the minimum of the distance averaged decelerations demonstrated by the wheel, brake, and tyre assembly during the KE_{RT} stops in paragraph 3.3.3 of this Appendix 1.

1.4.10 D_{SS} - Rated Most Severe Landing Stop Deceleration.

D_{SS} is the distance averaged deceleration demonstrated by the wheel, brake and tyre assembly during the KE_{SS} Stop in paragraph 3.3.4 of this Appendix 1.

1.4.11 Heat Sink.

The heat sink is the mass of the brake that is primarily responsible for absorbing energy during a stop.

For a typical brake, this would consist of the stationary and rotating disc assemblies.

1.4.12 KE_{DL} - Wheel/Brake Rated Design Landing Stop Energy.

KE_{DL} is the minimum energy absorbed by the wheel/brake/tyre assembly during every stop of the 100 stop design landing stop test. (paragraph 3.3.2 of this Appendix 1).

1.4.13 KE_{RT} - Wheel/Brake Rated Accelerate-Stop Energy.

KE_{RT} is the energy absorbed by the wheel/brake/tyre assembly demonstrated in accordance with the accelerate-stop test in paragraph 3.3.3 of this Appendix 1.

1.4.14 KE_{SS} - Wheel/Brake Rated Most Severe Landing Stop Energy.

KE_{SS} is the energy absorbed by the wheel/brake/tyre assembly demonstrated in accordance with paragraph 3.3.4 of this Appendix 1.

1.4.15 L - Wheel Rated Radial Limit Load.

L is the wheel rated maximum radial limit load (paragraph 3.2.1 of this Appendix 1).

1.4.16 R - Wheel Rated Tyre Loaded Radius.

R is the static radius at load “S” for the wheel rated tyre size at WRP. The static radius is defined as the minimum distance from the axle centreline to the tyre/ground contact interface.

1.4.17 S - Wheel Rated Static Load.

S is the maximum static load (Reference CS 25.731(b)).

1.4.18 ST_R - Wheel/Brake Rated Structural Torque.

ST_R is the maximum structural torque demonstrated (paragraph 3.3.5 of this Appendix 1).

1.4.19 TS_{BR} - Brake Rated Tyre Type(s) and Size(s).

TS_{BR} is the tyre type(s) and size(s) used to achieve the KE_{DL}, KE_{RT}, and KE_{SS} brake ratings.

TS_{BR} must be a tyre type and size approved for installation on the wheel (TS_{WR}).

1.4.20 TS_{WR} - Wheel Rated Tyre Type(s) and Size(s).

TS_{WR} is the wheel rated tyre type(s) and Size(s) defined for use and approved by the aeroplane manufacturer for installation on the wheel.

1.4.21 TT_{BT} - Suitable Tyre for Brake Tests.

TT_{BT} is the rated tyre type and size.

TT_{BT} is the tyre type and size that has been determined as being the most critical for brake performance and/or energy absorption tests. The TT_{BT} must be a tyre type and size approved for installation on the wheel (TS_{WR}). The suitable tyre may be different for different tests.

1.4.22 TT_{WT} - Suitable Tyre for Wheel Test.

TT_{WT} is the wheel rated tyre type and size for wheel test.

TT_{WT} is the tyre type and size determined as being the most appropriate to introduce loads and/or pressure that would induce the most severe stresses in the wheel.

TT_{WT} must be a tyre type and size approved for installation on the wheel (TS_{WR}). The suitable tyre may be different for different tests.

1.4.23 V_{DL} - Wheel/Brake Design Landing Stop Speed.

V_{DL} is the initial brakes-on speed for a design landing stop (paragraph 3.3.2 of this Appendix 1).

1.4.24 V_R - Aeroplane Maximum Rotation Speed.**1.4.25 V_{RT} - Wheel/Brake Accelerate-Stop Speed.**

V_{RT} is the initial brakes-on speed used to demonstrate KE_{RT} (paragraph 3.3.3 of this Appendix 1).

1.4.26 V_{SS} - Wheel/Brake Most Severe Landing Stop Speed.

V_{SS} is the initial brakes-on speed used to demonstrate KE_{SS} (paragraph 3.3.4 of this Appendix 1).

1.4.27 W_{RP} - Wheel Rated Inflation Pressure.

W_{RP} is the wheel rated inflation pressure (wheel unloaded).

CHAPTER 2**GENERAL DESIGN SPECIFICATION****2.1 AIRWORTHINESS.**

The continued airworthiness of the wheels (without brakes) and wheel and brake assemblies must be considered. See chapter 4 of this Appendix 1, titled “DATA REQUIREMENTS”.

2.2 FIRE PROTECTION.

Except for small parts (such as fasteners, seals, grommets, and small electrical parts) that would not contribute significantly to the propagation of a fire, all solid materials used must be self-extinguishing. See also paragraphs 2.4.5, 3.3.3.5 and 3.3.4.5 of this Appendix 1.

2.3 DESIGN.

Unless shown to be unnecessary by test or analysis, the equipment must comply with the following:

2.3.1 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 lubricated cavity.

2.3.2 Removable Flanges.

All removable flanges must be assembled onto the wheel in a manner that will prevent the removable flanges and retaining devices from leaving the wheel if a tyre deflates while the wheel is rolling.

2.3.3 Adjustment.

The brake mechanism must be equipped with suitable adjustment devices to maintain appropriate running clearance when subjected to BRP_{RET}.

2.3.4 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.

2.3.5 Burst Prevention.

Means must be provided to prevent wheel failure and tyre burst that might result from over-pressurisation or from elevated brake temperatures. The means must take into account the pressure and the temperature gradients over the full operating range.

2.3.6 Wheel Rim and Inflation Valve.

Tyre and Rim Association (Reference: Aircraft Year Book-Tyre and Rim Association Inc.) or, The European Tyre and Rim Technical Organisation (Reference: Aircraft Tyre and Rim Data Book) approval of the rim dimensions and inflation valve is encouraged.

2.3.7 Brake Piston Retention.

The brake must incorporate means to ensure that the actuation system does not allow hydraulic fluid to escape if the limits of piston travel are reached.

2.3.8 Wear Indicator.

A reliable method must be provided for determining when the heat sink is worn to its permissible limit.

2.3.9 Wheel Bearings.

Means should be incorporated to avoid mis-assembly of wheel bearings.

2.3.10 Fatigue.

The design of the wheel must incorporate techniques to improve fatigue resistance of critical areas of the wheel and minimise the effects of the expected corrosion and temperature environment. The wheel must include design provisions to minimise the probability of fatigue failures that could lead to flange separation or other wheel burst failures.

2.3.11 Dissimilar Materials.

When dissimilar materials are used in the construction and the galvanic potential between the materials indicate galvanic corrosion is likely, effective means to prevent the corrosion must be incorporated in the design. In addition, differential thermal expansion must not unduly affect the functioning, load capability, and the fatigue life of the components.

2.4 CONSTRUCTION.

The suitability and durability of the materials used for components must be established on the basis of experience or tests. In addition, the materials must conform to approved specifications that ensure the strength and other properties are those that were assumed in the design.

2.4.1 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 serviceability is not impaired.

2.4.2 Forgings.

Forgings must be of uniform condition, free from blisters, fins, folds, seams, laps, cracks, segregation, and other defects. Imperfections may be removed if strength and serviceability would not be impaired as a result.

2.4.3 Bolts and Studs.

When bolts or studs are used for fastening together sections of a wheel or brake, the length of the threads must be sufficient to fully engage the nut, including its locking feature, and there must be sufficient unthreaded bearing area to carry the required load.

2.4.4 Environmental Protection.

All the components used must be suitably protected against deterioration or loss of strength in service due to any environmental cause, such as weathering, corrosion, and abrasion.

2.4.5 Magnesium Parts.

Magnesium and alloys having magnesium as a major constituent must not be used on brakes or braked wheels.

CHAPTER 3**MINIMUM PERFORMANCE UNDER STANDARD TEST CONDITIONS.****3.1 INTRODUCTION.**

The test conditions and performance criteria described in this chapter provide a laboratory means of demonstrating compliance with this ETSO minimum performance standard. The aeroplane manufacturer normally defines relevant test parameter values, however these may also be derived from published aircraft data for applicants for supplementary type certificates (STC).

3.2 WHEEL TESTS.

To establish the ratings for a wheel, it must be substantiated that standard production wheel samples will meet the following radial load, combined load, roll load, roll-on-rim (if applicable) and overpressure test requirements.

For all tests, except the roll-on-rim test in paragraph 3.2.4 of this Appendix 1, the wheel must be fitted with a suitable tyre, TT_{WT} , and wheel loads must be applied through the tyre. The ultimate load tests in paragraphs 3.2.1.3 and 3.2.2.3 of this Appendix 1 provide for an alternative method of loading if it is not possible to conduct these tests with the tyre mounted.

3.2.1 Radial Load Test.

If the radial limit load of paragraph 3.2.2 of this Appendix 1 is equal to or greater than the radial limit load in this paragraph, the test specified in this paragraph may be omitted.

Test the wheel for yield and ultimate loads as follows:

3.2.1.1 Test method.

With a suitable tyre, TT_{WT} , installed, mount the wheel on its axle, and position it against a flat, non-deflecting surface. The wheel axle must have the same angular orientation to the non-deflecting surface that it will have to a flat runway when it is mounted on an aeroplane and is under the maximum radial limit load, L . Inflate the tyre to the pressure recommended for the Wheel Rated Static Load, S , with gas and/or liquid.

If liquid inflation is used, liquid must be bled off to obtain the same tyre deflection that would result if gas inflation were used.

Liquid pressure must not exceed the pressure that would develop if gas inflation were used and the tyre was deflected to its maximum extent. Load the wheel through its axle with the load applied perpendicular to the flat, non-deflecting surface. Deflection readings must be taken at suitable points to indicate deflection and permanent set of the wheel rim at the bead seat.

3.2.1.2 Yield Load.

Apply to the wheel and tyre assembly a load not less than 1.15 times the maximum radial limit load, L , reference CS 25.471 through 25.511, as appropriate.

Determine the most critical wheel orientation with respect to the non-deflecting surface. Apply the load with the tyre loaded against the non-deflecting surface, and with the wheel rotated 90 degrees with respect to the most critical orientation. Repeat the loading with the wheel 180, 270, and 0 degrees from the most critical orientation. The bearing cups, cones, and rollers used in operation must be used for these loadings. If at a point of loading during the test bottoming of the tyre

occurs, then the tyre pressure may be increased an amount sufficient only to prevent bottoming.

Three successive loadings at the 0 degree position must 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 (0.125mm), whichever is greater. There must be no yielding of the wheel such as would result in loose bearing cups, liquid or gas leakage through the wheel or past the wheel seal.

3.2.1.3 Ultimate Load.

Apply to the wheel used in the yield test in paragraph 3.2.1.2 of this Appendix 1, and the tyre assembly, a load not less than 2 times the maximum radial limit load, L, for castings, and 1.5 times the maximum radial limit load, L, for forgings. Reference CS 25.471 through 25.511, as appropriate.

Apply the load with the tyre and wheel against the non-deflecting surface and the wheel positioned at 0 degree orientation (paragraph 3.2.1.2 of this Appendix 1). 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 tyre will not successfully maintain pressure or if bottoming of the tyre occurs, the tyre pressure may be increased. If bottoming of the tyre continues to occur with increased pressure, then a loading block that fits between the rim flanges and simulates the load transfer of the inflated tyre may be used. The arc of the wheel supported by the loading block must be no greater than 60 degrees.

The wheel must support the load without failure for at least 3 seconds. Abrupt loss of load-carrying capability or fragmentation during the test constitutes failure.

3.2.2 Combined Radial and Side Load Test.

Test the wheel for the yield and ultimate loads as follows:

3.2.2.1 Test Method.

With a suitable tyre, TT_{WT} , installed, mount the wheel on its axle and position it against a flat, non-deflecting surface. The wheel axle must have the same angular orientation to the non-deflecting surface that it will have to a flat runway when it is mounted on an aeroplane and is under the combined radial and side limit loads. Inflate the tyre to the pressure recommended for the maximum static load with gas and/or liquid.

If liquid inflation is used, liquid must be bled off to obtain the same tyre deflection that would result if gas inflation were used.

For the radial load component, load the wheel through its axle with load applied perpendicular to the flat non deflecting surface. Apply the two loads simultaneously, increasing them either continuously or in increments no greater than 10 percent of the total loads to be applied.

If it is impossible to generate the side load because of friction limitations, the radial load may be increased, or a portion of the side load may be applied directly to the tyre/wheel. In such circumstances it must be demonstrated that the moment resulting from the side load is no less severe than would otherwise have occurred.

Alternatively, the vector resultant of 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.

3.2.2.2 Combined Yield Load.

Apply to the wheel and tyre assembly radial and side loads not less than 1.15 times the respective ground limit loads, reference CS 25.485, 25.495, 25.497, and 25.499, as appropriate. If at a point of loading during the test bottoming of the tyre occurs, then the tyre pressure may be increased an amount sufficient only to prevent bottoming.

Determine the most critical wheel orientation with respect to the non-deflected surface.

Apply the load with the tyre loaded against the non-deflecting surface, and with the wheel rotated 90 degrees with respect to the most critical orientation. Repeat the loading with the wheel 180, 270, and 0 degrees from the most critical orientation.

The bearing cups, cones, and rollers used in operation must be used in this test.

A tube may be used in a tubeless tyre only when it has been demonstrated that pressure will be lost due to the inability of a tyre bead to remain properly positioned under the load. The wheel must be tested for the most critical inboard and outboard side loads.

Three successive loadings at the 0 degree position must not cause permanent set increments of increasing magnitude. The permanent set increment caused by the last loadings at the 0 degree position must not exceed 5 percent of the deflection caused by the loading, or 0.005 inches (0.125mm), whichever is greater. There must be no yielding of the wheel such as would result in loose bearing cups, gas or liquid leakage through the wheel or past the wheel seal.

3.2.2.3 Combined Ultimate Load.

Apply to the wheel, used in the yield test of paragraph 3.2.2.2 of this Appendix 1, radial and side loads not less than 2 times for castings and 1.5 times for forgings, the respective ground limit loads reference CS 25.485, 25.495, 25.497, and 25.499, as appropriate.

Apply these loads with a tyre and wheel against the non-deflecting surface and the wheel oriented at the 0 degree position (paragraph 3.2.2.2 of this Appendix 1). The bearing cones may be replaced with conical bushings, but the cups used in operation must be used for this loading.

If at any point of loading during the test it is shown that the tyre will not successfully maintain pressure, or if bottoming of the tyre on the non-deflecting surface occurs, the tyre pressure may be increased. If bottoming of the tyre continues to occur with this increased pressure, then a loading block that fits between the rim flanges and simulates the load transfer of the inflated tyre may be used. The arc of wheel supported by the loading block must be no greater than 60 degrees.

The wheel must support the loads without failure for at least 3 seconds. Abrupt loss of load-carrying capability or fragmentation during the test constitutes failure.

3.2.3 Wheel Roll Test.

3.2.3.1 Test Method.

With a suitable tyre, TT_{WT} , installed, mount the wheel on its axle and position it against a flat non-deflecting surface or a flywheel. The wheel axle must have the same angular orientation to the non-deflecting surface that it will have to a flat runway when it is mounted on an aeroplane and is under the Wheel Rated Static Load, S . During the roll test, the tyre pressure must not be less than 1.14 times the Wheel Rated Inflation Pressure, WRP, (0.10 to account for temperature rise and 0.04 to account for loaded tyre pressure). For side load conditions, the wheel axle must be yawed to the angle that will produce a wheel side load component equal to 0.15 S while the wheel is being roll tested.

3.2.3.2 Roll Test.

The wheel must be tested under the loads and for the distances shown in Table 3-1.

TABLE 3-1 Load Conditions and Roll Distances for Roll Test

Load Conditions	Roll Distance Miles (km)
Wheel Rated Static Load, S	2 000 (3 220)
Wheel Rated Static Load, S , plus a 0.15x S side load applied in the outboard direction	100 (161)
Wheel Rated Static Load, S , plus a 0.15x S side load applied in the inboard direction	100 (161)

At the end of the test, the wheel must not be cracked, there must be no leakage through the wheel or past the wheel seal(s), and the bearing cups must not be loose.

3.2.4 Roll-on-Rim Test (not applicable to nose wheels).

The wheel assembly without a tyre must be tested at a speed of no less than 10 mph (4.6 m/s) under a load equal to the Wheel Rated Static Load, S . The test roll distance (in feet) must be determined as $0.5V_R^2$ but need not exceed 15,000 feet (4,572 meters). The test axle angular orientation with the load surface must represent that of the aeroplane axle to the runway under the static load S .

The wheel assembly must support the load for the distance defined above. During the test, no fragmentation of the wheel is permitted; cracks are allowed.

3.2.5 Overpressure Test.

The wheel assembly, with a suitable tyre, TT_{WT} , installed, must be tested to demonstrate that it can withstand the application of 4.0 times the wheel rated inflation pressure, WRP. The wheel must retain the pressure for at least 3 seconds. Abrupt loss of pressure containment capability or fragmentation during the test constitutes failure. Plugs may be used in place of over-pressurisation protection device(s) to conduct this test (reference CS 25.731(d)).

3.2.6 Diffusion Test.

A tubeless tyre and wheel assembly must hold its rated inflation pressure, WRP, for 24 hours with a pressure drop no greater than 5 percent. This test must be performed after the tyre growth has stabilised.

3.3 WHEEL AND BRAKE ASSEMBLY TESTS.

3.3.1 General.

3.3.1.1 The wheel and brake assembly, with a suitable tyre, TT_{BT} , installed, must be tested on a testing machine in accordance with the following, as well as paragraphs 3.3.2, 3.3.3, 3.3.5 and, if applicable, 3.3.4 of this Appendix 1.

3.3.1.2 For tests detailed in paragraphs 3.3.2, 3.3.3, and 3.3.4 of this Appendix 1, the test energies KE_{DL} , KE_{RT} , and KE_{SS} and brake application speeds V_{DL} , V_{RT} , and V_{SS} are as normally defined by the aeroplane manufacturer.

3.3.1.3 For tests detailed in paragraphs 3.3.2, 3.3.3, and 3.3.4 of this Appendix 1, the initial brake application speed must be as close as practicable to, but not greater than, the speed established in accordance with paragraph 3.3.1.2 of this Appendix 1, with the exception that marginal speed increases are allowed to compensate for brake pressure release permitted in paragraphs 3.3.3.4 and 3.3.4.4 of this Appendix 1. An increase in the initial brake application speed is not a permissible method of accounting for a reduced (i.e., lower than ideal) dynamometer mass. This method is not permissible because, for a target test deceleration, a reduction in the energy absorption rate would result, and could produce performance different from that which would be achieved with the correct brake application speed. The energy to be absorbed during any stop must not be less than that established in accordance with paragraph 3.3.1.2 of this Appendix 1. Additionally, forced air or other artificial cooling means are not permitted during these stops.

3.3.1.4 The brake assembly must be tested using the fluid (or other actuating means) specified for use with the brake on the aeroplane.

3.3.2 Design Landing Stop Test.

3.3.2.1 The wheel and brake assembly under test must complete 100 stops at the KE_{DL} energy, each at the mean distance averaged deceleration, D , normally defined by the aeroplane manufacturer, but not less than 10 ft/s^2 (3.05 m/s^2). (Reference CS 25.735(f)(1)).

3.3.2.2 During the design landing stop test, the disc support structure must not be changed if it is intended for reuse, or if the wearable material is integral to the structure of the disc. One change of individual blocks or integrally bonded wearable material is permitted. For discs using integrally bonded wearable material, one change is permitted, provided that the disc support structure is not intended for reuse. The remainder of the wheel/brake assembly parts must withstand the 100 KE_{DL} stops without failure or impairment of operation.

3.3.3 Accelerate-Stop Test.

3.3.3.1 The wheel and brake assembly under test must complete the accelerate-stop test at the mean distance averaged deceleration, D , normally defined by the aeroplane manufacturer, but not less than 6 ft/s^2 (1.83 m/s^2). (Reference CS 25.735(f)(2)).

This test establishes the maximum accelerate-stop energy rating, KE_{RT} , of the wheel and brake assembly using:

- a. The Brake Rated Maximum Operating Pressure, $BROP_{MAX}$; or
- b. The maximum brake pressure consistent with the aeroplane's braking pressure limitations (e.g. tyre/runway drag capability based on substantiated data).

3.3.3.2 For the accelerate-stop test, the tyre, wheel, and brake assembly must be tested at KE_{RT} for both a new brake and a fully worn brake.

- a. A new brake is defined as a brake on which less than 5 percent of the usable wear range of the heat sink has been consumed.
- b. A worn brake is defined as a brake on which the usable wear range of the heat sink has already been fully consumed to BR_{WL} .

The proportioning of wear through the brake for the various friction pairs for this test must be based on service wear experience or wear test data of an equivalent or similar brake. Either operationally worn or mechanically worn brake components may be used. If mechanically worn components are used, it must be shown that they can be expected to provide similar results to operationally worn components. The test brake must be subjected to a sufficient number and type of stops to ensure that the brake's performance is representative of in-service use; at least one of these stops, with the brake near the fully worn condition, must be a design landing stop.

3.3.3.3 At the time of brake application, the temperatures of the tyre, wheel, and brake, particularly the heat sink, must, as closely as practicable, be representative of a typical in-service condition. Preheating by taxi stops is an acceptable means.

These temperatures must be based on a rational analysis of a braking cycle, taking into account a typical brake temperature at which an aeroplane may be dispatched from the ramp, plus a conservative estimate of heat sink temperature change during subsequent taxiing and takeoff acceleration, as appropriate.

Alternatively, in the absence of a rational analysis, the starting heat sink temperature must be that resulting from the application of 10 percent KE_{RT} to the tyre, wheel and brake assembly, initially at not less than normal ambient temperature (59°F/15°C).

3.3.3.4 A full stop demonstration is not required for the accelerate-stop test. The test brake pressure may be released at a test speed of up to 23 mph (10 m/s). In this case, the initial brakes-on speed must be adjusted such that the energy absorbed by the tyre, wheel and brake assembly during the test is not less than the energy absorbed if the test had commenced at the specified speed and continued to zero ground speed.

3.3.3.5 Within 20 seconds of completion of the stop, or of the brake pressure release in accordance with paragraph 3.3.3.4 of this Appendix 1, the brake pressure must be adjusted to the Brake Rated Maximum Parking Pressure, $BRPP_{MAX}$, and maintained for at least 3 minutes (Reference CS 25.735(g)).

No sustained fire that extends above the level of the highest point of the tyre is allowed before 5 minutes have elapsed after application of parking brake pressure; until this time has elapsed, neither fire fighting means nor coolants may be applied.

The time of initiation of tyre pressure release (e.g., by wheel fuse plug), if applicable, is to be recorded. The sequence of events described in paragraphs 3.3.3.4 and 3.3.3.5 of this Appendix 1 is illustrated in figure 3-1.

3.3.4 Most Severe Landing Stop Test.

3.3.4.1 The wheel and brake assembly under test must complete the most severe landing braking condition expected on the aeroplane as normally defined by the aeroplane manufacturer. This test is not required if the testing required in paragraph 3.3.3 of this Appendix 1 is more severe or the condition is shown to be extremely improbable, normally by the aeroplane manufacturer..

This test establishes, if required, the maximum energy rating, KE_{SS} , of the wheel/brake assembly for landings under abnormal conditions using:

- a. The Brake Rated Maximum Operating Pressure, $BROP_{MAX}$; or
- b. The maximum brake pressure consistent with an aeroplane's braking pressure limitations (e.g. tyre/runway drag capability based on substantiated data).

3.3.4.2 For the most severe landing stop test, the tyre, wheel and brake assembly must be capable of absorbing the test energy, KE_{SS} , with a brake on which the usable wear range of the heat sink has already been fully consumed to BR_{WL} (Reference CS 25.735(f)(3)).

The proportioning of wear through the brake for the various friction pairs for this test must be based on service wear experience or wear test data of an equivalent or similar brake. Either operationally worn or mechanically worn brake components may be used. If mechanically worn components are used, it must be shown that they can be expected to provide similar results to operationally worn components. The test brake must be subjected to a sufficient number and type of stops to ensure that the brake's performance is representative of in-service use; at least one of these stops with the brake near the fully worn condition, must be a design landing stop.

3.3.4.3 At the time of brake application, the temperatures of the tyre, wheel, and brake, particularly the heat sink, must, as closely as practicable, be representative of a typical in-service condition. Preheating by taxi stops is an acceptable means.

These temperatures must be based on a rational analysis of a braking cycle, taking into account a typical brake temperature at which the aeroplane may be dispatched from the ramp, plus a conservative estimate of heat sink temperature change during taxi, takeoff, and flight, as appropriate.

Alternatively, in the absence of a rational analysis, the starting heat sink temperature must be that resulting from the application of 5 percent KE_{RT} to the tyre, wheel and brake assembly initially at not less than normal ambient temperature (59°F/15°C).

3.3.4.4 A full stop demonstration is not required for the most severe landing-stop test. The test brake pressure may be released at a test speed of up to 20 knots. In this case, the initial brakes-on speed must be adjusted such that the energy absorbed by the tyre, wheel, and brake assembly during the test is not less than the energy absorbed if the test had commenced at the specified speed and continued to zero ground speed.

3.3.4.5 Within 20 seconds of completion of the stop, or of the brake pressure release in accordance with paragraph 3.3.4.4 of this Appendix 1, the brake pressure must be adjusted to the Brake Rated Maximum Parking Pressure, $BRPP_{MAX}$, and maintained for at least 3 minutes.

No sustained fire that extends above the level of the highest point of the tyre is allowed before 5 minutes have elapsed after application of parking brake pressure; until this time has elapsed, neither fire fighting means nor coolants may be applied.

The time of initiation of tyre pressure release (e.g., by wheel fuse plug), if applicable, is to be recorded. The sequence of events described in paragraphs 3.3.4.4 and 3.3.4.5 of this Appendix 1 is illustrated in Figure 3-2.

3.3.5 Structural Torque Test.

The Wheel/Brake Rated Structural Torque, S_{TR} , is equal to the torque demonstrated in the test defined in 3.3.5.1 of this Appendix 1.

3.3.5.1 Apply to the wheel, brake and tyre assembly, the radial load S and the drag load corresponding to the torque specified in paragraph 3.3.5.2 or 3.3.5.3 of this Appendix 1, 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 the application of at least Brake Rated Maximum Operating Pressure, $BROP_{MAX}$, or equivalent. If such pressure or its equivalent is insufficient to prevent rotation, the friction surface may be clamped, bolted, or otherwise restrained while applying the pressure. A fully worn brake configuration, BR_{WL} , must be used for this test. The proportioning of wear through the brake for the various friction pairs for this test must be based on service wear experience of an equivalent or similar brake or test machine wear test data. Either operationally worn or mechanically worn brake components may be used. An actuating fluid other than that specified for use on the aeroplane may be used for the structural torque test.

3.3.5.2 For landing gear with one wheel per landing gear strut, the torque is $1.2 (SxR)$.

3.3.5.3 For landing gear with more than one wheel per landing gear strut, the torque is $1.44 (SxR)$.

3.3.5.4 The wheel and brake assembly must support the loads without failure for at least 3 seconds.

3.3.6 Wheel to Brake Clearance

There must be no interference in any critical areas between the wheel and brake assembly (with fittings) up to limit load conditions, taking into account the axle angular orientation. Lack of interference can be established by analyses and/or tests. If chosen, testing shall be conducted per the following methods:

3.3.6.1 Radial Limit Load Wheel and Brake Clearance Test.

With a suitable tyre, TT_{WT} , installed, mount the wheel and brake on a suitable axle, and position it against a flat, non-deflecting surface. The wheel axle must have the same angular orientation to the non-deflecting surface that it will have to a flat runway when it is mounted on an airplane and is under the maximum radial limit load, L .

Inflate the tyre to the pressure recommended for the Wheel Rated Static Load, S , with gas and/or liquid. If liquid inflation is used, liquid must be bled off to obtain

the same tire deflection that would result if gas inflation were used. Liquid pressure must not exceed the pressure that would develop if gas inflation were used and the tyre was deflected to its maximum extent. Load the wheel through its axle with the load applied perpendicular to the flat, non-deflecting surface. Reference CS 25.471 through 25.511, as appropriate. If the radial limit load of paragraph 3.3.6.2 of this Appendix 1 is equal to or greater than the radial limit load specified in this paragraph, the test specified in this paragraph may be omitted.

Determine the most critical wheel orientation with respect to the non-deflecting surface. Apply the load with the tire loaded against the non-deflecting surface. If multiple critical orientations are determined, repeat the testing for each critical orientation. The bearing cups, cones, and rollers used in operation must be used for this loading. If at a point of loading during the test bottoming of the tire occurs, then the tire pressure may be increased an amount sufficient only to prevent bottoming.

3.3.6.2 Combined Limit Load Wheel and Brake Clearance Test.

With a suitable tyre, TT_{WT} , installed, mount the wheel and brake on a suitable axle, and position it against a flat, non-deflecting surface. The wheel axle must have the same angular orientation to the non-deflecting surface that it will have to a flat runway when it is mounted on an airplane and is under the maximum radial limit load, L . Apply to the wheel and tyre assembly radial and side loads not less than the respective ground limit loads. Reference, CS 25.485, 25.495, 25.497, and 25.499, as appropriate.

If at a point of loading during the test bottoming of the tyre occurs, then the tyre pressure may be increased an amount sufficient only to prevent bottoming.

Determine the most critical wheel orientation with respect to the nondeflected surface.

Apply the load with the tyre loaded against the non-deflecting surface with the wheel in the most critical orientation.

The bearing cups, cones, and rollers used in operation must be used in this test.

A tube may be used in a tubeless tire only when it has been demonstrated that pressure will be lost due to the inability of a tyre bead to remain properly positioned under the load. The wheel must be tested for the most critical inboard and outboard side loads. If multiple critical orientations are determined to apply, repeat the testing for each critical orientation.

3.4 BRAKE TESTS.

The brake assembly must be tested using the fluid (or other actuating means) specified for use with the brake on the aeroplane. It must be substantiated that standard production samples of the brake will pass the following tests:

3.4.1 Yield & Overpressure Test.

The brake must withstand a pressure equal to 1.5 times BRP_{MAX} for at least 5 minutes without permanent deformation of the structural components under test.

The brake, with actuator piston(s) extended to simulate a maximum worn condition, must, for at least 3 seconds, withstand hydraulic pressure equal to 2.0 times the Brake

Rated Maximum Pressure, BRP_{MAX}, available to the brakes. If necessary, piston extension must be adjusted to prevent contact with retention devices during this test.

3.4.2 Endurance Test.

A brake assembly must be subjected to an endurance test during which structural failure or malfunction must not occur. If desired, the heat sink components may be replaced by a reasonably representative dummy mass for this test.

The test must be conducted by subjecting the brake assembly to 100,000 cycles of an application of the average of the peak brake pressures needed in the design landing stop test (paragraph 3.3.2 of this Appendix 1) and release to a pressure not exceeding the Brake Rated Retraction Pressure, BRP_{RET}. The pistons must be adjusted so that 25,000 cycles are performed at each of the four positions where the pistons would be at rest when adjusted to nominally 25, 50, 75, and 100 percent of the wear limit, BRWL. The brake must then be subjected to 5 000 cycles of application of pressure to BRP_{MAX} and release to BRP_{RET} at the 100 percent wear limit.

Hydraulic brakes must not exceed a total leakage of 5cc during the test.

3.4.3 Piston Retention.

The hydraulic pistons must be positively retained without leakage at 1.5 times BRP_{MAX} for at least 10 seconds with the heat sink removed.

3.4.4 Extreme Temperature Soak Test.

Hydraulic brakes must not exceed a total leakage of 5cc during the following tests.

Subject the brake to at least a 24-hour hot soak at the maximum piston housing fluid temperature experienced during a design landing stop test (paragraph 3.3.2 of this Appendix 1), conducted without forced air cooling. While at the hot soak temperature, the brake must be subjected to the application of the average of the peak brake pressures required during the 100 design landing stops and release to a pressure not exceeding BRP_{RET} for 1000 cycles, followed by 25 cycles of BRP_{MAX} and release to a pressure not exceeding BRP_{RET}.

The brake must then be cooled from the hot soak temperature to a cold soak temperature of - 40°F (-40°C) and maintained at this temperature for at least 24 hours. While at the cold soak temperature, the brake must be subjected to the application of the average of the peak brake pressures required during the KEDL stops and release to a pressure not exceeding BRP_{RET}, for 25 cycles, followed by 5 cycles of BRP_{MAX} and release to a pressure not exceeding BRP_{RET}.

3.4.5 Leakage Tests (Hydraulic Brakes).

3.4.5.1 Static Leakage Test.

The brake must be subjected to a pressure equal to 1.5 times BRP_{MAX} for at least 5 minutes. The brake pressure must then be adjusted to an operating pressure of 5 psig (35 kPa) for at least 5 minutes. There must be no measurable leakage (less than one drop) during this test.

3.4.5.2 Dynamic Leakage Test.

The brake must be subjected to 25 applications of BRP_{MAX}, each followed by the release to a pressure not exceeding BRP_{RET}. Leakage at static seals must not exceed

a trace. Leakage at moving seals must not exceed one drop of fluid per each 3 inches (76mm) of peripheral seal length.

CHAPTER 4**DATA REQUIREMENTS**

4.1 The applicant must provide the following data with any application for approval of equipment.

4.1.1 The following wheel and brake assembly ratings:

a. Wheel Ratings.

Wheel Rated Static Load, S ,

Wheel Rated Inflation Pressure, WRP ,

Wheel Rated Tyre Loaded Radius, R .

Wheel Rated Maximum Limit Load, L ,

Wheel Rated Tyre Size, TS_{WR} .

b. Wheel/Brake and Brake Ratings.

Wheel/Brake Rated Design Landing Energy, KE_{DL} , and associated brakes-on-speed, V_{DL} ,

Wheel/Brake Rated Accelerate-Stop Energy, KE_{RT} , and associated brakes-on-speed, V_{RT} ,

Wheel/Brake Rated Most Severe Landing Stop Energy, KE_{SS} , and associated brakes-on-speed, V_{SS} (if applicable),

Brake Rated Maximum Operating Pressure, $BROP_{MAX}$,

Brake Rated Maximum Pressure, BRP_{MAX} ,

Brake Rated Retraction Pressure, BRP_{RET} ,

Wheel/Brake Rated Structural Torque, ST_R ,

Rated Design Landing Deceleration, D_{DL} ,

Rated Accelerate-Stop Deceleration, D_{RT} ,

Rated Most Severe Landing Stop Deceleration, D_{SS} (if applicable),

Brake Rated Tyre Size, TS_{BR} ,

Brake Rated Wear Limit, $BRWL$.

4.1.2 The weight of the wheel or brake, as applicable.

4.1.3 Specification of hydraulic fluid used, as applicable.

4.1.4 One copy of the test report showing compliance with the test requirements.

NOTE: When test results are being recorded for incorporation in the compliance test report, it is not sufficient to note merely that the specified performance was achieved. The actual numerical values obtained for each of the parameters tested must be recorded, except where tests are pass/fail in character.

4.2 Prior to entry into service, a component maintenance manual (CMM), covering periodic maintenance, calibration, and repair, for the continued airworthiness of installed wheels and wheel and brake assemblies, including recommended inspection intervals and service life.

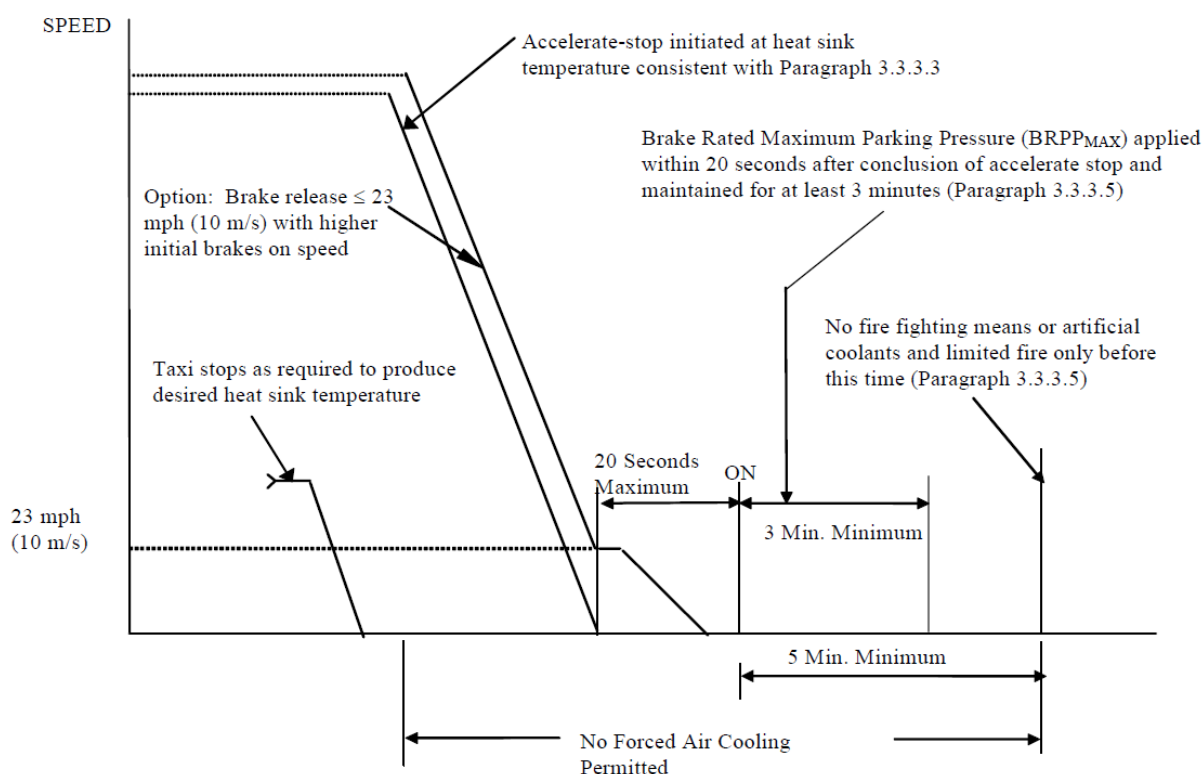


Figure 3-1. Taxi, Accelerate-Stop, Park Test Sequence

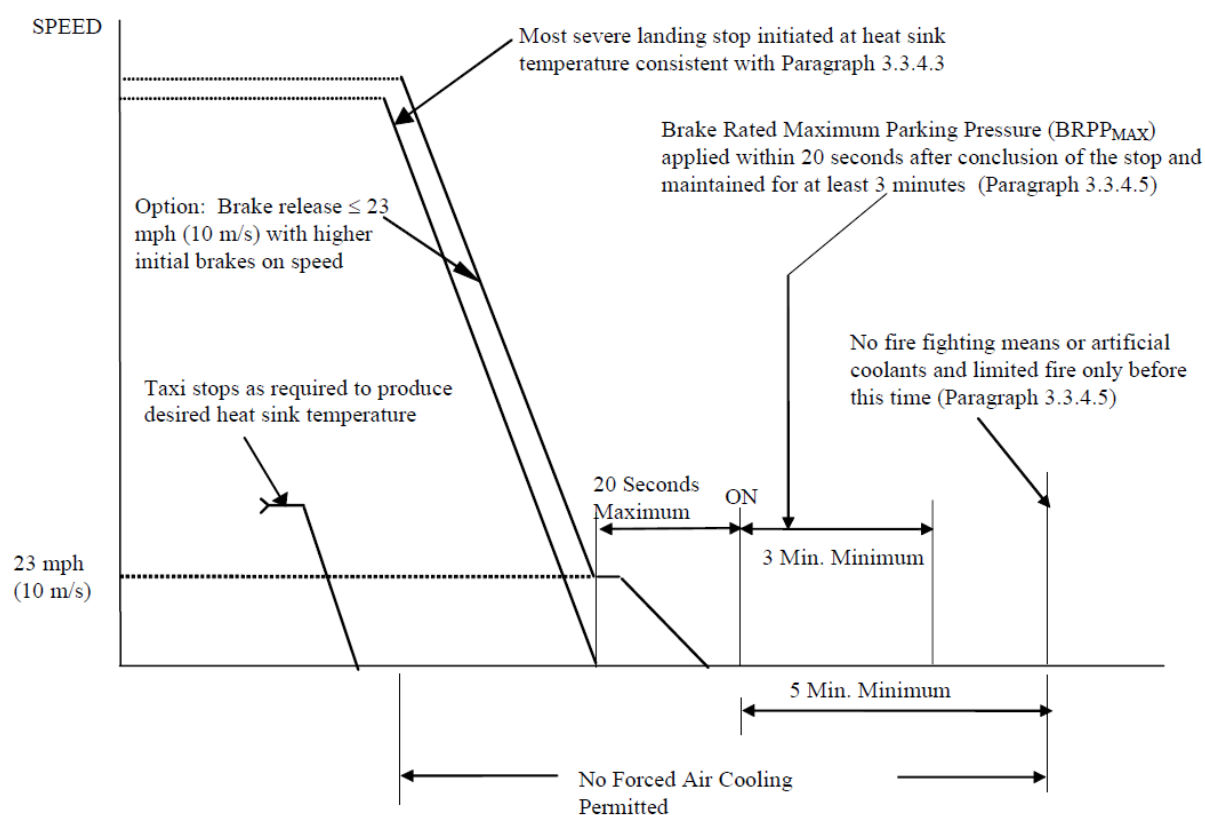


Figure 3-2. Most Severe Landing-Stop, Park Test Sequence

[Amdt ETSO/6]

APPENDIX 2 TO ETSO-C135A – MPS FOR LARGE WHEEL AND BRAKE ASSEMBLIES FOR ELECTRICALLY ACTUATED BRAKES

ED Decision 2010/010/R

CHAPTER 1

INTRODUCTION

1.1 PURPOSE AND SCOPE.

This Minimum Performance Specification defines the minimum performance standards for wheels, brakes, and wheel and brake assemblies to be used on aeroplanes certificated under CS-25. Compliance with this specification is not considered approval for installation on any Large Aeroplane.

1.2 APPLICATION.

Compliance with this minimum specification by the applicant is required as a means of assuring that the equipment will have the capability to satisfactorily perform its intended function(s).

Note: Certain performance capabilities may be affected by aeroplane operational characteristics and other external influences. Consequently, anticipated aeroplane braking performance should be verified by aeroplane testing.

1.3 COMPOSITION OF EQUIPMENT.

The words “equipment” or “brake assembly” or “wheel assembly,” as used in this document, include all components that form part of the particular unit.

For example, a wheel assembly typically includes a hub or hubs, bearings, flanges, drive bars, heat shields, and fuse plugs. A brake assembly typically includes a backing plate, torque tube, electro-mechanical actuators, pressure plate, heat sink, temperature sensor, and other axle mounted components integral to the braking activity.

For the purpose of this specification, the interface boundaries of the equipment are the wheel and brake attachments to the landing gear and the electrical connectors to the aircraft brake control system.

It should not be inferred from these examples that each wheel assembly and brake assembly will necessarily include either all or any of the above example components; the actual assembly will depend on the specific design chosen by the applicant.

1.4 DEFINITIONS AND ABBREVIATIONS.

1.4.1 Brake Lining.

Brake lining is individual blocks of wearable material, discs that have wearable material integrally bonded to them, or discs in which the wearable material is an integral part of the disc structure.

1.4.2 BOP – Brake Off Position

BOP is a retracted EMA position that permits free rotation of the wheel and brake assembly after a brake application and release cycle.

1.4.3 BRWL - Brake Rated Wear Limit.

BRWL is the brake maximum wear limit to ensure compliance with paragraph 3.3.3, and, if applicable, paragraph 3.3.4 of this Appendix 2.

1.4.4 D - Distance Averaged Deceleration.

$$D = (\text{Initial brakes-on speed})^2 - (\text{Final brakes-on speed})^2 / (2(\text{braked flywheel distance}))$$

D is the distance averaged deceleration to be used in all deceleration calculations.

1.4.5 D_{DL} - Rated Design Landing Deceleration.

D_{DL} is the minimum of the distance averaged decelerations demonstrated by the wheel, brake and tire assembly during the 100 KE_{DL} stops in paragraph 3.3.2 of this Appendix 2.

1.4.6 D_{RT} - Rated Accelerate-Stop Deceleration.

D_{RT} is the minimum of the distance averaged decelerations demonstrated by the wheel, brake, and tire assembly during the KE_{RT} stops in paragraph 3.3.3 of this Appendix 2.

1.4.7 D_{SS} - Rated Most Severe Landing Stop Deceleration.

D_{SS} is the distance averaged deceleration demonstrated by the wheel, brake and tire assembly during the KE_{SS} Stop in paragraph 3.3.4 of this Appendix 2.

1.4.8 EMA – Electro-Mechanical Actuator

The EMA is the brake subassembly, typically comprised of but not limited to, the ball screw or roller screw, electric motor, and gear train that converts electrical power to brake clamping force.

1.4.9 Heat Sink.

The heat sink is the mass of the brake that is primarily responsible for absorbing energy during a stop. For a typical brake, this would consist of the stationary and rotating disc assemblies.

1.4.10 I_{BMAX} - Maximum Brake Current

I_{BMAX} is the maximum current drawn by the brake in the most critical of the dynamic tests of paragraph 3.3.3 or 3.3.4 of this Appendix 2. as determined by test or analysis of test results.

1.4.11 I_{SMAX} – Maximum Brake System Current

I_{SMAX} is the maximum current the aircraft brake control system can deliver to the brake assembly in normal operation.

1.4.12 KE_{DL} - Wheel/Brake Rated Design Landing Stop Energy.

KE_{DL} is the minimum energy absorbed by the wheel/brake/tire assembly during every stop of the 100 stop design landing stop test in paragraph 3.3.2 of this Appendix 2.

1.4.13 KE_{RT} - Wheel/Brake Rated Accelerate-Stop Energy.

KE_{RT} is the energy absorbed by the wheel/brake/tire assembly demonstrated in accordance with the accelerate-stop test in paragraph 3.3.3 of this Appendix 2.

1.4.14 KE_{SS} - Wheel/Brake Rated Most Severe Landing Stop Energy.

KE_{SS} is the energy absorbed by the wheel/brake/tire assembly demonstrated in accordance with paragraph 3.3.4 of this Appendix 2.

1.4.15 L_{BMAX} - Maximum Brake Load

L_{BMAX} is the nominal maximum clamping load the brake is designed to generate with maximum brake control system command under normal conditions established by analysis or test.

1.4.16 L_{DL} - Brake Design Landing Load

L_{DL} is the average of the 100 peak clamping loads generated in the brake assembly during the KE_{DL} stop test of paragraph 3.3.2 of this Appendix 2 as determined by test or analysis of test results.

1.4.17 L_{LMT} - Brake Limit Load

L_{LMT} is the maximum clamping load the brake structure may be subjected to in its operation which would not result in permanent deformation that would prevent it from performing its intended function.

1.4.18 P_{BMAX} - Maximum EMA Brake Power

P_{BMAX} is the maximum power supplied to the brake during the most critical of the dynamic tests of Section 3 of this Appendix 2 as determined by test or analysis of test results.

1.4.19 P_{SMAX} - Maximum Brake System Power

P_{SMAX} is the maximum power that is available to the brake assembly from the aircraft brake control system.

1.4.20 PBC – Parking Brake Command

PBC is the configuration to which the EMAs are commanded following a high energy stop as normally defined by the aeroplane manufacturer associated with the parking brake applications in paragraphs 3.3.3.5 and 3.3.4.5 of this Appendix 2.

1.4.21 R - Wheel Rated Tyre Loaded Radius.

R is the static radius at load “S” for the wheel rated tyre size at WRP. The static radius is defined as the minimum distance from the axle centreline to the tyre/ground contact interface.

1.4.22 S -Wheel Rated Static Load.

S is the maximum static load (Reference CS 25.731(b)).

1.4.23 ST_R - Wheel/Brake Rated Structural Torque.

ST_R is the maximum structural torque demonstrated in paragraph 3.3.5 of this Appendix 2.

1.4.24 TS_{BR} - Brake Rated Tyre Type(s) and Size(s).

TS_{BR} is the tyre type(s) and size(s) used to achieve the KE_{DL} , KE_{RT} , and KE_{SS} brake ratings. TS_{BR} must be a tyre type and size approved for installation on the wheel (TS_{WR}).

1.4.25 TS_{WR} - Wheel Rated Tyre Type(s) and Size(s).

TS_{WR} is the wheel rated tyre type(s) and Size(s) defined for use and approved for installation on the wheel (TS_{WR}), normally by the aeroplane manufacturer.

1.4.26 TT_{BT} - Suitable Tire for Brake Tests.

TT_{BT} is the rated tire type and size.

TT_{BT} is the tyre type and size that has been determined as being the most critical for brake performance and/or energy absorption tests. The TT_{BT} must be a tyre type and size approved for installation on the wheel (TS_{WR}), normally by the aeroplane manufacturer. The suitable tyre may be different for different tests.

1.4.27 V_{BMAX} - Maximum EMA Brake Voltage

V_{BMAX} is the maximum voltage applied to the brake assembly during the most critical of the dynamic tests of Section 3 of this Appendix 2 as determined by test or analysis of test results.

1.4.28 V_{SMAX} – Maximum Brake System Voltage

V_{SMAX} is the maximum voltage that is available to the brake assembly from the aircraft brake control system.

1.4.29 V_{DL} - Wheel/Brake Design Landing Stop Speed

V_{DL} is the initial brakes-on speed for a design-landing stop in paragraph 3.3.2 of this Appendix 2.

1.4.30 V_{RT} – wheel/brake accelerate-stop speed

V_{RT} is the initial brakes-on speed used to demonstrate KE_{RT} in paragraph 3.3.3 of this Appendix 2.

1.4.31 V_{SS} - wheel/brake most severe landing stop speed

V_{SS} is the initial brakes-on speed used to demonstrate KE_{SS} in paragraph 3.3.4 of this Appendix 2.

CHAPTER 2**GENERAL DESIGN SPECIFICATIONS****2.1 AIRWORTHINESS**

The continued airworthiness of the wheels and wheel and brake assemblies must be considered. See paragraph 4 of this Appendix 2 titled “DATA REQUIREMENTS”.

2.2 FIRE PROTECTION

Except for small parts such as fasteners, seals, grommets, and small electrical parts that would not contribute significantly to the propagation of a fire, all solid materials used must be self-extinguishing. See also paragraphs 2.4.5, 3.3.3.5 and 3.3.4.5 of this Appendix 2.

2.3 DESIGN

Unless shown to be unnecessary by test or analysis, the equipment must comply with the following:

2.3.1 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 lubricated cavity.

2.3.2 Brake Release And Wear Adjustment

The brake assembly and its control system must provide a suitable means to maintain an appropriate running clearance throughout the entire heat sink wear and thermal range when no braking is commanded.

2.3.3 Wear Indicator

A reliable method must be provided for determining when the heat sink is worn to its permissible limit.

2.3.4 Dissimilar Materials

When dissimilar materials are used in the construction and the galvanic potential between the materials indicate galvanic corrosion is likely, effective means to prevent the corrosion must be incorporated in the design. In addition, differential thermal expansion must not unduly affect the functioning, load capability, and the fatigue life of the components.

2.3.5 Insulation Resistance

The equipment shall have an adequate insulation resistance level to ensure the design is robust to leakage current paths in accordance with established industry standards.

2.3.6 Dielectric Strength

The equipment shall have a suitable dielectric withstanding capability for the voltages and voltage surges to which it will be subjected in accordance with established industry standards.

2.3.7 Bonding, Grounding

The equipment shall employ suitable electrical bonding and grounding techniques in its design to protect ground personnel and the equipment, from fault currents and from the potentially high voltages that may be present, in accordance with established industry standards.

2.4 CONSTRUCTION

The suitability and durability of the materials used for components must be established on the basis of experience or tests. In addition, the materials must conform to approved specifications that ensure the strength and other properties are those that were assumed in the design.

2.4.1 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 serviceability is not impaired.

2.4.2 Forgings

Forgings must be of uniform condition, free from blisters, fins, folds, seams, laps, cracks, segregation, and other defects. Imperfections may be removed if strength and serviceability would not be impaired as a result.

2.4.3 Bolts and Studs

When bolts or studs are used for fastening together sections of a wheel or brake, the length of the threads must be sufficient to fully engage the nut, including its locking feature, and there must be sufficient unthreaded bearing area to carry the required load.

2.4.4 Environmental Protection

All the components used must be suitably protected against deterioration or loss of strength in service due to any environmental cause, such as weathering, corrosion, and abrasion.

2.4.5 Magnesium Parts

Magnesium and alloys having magnesium, as a major constituent, must not be used on brakes or braked wheels.

CHAPTER 3

MINIMUM PERFORMANCE UNDER STANDARD TEST CONDITIONS

3.1 INTRODUCTION

The test conditions and performance criteria described in this chapter provide a laboratory means of demonstrating compliance with this ETSO minimum performance standard. The aeroplane manufacturer normally defines relevant test parameter values, however these may also be derived from published aircraft data for applicants for supplementary type certificates (STC).

3.2 WHEEL TESTS

The wheel should be tested, results documented, and reported per Appendix 1, paragraphs 3.2, 4.1.1(a) and 4.1.4.

3.3 WHEEL AND BRAKE ASSEMBLY TESTS.

3.3.1 General

3.3.1.1 The wheel and brake assembly, with a suitable tyre, TTBT, installed, must be tested on a testing machine in accordance with the following, as well as paragraphs 3.3.2, 3.3.3, 3.3.5 and, if applicable, 3.3.4 of this Appendix 2.

3.3.1.2 For tests detailed in paragraphs 3.2.2, 3.3.3, and 3.3.4 of this Appendix 2 the test energies KEDL, KERT, and KESS and brake application speeds VDL, VRT and VSS are as normally defined by the aeroplane manufacturer.

3.3.1.3 For tests detailed in paragraphs 3.3.2, 3.3.3, and 3.3.4 of this Appendix 2 the initial brake application speed must be as close as practicable to, but not greater than the speed established in accordance with paragraph 3.3.1.2 of this Appendix 2, with the exception that marginal speed increases are allowed to compensate for brake clamping force release permitted in paragraphs 3.3.3.4 and 3.3.44 of this Appendix 2. An increase in the initial brake application speed is not a permissible method of accounting for a reduced (that is, lower than ideal) dynamometer mass. This method is not permissible because, for a target test deceleration, a reduction in the energy absorption rate would result, and could produce performance different from that which would be achieved with the correct brake application speed. The energy to be absorbed during any stop must not be less than that established in accordance with paragraph 3.3.1.2 of this Appendix 2. Additionally, forced air or other artificial cooling means are not permitted during these stops.

3.3.1.4 For brake stopping performance tests, the brake assembly must be tested using a control system and electrical power source providing representative characteristics of the actuating means to the EMAs, including limitations, specified for the aircraft braking system. IBMAX, VBMAX and PBMAX shall not exceed the capabilities of the aircraft brake control system, ISMAX, VSMAX and PSMAX, for which the equipment is intended.

3.3.1.5 For brake structural tests, the brake assembly may be tested with an alternate control system to that required for the brake stopping performance tests. The control system must be capable of structurally loading the EMA load path and brake structure to the static values required by the test conditions.

3.3.2 Design Landing Stop Test

3.3.2.1 The wheel and brake assembly under test must complete 100 stops at the KEDL energy, each at the mean distance averaged deceleration, D , normally defined by the aeroplane manufacturer, but not less than 10 ft/s^2 (3.05 m/s^2). (Reference CS 25.735(f)(1)).

3.3.2.2 During the design landing stop test, the disc support structure must not be changed if it is intended for reuse, or if the wearable material is integral to the structure of the disc. One change of individual blocks or integrally bonded wearable material is permitted. For discs using integrally bonded wearable material, one change is permitted, provided that the disc support structure is not intended for reuse. The remainder of the wheel/brake assembly parts must withstand the 100 KE_{DL} stops without failure or impairment of operation.

3.3.3 Accelerate-Stop Test

3.3.3.1 The wheel and brake assembly under test must complete the accelerate-stop test at the mean distance averaged deceleration, D , normally defined by the aeroplane manufacturer, but not less than 6 ft/s^2 (1.83 m/s^2). (Reference CS 25.735(f)(2)).

This test establishes the maximum accelerate-stop energy rating, KERT, of the wheel and brake assembly using:

- a. $I_{S_{MAX}}$, $V_{S_{MAX}}$ and $P_{S_{MAX}}$; or
- b. The maximum brake current, voltage and power inputs consistent with the airplane's braking force limitations (tyre/runway drag capability based on substantiated data).

3.3.3.2 For the accelerate-stop test, the tyre, wheel, and brake assembly must be tested at KE_{RT} for both a new brake and a fully worn brake.

- a. A new brake is defined as a brake on which less than 5 percent of the usable wear range of the heat sink has been consumed.
- b. A worn brake is defined as a brake on which the usable wear range of the heat sink has already been fully consumed to BRWL.

The proportioning of wear through the brake for the various friction pairs for this test must be based on service wear experience or wear test data of an equivalent or similar brake. Either operationally worn or mechanically worn brake components may be used. If mechanically worn components are used, it must be shown that they can be expected to provide similar results to operationally worn components. The test brake must be subjected to a sufficient number and type of stops to ensure that the brake's performance is representative of in-service use; at least one of these stops, with the brake near the fully worn condition, must be a design landing stop.

3.3.3.3 At the time of brake application, the temperatures of the tyre, wheel, and brake assembly, particularly the heat sink and EMAs, must, as closely as practicable, be representative of a typical in-service condition. Preheating by taxi stops is an acceptable means.

These temperatures must be based on a rational analysis of a braking cycle, taking into account a typical brake temperature at which an airplane may be dispatched from the ramp, plus a conservative estimate of heat sink temperature change during subsequent taxiing and takeoff acceleration, as appropriate.

Alternatively, in the absence of a rational analysis, the starting heat sink and EMA temperatures must be that resulting from the application of 10 percent KE_{RT} to the tire, wheel and brake assembly, initially at not less than normal ambient temperature (59°F/15°C).

3.3.3.4 A full stop demonstration is not required for the accelerate-stop test. The test brake clamping force may be released at a test speed of up to 23 mph (10 m/s). In this case, the initial brakes-on speed must be adjusted such that the energy absorbed by the tyre, wheel and brake assembly during the test is not less than the energy absorbed if the test had commenced at the specified speed and continued to zero ground speed.

3.3.3.5 Within 20 seconds of completion of the stop, or of the brake clamping force release in accordance with paragraph 3.3.3.4 of this Appendix 2, apply the Parking Brake Command (PBC) and maintain for at least 3 minutes (reference CS 25.735(g)).

No sustained fire that extends above the level of the highest point of the tire is allowed before 5 minutes have elapsed after application of brake clamping force; until this time has elapsed, neither fire fighting means nor coolants may be applied.

The time of initiation of tyre pressure release (for example, by wheel fuse plug), if applicable, is to be recorded. The sequence of events described in paragraphs 3.3.3.4 and 3.3.3.5 is illustrated in Figure 3-1 of this Appendix 2.

3.3.4 Most Severe Landing Stop Test

3.3.4.1 The wheel and brake assembly under test must complete the most severe landing braking condition expected on the aeroplane as normally defined by the aeroplane manufacturer. This test is not required if the testing required in paragraph 3.3.3 of this Appendix 2 is more severe or the condition is shown to be extremely improbable, normally by the aeroplane manufacturer.

This test establishes if required, the maximum energy rating, KE_{SS} , of the wheel/brake assembly for landings under abnormal conditions using:

- a. I_{SMAX} , V_{SMAX} and P_{SMAX} ; or
- b. The maximum brake current, voltage and power inputs consistent with the airplane's braking force limitations (for example, tyre/runway drag capability based on substantiated data).

3.3.4.2 For the most severe landing stop test, the tyre, wheel, and brake assembly must be capable of absorbing the test energy, KE_{SS} , with a brake on which the usable wear range of the heat sink has already been fully consumed to BRWL (reference CS 25.735(f)(3)).

The proportioning of wear through the brake for the various friction pairs for this test must be based on service wear experience or wear test data of an equivalent or similar brake. Either operationally worn or mechanically worn brake components may be used. If mechanically worn components are used, it must be shown that they can be expected to provide similar results to operationally worn components. The test brake must be subjected to a sufficient number and type of stops to ensure that the brake's performance is representative of in-service use; at least one of these stops, with the brake near the fully worn condition, must be a design landing stop.

- 3.3.4.3 At the time of brake application, the temperatures of the tyre, wheel, and brake, particularly the heat sink and EMA, must, as closely as practicable, be representative of a typical in service condition. Preheating by taxi stops is an acceptable means.

These temperatures must be based on a rational analysis of a braking cycle, taking into account a typical brake temperature at which the airplane may be dispatched from the ramp, plus a conservative estimate of heat sink temperature change during taxi, takeoff, and flight, as appropriate.

Alternatively, in the absence of a rational analysis, the starting heat sink and EMA temperatures must be that resulting from the application of 5 percent KE_{RT} to the tyre, wheel and brake assembly initially at not less than normal ambient temperature (59°F/15°C).

- 3.3.4.4 A full stop demonstration is not required for the most severe landing-stop test. The test brake clamping force may be released at a test speed of up to 23 mph (10 m/s). In this case, the initial brakes-on speed must be adjusted such that the energy absorbed by the tyre, wheel, and brake assembly during the test is not less than the energy absorbed if the test had commenced at the specified speed and continued to zero ground speed.

- 3.3.4.5 Within 20 seconds of completion of the stop, or of the brake clamping force release in accordance with paragraph 3.3.4.4 of this Appendix 2, apply the Parking Brake Command (PBC) and maintain for at least 3 minutes (reference CS 25.735(g)).

No sustained fire that extends above the level of the highest point of the tire is allowed before 5 minutes have elapsed after application of brake clamping force; until this time has elapsed, neither fire fighting means nor coolants may be applied.

The time of initiation of tyre pressure release (for example by wheel fuse plug), if applicable, is to be recorded. The sequence of events described in paragraphs 3.3.4.4 and 3.3.4.5 is illustrated in Figure 3-2 of this Appendix 2.

3.3.5 Structural Torque Test

The Wheel/Brake Rated Structural Torque, STR, is equal to the torque demonstrated in the test defined in paragraph 3.3.5.1 of this Appendix 2.

- 3.3.5.1 Apply to the wheel, brake and tyre assembly, the radial load S and the drag load corresponding to the torque specified in paragraphs 3.3.5.2 or 3.3.5.3 of this Appendix 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 the application of at least L_{BMAX} , or equivalent. If such clamping force or its equivalent is insufficient to prevent rotation, the friction surface may be clamped, bolted, or otherwise restrained while applying the clamping force. A fully worn brake

configuration, BRWL, must be used for this test. The proportioning of wear through the brake for the various friction pairs for this test must be based on service wear experience of an equivalent or similar brake or test machine wear test data. Either operationally worn or mechanically worn brake components may be used. The EMA may be cooled and/or restrained at the source of electromotive force generation after initial application of L_{BMAX} in lieu of maintaining application of electrical current throughout the test.

3.3.5.2 For landing gear with one wheel per landing gear strut, the torque is $1.2(S \times R)$.

3.3.5.3 For landing gear with more than one wheel per landing gear strut, the torque is $1.44(S \times R)$.

3.3.5.4 The wheel and brake assembly must support the loads without failure for at least 3 seconds. Abrupt loss of load-carrying capability or fragmentation during the test constitutes failure.

3.3.6 Wheel to Brake Clearance

There must be no interference in any critical areas between the wheel and brake assembly (with fittings) up to limit load conditions, taking into account the axle angular orientation. Lack of interference can be established by analyses and/or tests. If chosen, testing shall be conducted per the following methods:

3.3.6.1 Radial Limit Load Wheel and Brake Clearance Test.

With a suitable tyre, TT_{WT} , installed, mount the wheel and brake on a suitable axle, and position it against a flat, non-deflecting surface. The wheel axle must have the same angular orientation to the non-deflecting surface that it will have to a flat runway when it is mounted on an airplane and is under the maximum radial limit load, L .

Inflate the tyre to the pressure recommended for the Wheel Rated Static Load, S , with gas and/or liquid. If liquid inflation is used, liquid must be bled off to obtain the same tire deflection that would result if gas inflation were used. Liquid pressure must not exceed the pressure that would develop if gas inflation were used and the tyre was deflected to its maximum extent. Load the wheel through its axle with the load applied perpendicular to the flat, non-deflecting surface. Reference CS 25.471 through 25.511, as appropriate. If the radial limit load of paragraph 3.3.6.2 of this Appendix 2 is equal to or greater than the radial limit load specified in this paragraph, the test specified in this paragraph may be omitted.

Determine the most critical wheel orientation with respect to the non-deflecting surface. Apply the load with the tyre loaded against the non-deflecting surface. If multiple critical orientations are determined, repeat the testing for each critical orientation. The bearing cups, cones, and rollers used in operation must be used for this loading. If at a point of loading during the test bottoming of the tyre occurs, then the tyre pressure may be increased an amount sufficient only to prevent bottoming.

3.3.6.2 Combined Limit Load Wheel and Brake Clearance Test.

With a suitable tyre, TT_{WT} , installed, mount the wheel and brake on a suitable axle, and position it against a flat, non-deflecting surface. The wheel axle must have the same angular orientation to the non-deflecting surface that it will have to a flat runway when it is mounted on an aeroplane and is under the maximum radial limit load, L . Apply to the wheel and tyre assembly radial and side loads not less than the respective ground limit loads. Reference CS 25.485, 25.495, 25.497, and 25.499, as appropriate. If at a point of loading during the test bottoming of the tyre occurs, then the tyre pressure may be increased an amount sufficient only to prevent bottoming.

Determine the most critical wheel orientation with respect to the non-deflected surface.

Apply the load with the tyre loaded against the non-deflecting surface with the wheel in the most critical orientation.

The bearing cups, cones, and rollers used in operation must be used in this test.

A tube may be used in a tubeless tyre only when it has been demonstrated that pressure will be lost due to the inability of a tyre bead to remain properly positioned under the load. The wheel must be tested for the most critical inboard and outboard side loads. If multiple critical orientations are determined to apply, repeat the testing for each critical orientation.

3.4 BRAKE TESTS

It must be substantiated that standard production samples of the brake will pass the following tests:

3.4.1 Limit and Ultimate Load Test

Alternative control systems and artificial cooling of the electromotive devices may be used for the following tests if needed to generate and maintain the required clamping forces.

Limit Load: The brake must withstand for at least 5 seconds a force equal to the Brake Limit Load (L_{LMT}) without permanent deformation that would prevent it from performing its intended function after the test.

Ultimate Load: The brake, with EMAs extended to simulate a maximum worn condition, must for at least 3 seconds withstand a force equal to 1.5 times L_{LMT} . If necessary, EMA extension may be adjusted to prevent interaction with any retention means during this test.

3.4.2 Endurance Test

A brake assembly must be subjected to an endurance test during which structural failure or malfunction must not occur. If desired, the heat sink components may be replaced by a reasonably representative dummy mass for this test.

The test must be conducted by subjecting the brake assembly to 100,000 cycles of an application of the Brake Design Landing Load (L_{DL}) in the design landing stop test (paragraph 3.3.2 of this Appendix 2) and release to the Brake Off Position (BOP). The EMAs must be adjusted so that the cycles are equally divided among at least five or more equally incremented wear positions, including the new and fully worn positions, BRWL.

The brake must then be subjected to 5000 cycles of application of force to the Maximum Brake Load (L_{BMAX}) and release to BOP. The EMAs must be adjusted so that the cycles are equally divided between at least five or more equally incremented, wear positions including the new and fully worn positions, BRWL.

The brake assembly must meet the integrity requirements of paragraph 3.4.4 of this Appendix 2 at the completion of this test.

3.4.3 Extreme Temperature Soak Test

Subject the brake to at least a 24-hour hot soak at the maximum actuator housing temperature experienced during a design landing stop test (paragraph 3.3.2 of this Appendix 2), conducted without forced air cooling. While at the hot soak temperature, the brake must be subjected to the application of the Brake Design Landing Load (L_{DL}) required during the 100 design landing stops and release to BOP for 1000 cycles, followed by 25 cycles of Maximum Brake Load (L_{BMAX}) and release to BOP.

The brake must then be cooled from the hot soak temperature to a cold soak temperature of -40°F (-40°C) and maintained at this temperature for at least 24 hours. While at the cold soak temperature, the brake must be subjected to the application of the Brake Design Landing Load (L_{DL}) required during the KE_{DL} stops and release to BOP, for 25 cycles, followed by 5 cycles of Maximum Brake Load (L_{BMAX}) and release to BOP.

The brake assembly must meet the integrity requirements of paragraph 3.4.4 of this Appendix 2 at the completion of this test.

3.4.4 Brake Assembly Integrity

The brake assembly shall meet the functional test requirements (acceptance tests) established to assure continued airworthiness.

CHAPTER 4**DATA REQUIREMENTS**

4.1 The applicant must provide the following data with any application for approval of equipment:

4.1.1 The following wheel and brake assembly ratings:

a. Wheel Ratings

See Appendix 1, paragraph 4.1.1a.

b. Wheel/Brake and Brake Ratings

Wheel/Brake Rated Design Landing Energy, KE_{DL} , and associated brakes-on-speed, V_{DL}
Wheel/Brake Rated Accelerate-Stop Energy, KE_{RT} , and associated brakes-on-speed, V_{RT}
Wheel/Brake Rated Most Severe Landing Stop Energy, KE_{SS} , and associated brakes-on-speed, V_{SS} (if applicable)

Maximum Brake Load, L_{BMAX}

Brake Limit Load, L_{LMT}

Wheel/Brake Rated Structural Torque, ST_R

Rated Design Landing Deceleration, D_{DL}

Rated Accelerate-Stop Deceleration, D_{RT}

Rated Most Severe Landing Stop Deceleration, D_{SS} (if applicable)

Brake Rated Tire Size, TS_{BR}

Brake Rated Wear Limit, $BRWL$

Maximum EMA Brake Voltage, V_{BMAX}

Maximum EMA Brake Current, I_{BMAX}

Maximum EMA Brake Power, P_{BMAX}

Maximum System Voltage, V_{SMAX}

Maximum System Current, I_{SMAX}

Maximum System Power, P_{SMAX}

4.1.2 The weight of the wheel and brake assemblies, as applicable.

4.1.3 Specification of the voltage and current supply limitations used during the tests.

4.1.4 Analysis and/or data substantiating I_{BMAX} , L_{BMAX} , L_{DL} , L_{LMT} , P_{BMAX} and V_{BMAX} , as appropriate.

4.1.5 One copy of the test report showing compliance with the test requirements.

NOTE: When test results are being recorded for incorporation in the compliance test report, it is not sufficient to note merely that the specified performance was achieved. The actual numerical values obtained for each of the parameters tested must be recorded, except where tests are pass/fail in character.

4.2 Prior to entry into service, a component maintenance manual (CMM), covering periodic maintenance, calibration, and repair, for the continued airworthiness of installed wheels and wheel and brake assemblies, including recommended inspection intervals and service life.

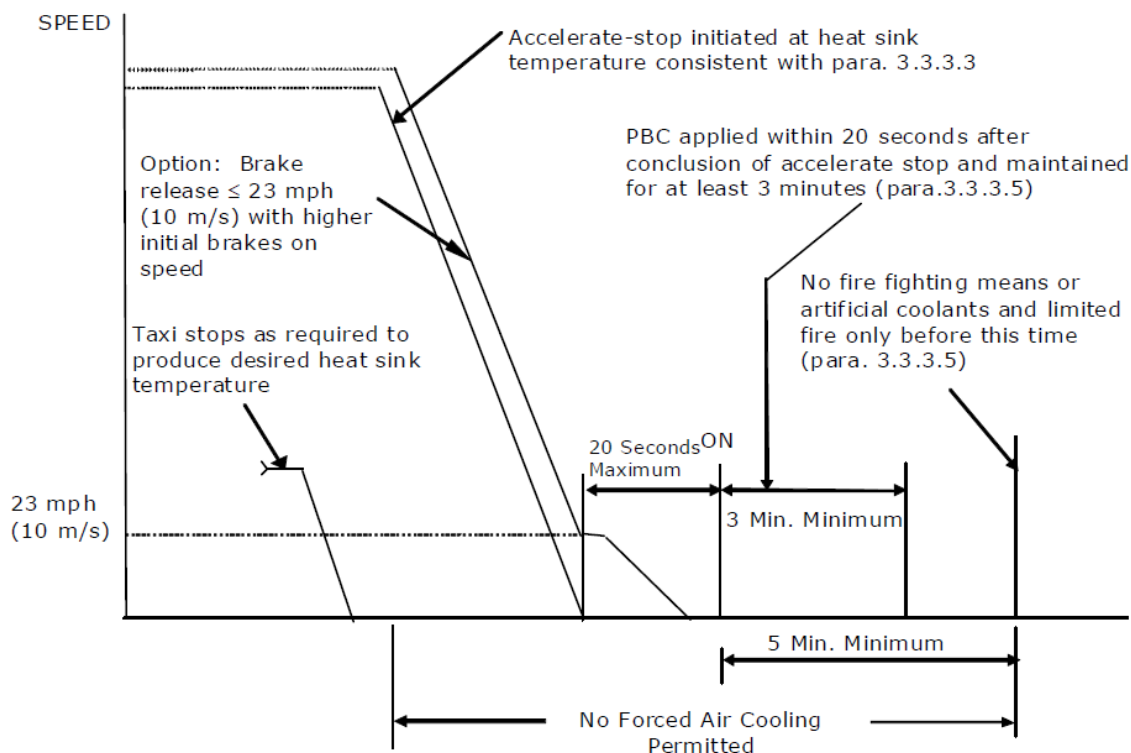


Figure 3-1 - Taxi, Accelerate-Stop, Park Test Sequence

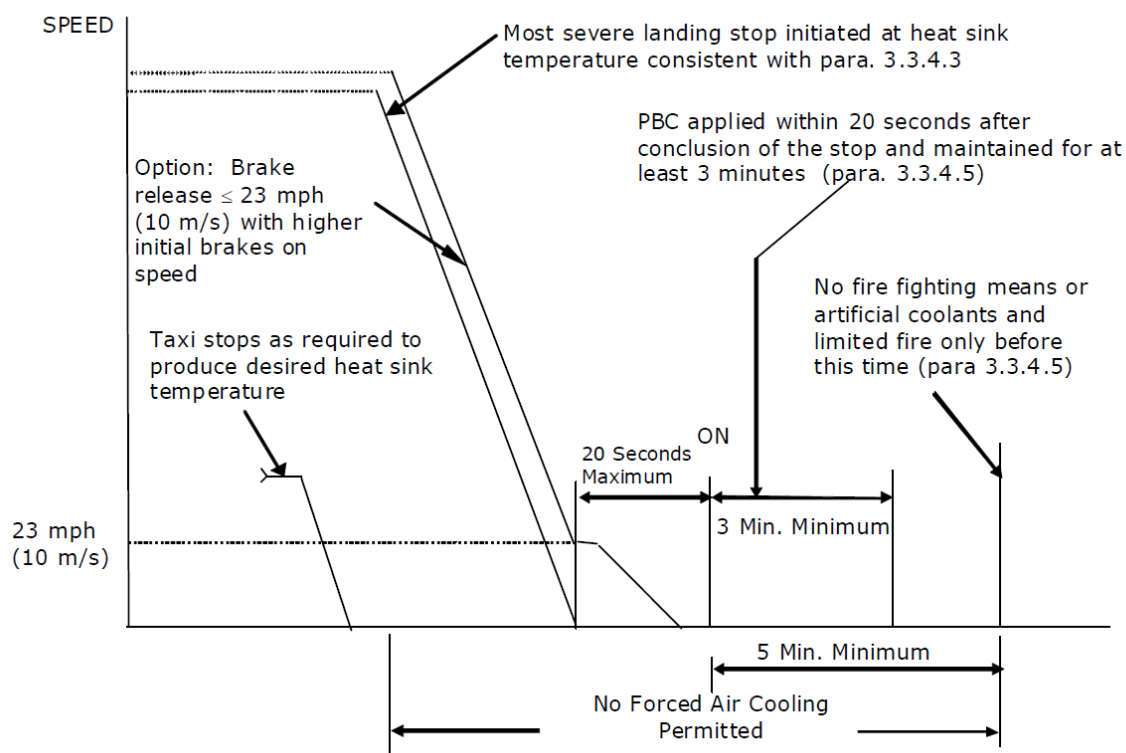


Figure 3-2 - Most Severe Landing-Stop, Park Test Sequence

[Amdt ETSO/6]

ETSO-C139a

ED Decision 2016/013/R

AUDIO SYSTEMS AND EQUIPMENT**1 Applicability**

This ETSO provides the requirements which Audio Systems and Equipment that are designed and 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 RTCA DO-214A, Audio Systems Characteristics and Minimum Performance Standards for Aircraft Audio Systems and Equipment, dated 18 December 2013.

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.

3.1.4 Electronic Hardware Qualification

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific

None.

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

4 Marking**4.1 General**

Marking as 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.

[Amdt ETSO/11]

ETSO-C141

ED Decision 2003/10/RM

AIRCRAFT FLUORESCENT LIGHTING BALLAST/FIXTURE EQUIPMENT**1 Applicability**

This ETSO gives the requirements that fluorescent lighting ballast/fixture equipment that are manufactured on or after the date of this ETSO must meet in order to be identified with 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) 4914, Revision A “Aircraft Fluorescent Lighting Ballast/Fixture Safety Design Standard,” dated May 1999.

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.

ETSO-C142b

ED Decision 2020/011/R

NON-RECHARGEABLE LITHIUM CELLS AND BATTERIES**1 Applicability**

This ETSO provides the requirements which non-rechargeable lithium cells and batteries that are intended to provide power for aircraft equipment, including emergency systems, that are designed and manufactured on or after the effective date of this ETSO must meet in order to be identified with the applicable ETSO marking.

This ETSO is not applicable to coin or button cells that contain less than 2 watt-hours (Wh) of capacity, and that is are compliant with the requirements of UL 1642 and the UN transport regulations.

2 Procedures**2.1 General**

The 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**

RTCA document DO-227A 'Minimum Operational Performance Standard (MOPS) for Non Rechargeable Lithium Batteries' from 21 September 2017, as amended by [Appendix 1](#) to this ETSO.

3.1.2 Environmental Standard

Non-rechargeable lithium cells and batteries must be tested according to RTCA document DO-227A Section 2.0 unless otherwise specified by [Appendix 1](#) to this ETSO.

3.1.3 Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 Specific**3.2.1 Failure Condition Classification**

See CS-ETSO, Subpart A, paragraph 2.4.

4 Marking

4.1 General

See CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

Each lithium cell or battery must be marked in accordance with RTCA document DO-227A, Section 2.1.10.

In addition, the non-rechargeable lithium cell, battery or end item must be marked as ETSO-C142b-X as described in the following table:

X	Cell, Battery or End Item
– 1	Cell
– 3	Battery
– 5	End Item
– 7	< 5 Wh within End Item Cells and batteries must meet at a minimum UL1642 and UN 38.3 certification. (see Note below)

Note: For ETSO-C142b-7 approvals, the ETSO marking must be on the End Item. The cell or battery within the End Item must be part marked and identified as a component within the End Item. The cell or battery must have a notation in the manufacturer's documentation that the cell or battery is not to be used in another End Item unless it is tested separately in the new End Item. The End Item is required in order to meet the requirement of this ETSO, and the configuration control documentation must state that the cell or battery is approved based solely on the fact that it is tested and validated within the approved End Item. Only cells or batteries that are approved under the ETSO-C142b End Item article may be used. Cells or batteries should only be used if they are approved by the manufacturer of the article. If a different cell or battery is to be used with this End Item, the manufacturer must submit a new ETSO application (for the End Item) to EASA.

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/3]

[Amdt ETSO/16]

APPENDIX 1 TO ETSO-C142B – MINIMUM PERFORMANCE STANDARD FOR LITHIUM BATTERIES

ED Decision 2020/011/R

This Appendix prescribes the MPS for lithium batteries, as modified by this ETSO.

The standard is modified as follows:

Table 1— Text modifications to RTCA document DO-227A

RTCA DO-227A Section and title:	Current wording:	Modified wording:
1.4 Specific Exclusions from this document	c. Cells or batteries containing less than 2 Watt-hours (Wh) of capacity have sufficiently low energy that the possible hazard is considered low and therefore these cells and batteries are assessed as presenting an acceptably low risk for installation as long as they are compliant with the requirements of UL 1642 [Reference 9]. If compliant with UL 1642 and the UN transport regulations [Reference 10], no other requirements from this MOPS will apply to cells or batteries with less than 2 Wh of capacity.	c. Coin or button cells that contain less than 2 watt-hours (Wh) of capacity have sufficiently low energy that the possible hazard is considered to be low, and therefore these cells and batteries are assessed as presenting an acceptably low risk for installation as long as they are compliant with the requirements of UL 1642 [Reference 9]. If they are compliant with UL 1642 and the UN transport regulations [Reference 10], no other requirements from this MOPS will apply to <u>coin or button</u> cells with less than 2 Wh of capacity.
n/a	./.	d. For non-rechargeable cells and/or batteries that contain less than 5 Wh and have not been tested to RTCA document DO-227A, Sections 1.0 and 2.0, the requirement of this ETSO can be met under the ‘End Item testing’ described in DO-227A, Sections 2.2.3 and 2.4.3. Mark the cell or battery per Section 4.2 of this ETSO (ETSO-C142b-7). Note: For ETSO-C142b-7 approvals, the ETSO marking must be on the End Item and the cell or battery as well. The cell or battery must have a notation in the manufacturer’s documentation that the cell or battery is not to be used in another End Item. The End Item is needed in order to meet the requirement of this ETSO, and the configuration control documentation must state that the cell or battery is approved based solely on the fact that it is tested and validated within the approved End Item. Only cells or batteries that are approved under the ETSO-C142b End Item article may be used. Cells or batteries should only be used if they are approved by the manufacturer of the article. If a different cell or battery is to be used with this End

		Item, a new ETSO application (for the End Item) must be submitted to EASA.
2.4.1.2.1	(...) Test procedure (...) d. immediately start to discharge the sample cells using the DC power supply set at a constant current and with a voltage of limit of 3 volts. (...)	(...) Test procedure (...) d. immediately start to discharge the sample cells using the DC power supply set at a constant current and with a voltage of limit set to the cell nominal voltage. (...)
2.4.3	(...) Testing shall be accomplished in the order indicated in Figure 2-27. (...) End Item safety tests may be conducted using just two End Items by performing the non-destructive thermal management and load profile test first, followed by the thermal runaway containment tests using the same two End Items (with new batteries). All actual batteries used in the End Item safety tests will have previously passed the End Item vibration and shock tests.	(...) Remove 'Testing shall be accomplished in the order indicated in Figure 2-27'. (...) End Item safety tests may be conducted using just two End Items by performing the non-destructive thermal management and load profile test first, followed by the thermal runaway containment tests using the same two End Items (with new batteries). Remove 'All actual batteries used in the End Item safety tests will have previously passed the End Item vibration and shock tests'.

In addition, in Section 2.4.2.1.7, replace Table 2-2 and Figure 2-16 with the following table and figure:

<i>Time (Hours)</i>	<i>Duration (Hours)</i>	<i>Temperature (°C)</i>	<i>% Relative Humidity</i>
0-24	24	23	50
24-26	2	Ramp to 30	Ramp to 95
26-28	2	Soak 30	95
28-30	2	Ramp to 60	95
30-42	12	Soak 60	95
42-44	2	Ramp to 30	95
44-56	12	Soak 30	95
56-58	2	Ramp to 60	95
58-70	12	Soak 60	95
70-72	2	Ramp to 30	95
72-84	12	Soak 30	95
84-86	2	Ramp to 60	95
86-98	12	Soak 60	95
98-100	2	Ramp to 30	95
100-112	12	Soak 30	95
112-114	2	Ramp to 60	95
114-126	12	Soak 60	95
126-128	2	Ramp to 30	95
128-140	12	Soak 30	95
140-141	1	Ramp to 23	95

Table 2-2: Table of relative humidity / temperature test profile values

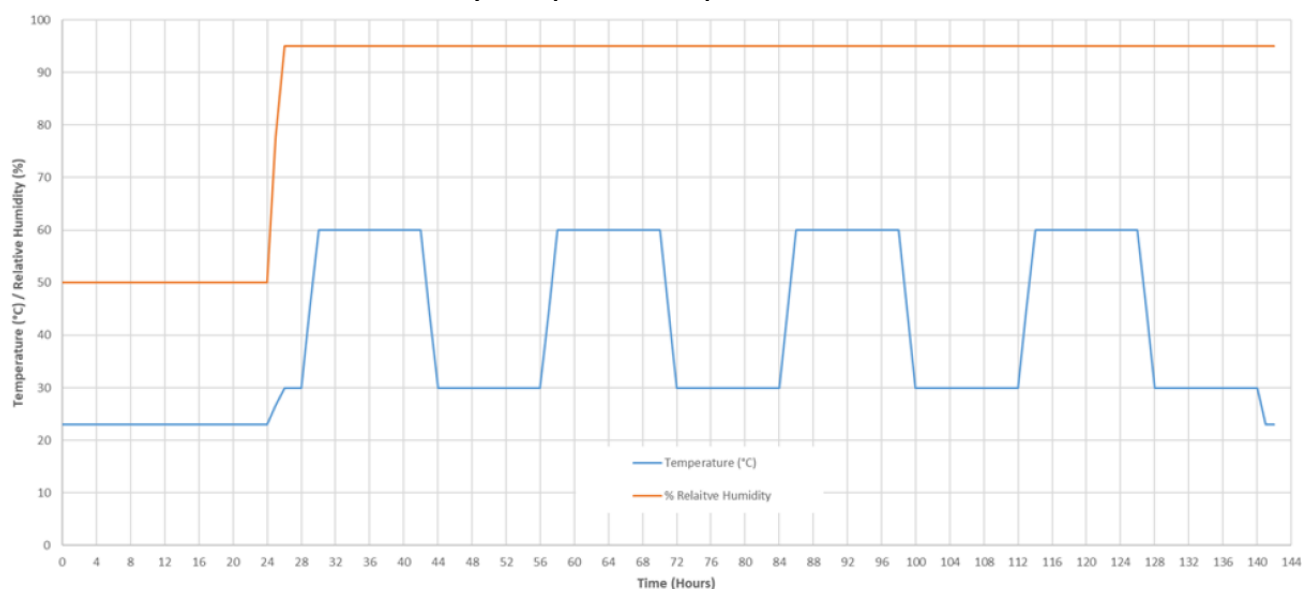


Figure 2-16: Humidity test profile of temperature and humidity versus time

[Amdt ETSO/3]

[Amdt ETSO/16]

ETSO-C144a

ED Decision 2010/010/R

PASSIVE AIRBORNE GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS) ANTENNA**1 Applicability**

This ETSO gives the requirements which new models of passive airborne Global Navigation Satellite System (GNSS) Antenna that are manufactured on or after the date of this ETSO must meet in order to be identified with 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-228, “Minimum Operational Performance Standards for Global Navigation Satellite System (GNSS) Airborne Antenna Equipment” dated October 20, 1995, Section 2 (excluding Sections 2.2.2 and 2.4.3) and Change 1 to DO-228.

Note 1: For Active Airborne Global Navigation Satellite System (GNSS) Antenna, see ETSO-C190

Note 2: The ETSO standards herein apply to equipment intended to receive and provide signals to a global positioning system (GPS)/satellite based augmentation system (SBAS) operational Class 1, or GPS, sensor or system that will provide flight path deviation commands to the pilot or autopilot. These standards do not address the use of the signals received through this antenna for other applications. GPS/SBAS operational classes are defined in RTCA document DO-229D “Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment”, dated December 13, 2006, Section 1.4.2.

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.

3.1.4 Electronic Hardware Qualification

See CS-ETSO [Subpart A](#) paragraph 2.3.

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO [Subpart A](#) paragraph 2.4

Failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a major failure condition.

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.

[Amdt ETSO/6]

ETSO-C145e A1

ED Decision 2020/011/R

**AIRBORNE NAVIGATION SENSORS USING THE GLOBAL POSITIONING SYSTEM
AUGMENTED BY THE SATELLITE-BASED AUGMENTATION SYSTEM****1 Applicability**

This ETSO provides the requirements which airborne navigation sensors using the Global Positioning System (GPS) augmented by the Satellite Based Augmentation System (SBAS) that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

The standards of this ETSO apply to equipment intended to provide position information to a navigation management unit that outputs deviation commands referenced to a desired flight path, pilots or autopilots will use these deviations to guide the aircraft.

Note: Revision A1 provides applicants with an option to use an ETSO-2C204a SBAS circuit card assembly (CCA) functional sensor as part of their ETSO application. There is no change to the technical MOPS in comparison with ETSO-C145e.

2 Procedures**2.1 General**

The applicable procedures are detailed in CS-ETSO, [Subpart A](#).

2.2 Specific

This section applies only for ETSO articles that use an ETSO-2C204a Beta CCA.

Applicants who use an ETSO-2C204a Beta CCA will need to coordinate with their Beta CCA supplier at least for the following aspects:

2.2.1 Access to the Information of the Selected ETSO-2C204a CCA

The applicant is responsible for establishing the necessary communication channels with the ETSO 2C204a holder company. Applicants who use an ETSO-2C204a SBAS CCA will need to coordinate with their SBAS CCA supplier to obtain the documentation that supports ETSO 2C204a.

The applicant's organisation shall establish a means of communication to obtain timely notifications of design changes, open problem reports (at least the ones that impact the usage of the circuit card assembly), occurrence reports and airworthiness directives that affect or are related to the ETSO 2C204a article.

2.2.2 Assessment of Design Changes

The applicant shall perform an impact analysis of the design changes to the ETSO-2C204a article, and shall perform the necessary development life-cycle activities that are impacted by the ETSO 2C204a changes.

Note: When a major change (as assessed per point 21.A.611) is applied to the ETSO 2C204a article, which is installed in the ETSO-C145e article, it is systematically also considered to be a major change for the ETSO-C145e function.

2.2.3 Assessment and Reporting of Open Problem Reports (OPRs)

The applicant shall perform an assessment of the ETSO-2C204a CCA OPRs. The applicant shall report the resulting open problem reports that affect the ETSO-C145e article.

3 Technical Conditions

3.1 Basic

3.1.1 Minimum Performance Standard

The applicable standards are those provided for functional equipment Class Beta in RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment dated 15 December 2016, Section 2, as amended by [Appendices 2](#) and [4](#) to this ETSO.

Class Beta equipment is defined in DO-229E, Section 1.4.

The test procedures are defined in DO-229E, Section 2.5.

The standards in this ETSO apply to equipment intended to provide position, velocity, and time information for a navigation management unit application that outputs deviation commands keyed to a desired flight path, or a non-navigation application such as an automatic dependent surveillance — broadcast (ADS-B) or terrain awareness and warning system (TAWS). In navigation applications, pilots or autopilots will use the deviations output by the navigation management unit to guide the aircraft. In non-navigation applications, the position, velocity, and time outputs will provide the necessary inputs for the end-use equipment. These ETSO standards do not address integration issues with other avionics.

Use of an ETSO-2C204a SBAS CCA functional sensor

ETSO-145e applicants have the option to use an ETSO-2C204a SBAS CCA functional sensor. Applicants who choose to use an ETSO-2C204a SBAS CCA functional sensor can take credit for certification compliance by virtue of the ETSO-2C204a ETSOA for:

- meeting the MPS Section 2.1 requirements;
- the development assurance of the hardware/software;
- the classification of the failure conditions; and
- the MPS Section 2.5 performance testing (functional qualification) except those tests that are specified in Appendix 1 to this document;
- the partial environmental testing performed on the ETSO-2C204a CCA.

After the integration of the ETSO-2C204a CCA into the ETSO-145e article, the applicant shall perform the testing described in Appendix 1. The applicant shall also complete the environmental qualification testing. The testing shall include the detailed functional test procedures delivered by the ETSO-2C204a CCA provider. This testing is required to address the paragraphs of this ETSO that are not covered by the points listed above.

Note: The manufacturer of end-use equipment that uses an ETSO-2C204a SBAS CCA functional sensor assumes full responsibility for its design and function under their ETSO-C145e authorisation.

3.1.2 Environmental Standard

See CS-ETSO Subpart A paragraph 2.1.

The required performance under test conditions is defined in RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite Based Augmentation System Airborne Equipment, dated 15 December 2016, Section 2.4.

3.1.3 Software

See CS-ETSO, Subpart A, paragraph 2.2.

Applicants who use an ETSO-2C204a SBAS CCA functional sensor may use the ETSO-2C204a authorisation as substantiation for compliance with the software development assurance aspects of the CCA.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

Applicants who use an ETSO-2C204a SBAS CCA functional sensor may use the ETSO-2C204a authorisation as substantiation for compliance with the hardware development assurance aspects of the CCA.

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4

Failure of the function defined in paragraph 3.1.1 of this ETSO is a:

- major failure condition for a loss of function or malfunction of en route, terminal, approach lateral navigation (LNAV), and approach LNAV/vertical navigation (VNAV) position data,
- major failure condition a for loss of function of approach localiser performance without vertical guidance (LP), and of approach localiser performance with vertical guidance (LPV) position data, and
- hazardous failure condition for a malfunction of approach (LP and LPV) position data that results in misleading information.

Note: These failure condition classifications are considered to be the minimum classifications. Guidance for the installation of navigation systems at the aircraft level (e.g. Certification Specifications and Acceptable Means of Compliance for Airborne Communications, Navigation and Surveillance (CS ACNS)) could require a different failure condition classification.

3.2.2 Additional Specific

If the equipment can satisfy the requirements of RTCA document DO-229E only when used with a particular antenna, the use of that antenna (by part number) shall be a requirement on the installation. This requirement shall be included in the installation manual as a limitation.

The applicant shall have all the data necessary to evaluate the geostationary (GEO) satellite bias as defined in RTCA document DO-229E, Section 2.1.4.1.5, available for review by EASA.

If the equipment uses barometric-aiding to enhance availability of FDE, then the equipment shall meet the requirements in RTCA document DO-229E, Appendix G.

4 Marking

4.1 General

See CS-ETSO, Subpart A, paragraph 1.2.

4.2 Specific

At least one major component must be permanently and legibly marked with the operational equipment class as defined in Section 1.4.2 of RTCA document DO-229E (e.g. Class 2). The functional equipment class defined in Section 1.4.1 of RTCA document DO-229E (e.g. Beta) is not required to be marked.

It is sufficient to declare the proper functional equipment class in the declaration of design and performance (DDP).

5 Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

[Amdt ETSO/6]

[Amdt ETSO/13]

[Amdt ETSO/16]

APPENDIX 1 TO ETSO-C145e A1 – END-USE EQUIPMENT MANUFACTURER TESTS FOR SBAS CCA FUNCTIONAL POSITION, VELOCITY, TIME (PVT) SENSORS USED FOR NAVIGATION AND NON-NAVIGATION APPLICATIONS

ED Decision 2020/011/R

1. SCOPE

This Appendix describes the required supplementary equipment level testing, in addition to the environmental testing of RTCA document DO-229E, Section 2.4, that is required to be conducted by the manufacturer of the end-use equipment to receive an ETSO-C145e Class Beta authorisation when using an ETSO-2C204a SBAS CCA functional sensor.

To perform functional tests and measure the performance in the environment, the applicant will use the detailed functional test procedures delivered with the ETSO-2C204a CCA. These test procedures are intended to streamline and simplify the ETSO-C145e authorisation process for the manufacturer of the end-use equipment by allowing credit for the design and selected testing performed at the SBAS CCA functional sensor level. However, the manufacturer of the end-use equipment remains fully responsible for the design and control of the article per their ETSO-C145e ETSOA.

2. GENERAL PRINCIPLES

- (a) Testing methods for GPS/SBAS equipment have been standardised by RTCA document DO-229E, and serve as the basis for ETSO-C145e. RTCA document DO-229E was written to cover equipment that can be installed on aircraft. Section 2.4 specifically addresses the issues of the environment in which the equipment operates and provides the approved test methods to validate the performance of the equipment in this environment. Section 2.4 represents the RTCA consensus in identifying which RTCA document DO-229E requirements are sensitive to environmental effects. These requirements are listed in the environmental tables referenced in Section 2.4.1.
- (b) The determination that a MOPS requirement is susceptible to the environment does not depend on whether or not the implementation is a CCA installed within an ETSO-C145e article. This is the same concept as an equipment enclosure that is designed to protect against a benign environment compared with one that is designed for a severe environment; the identification of the susceptible requirements is the same.
- (c) Therefore, this Appendix uses the tables of RTCA document DO-229E Section 2.4.1 to identify the MOPS requirements that are susceptible to environmental effects for an SBAS CCA functional sensor in the end-use equipment. The focus is on the change in environment seen by the SBAS CCA functional sensor as a result of its installation in the end-use equipment. For example, other components inside the end-use equipment may radiate RF energy that could interfere with the GPS functions; therefore, the ambient testing performed at the CCA level is not equivalent to tests performed in the end-use equipment. This is the basis for defining the RTCA document DO-229E Section 2.5 performance tests that need to be repeated by the manufacturer of the end-use equipment.

- (d) The Class Beta environmental table referenced in RTCA document DO-229E Section 2.4.1 is the prime source to determine the MOPS performance requirements that are susceptible to environmental conditions. Based on the table, the susceptible requirements can be grouped into two categories: those that are susceptible to most types of environmental conditions (described in Section 3) and those that are susceptible to only a few (described in Section 4).

Note: The tables for Class Beta-1, -2, and -3 equipment identify similar requirements that are susceptible to the installed environment. The only difference is the applicable MOPS requirements that are consistent with the operational class (i.e. Class -1, -2, or -3).

3. PERFORMANCE REQUIREMENTS THAT ARE SUSCEPTIBLE TO MOST TYPES OF ENVIRONMENTAL CONDITIONS

The RTCA document DO-229E requirements for accuracy (Sections 2.1.3.1, 2.1.4.1, and 2.1.5.1) and sensitivity and dynamic range (Section 2.1.1.10) are sensitive to most types of environmental conditions. However, these requirements are linked to the message loss rate requirement in 2.1.1.3.2. Sections 3.1 and 3.2 below identify the testing that manufacturers of end-use equipment are required to repeat to demonstrate that the SBAS CCA functional sensor continues to meet the accuracy, dynamic range, and message loss rate performance requirements after installation in the end-use equipment. All the tests shall be run under conditions in which the functions of the end-use equipment are fully enabled to create the worst-case environment.

3.1. RTCA document DO-229E — 2.5.8 Accuracy Test

- (a) The accuracy test described in Section 2.5.8 is actually a joint test that covers accuracy, sensitivity and dynamic range. This joint testing also applies under the environment as stated in Section 2.4.1.1.5, with environmental adaptations as described in Section 2.4.1.1.1.
- (b) The demonstration of accuracy is performed in accordance with Section 2.5.8.1 only for the test case with broadband external interference noise. This test must be repeated when the CCA is installed in the end-use equipment, and it is sufficient to perform it using broadband interference.
- (1) The environmental testing is limited to broadband interference, as it represents the worst-case signal-to-noise condition, which is the most sensitive to environmental effects. This applies equally to the environment for the CCA that is created by the end-use equipment.
 - (2) Section 2.5.8 contains a measurement accuracy test in 2.5.8.1, with the detailed test procedure in Section 2.5.8.2. The Section 2.5.8.1 test must be run under the worst-case environment identified in the 'Additional Considerations for Internal Interference Sources' section below. The measurement accuracy testing can be combined with the message loss rate testing described in Section 2.5.2.1.
 - (3) Section 2.5.8.3 is a 24-hour actual satellite accuracy test. The Section 2.5.8.3 test exposes the equipment to a variety of signal conditions and data-processing conditions over varying satellite geometries that will increase the confidence that no unforeseen interactions between components within the end-use equipment and the SBAS CCA functional sensor will go undetected. The 24-hour testing in Section 2.5.8.3 can be combined with the 24-hour message loss rate testing described in Section 2.5.2.4 (see the section on 'Additional Considerations for Internal Interference Sources').

- (4) Section 2.5.8.4 (SBAS Tracking Bias) is an analysis of the GPS hardware, and it is therefore not necessary to repeat it at the end-use equipment level provided that no extra RF components that affect the RF filtering response are inserted in the RF path. Otherwise, the manufacturer of the end-use equipment must also repeat the SBAS Tracking Bias test.
 - (c) The test threshold is relaxed from 110 % to 125 % as specified in Table 2-25 of the 2.5.8.2.1 test procedure to shorten the duration of the test. However, the Section 2.5.8 testing (excluding the SBAS Tracking Bias test in Section 2.5.8.4) for the CCA in the end-use equipment shall be under ambient conditions per Section 2.5 with the 110-% test pass threshold for the maximum test sensitivity.
 - (d) The Section 2.5.8 testing (excluding the SBAS Tracking Bias test in Section 2.5.8.4) will be repeated against the accuracy requirements that are consistent with the desired operational class (i.e. the Section 2.1.3.1, 2.1.4.1, and 2.1.5.1 accuracy requirements, as appropriate).
 - (e) Only the broadband external interference noise test case using minimum satellite power will be executed in most cases, to shorten the duration of the test. The Section 2.5.8.1 testing will be repeated for both the minimum and the maximum satellite power only for the worst-case environment.
- 3.2. RTCA document DO-229E — 2.5.2 Message Loss Rate Test
- (a) Section 2.5.2 specifies the message loss rate test for the Section 2.1.1.3.2 message loss rate requirement. This test is conducted in conjunction with the Section 2.5.8 accuracy testing. Section 2.5.2.2 defines the test procedure to collect data to verify the SBAS message loss rate in the presence of interference using the test cases in which the SBAS satellite is at minimum power. Section 2.5.2.3 defines the pass-fail criteria.
 - (b) The test in Section 2.5.2.2 is performed during the measurement accuracy broadband interference test case described in paragraph 3.1.
 - (c) The test procedure in Section 2.5.2.4.1 is run in conjunction with the Section 2.5.8.3 24-hour accuracy test. Section 2.5.2.4.2 defines the pass-fail criteria for the test case described in paragraph 3.1(b)(3).
4. PERFORMANCE REQUIREMENTS THAT ARE PARTIALLY SUSCEPTIBLE TO ENVIRONMENTAL CONDITIONS
- (a) The Class Beta tables (Tables 2-14, 2-16, and 2-18) in Section 2.4.1 of RTCA document DO-229E indicate that the requirements for the initial acquisition time (2.1.1.7) and the satellite reacquisition time (2.1.1.9) are sensitive to four environmental conditions: icing, lightning-induced transient susceptibility, lightning direct effects, and normal/abnormal operating conditions. The requirements for loss of navigation (2.1.1.13.2, 2.1.4.12.2, and 2.1.5.12.2) and loss of integrity (2.1.1.13.1, 2.1.4.12.1, and 2.1.5.12.1) are sensitive to low and high operating temperatures.
 - (b) The lightning-induced transient susceptibility, lightning direct effects, or icing environmental conditions are not pertinent to the environment that is created by the end-use equipment relative to the SBAS CCA functional sensor. However, the manufacturer of the end-use equipment remains responsible for meeting the overall environmental qualification requirements at the end-use equipment level.

- (c) The loss of navigation and loss of integrity indications are limited to temperature testing, and the information in RTCA document DO-229E, Sections 2.4.1.1.2 and 2.4.1.1.3, is appropriate. The purpose is to ensure that the interface used to indicate the loss of navigation is functional under the environmental conditions that are present after the SBAS CCA functional sensor is installed in the end-use equipment. Sections 2.4.1.1.2 and 2.4.1.1.3 indicate that any source that generates the indication can be used, since it is the interface and not the detection mechanism that is verified. The temperature testing performed at the end-use equipment level is the worst-case scenario. It is not necessary to repeat the CCA-level test at room temperature in the end-use equipment, since the environmental qualification adequately addresses the testing for these requirements.
- (d) EUROCAE ED-14 Section 16 relates to aircraft power supplies (refer to ETSO Section 3.1.2 for the environmental qualification requirements). Sections 16.5.1.2 and 16.6.1.2 are for supply voltage modulation (AC)/ripple (DC). Given the potential susceptibility of the SBAS CCA functional sensor to power supply noise, it is prudent to repeat the tests at the end-use equipment level on this basis.
- (e) Sections 4.1 and 4.2 identify the testing that manufacturers of end-use equipment are required to repeat to demonstrate that the SBAS CCA functional sensor continues to meet the acquisition time and reacquisition time performance requirements relative to the normal/abnormal operating conditions after installation in the end-use equipment. All the tests shall be run under conditions in which the functions of the end-use equipment are fully enabled, to create the worst-case environment.

4.1. RTCA document DO-229E — 2.5.4 Initial acquisition test procedures

The information in RTCA document DO-229E, Section 2.4.1.1.4, on the initial acquisition test in Section 2.5.4 applies. The manufacturer of the end-use equipment shall repeat the initial acquisition testing described in RTCA DO-229E, Section 2.5.4.

4.2. RTCA document DO-229E — 2.5.6 Satellite reacquisition time test.

The manufacturer of the end-use equipment is required to repeat the satellite reacquisition time testing in RTCA document DO-229E, Section 2.5.6.

5. ADDITIONAL CONSIDERATIONS FOR INTERNAL INTERFERENCE SOURCES

- (a) Installing an SBAS CCA functional sensor into end-use equipment that also includes other functions requires a careful evaluation of the potential internal radiated and conducted interference. The manufacturer of the end-use equipment must evaluate each operating mode to determine whether the mode changes the environment for the installed SBAS CCA functional sensor. If there is only one environment, or there is clearly one worst-case environment, then the accuracy and message loss rate testing in Section 3 can be run in that operating mode only. For example, if the end-use equipment includes an RF transmitter that radiates at one frequency, one could reasonably argue that setting the transmitter at full power with maximum data throughput would generate a clear worst-case environment in which to run all the testing.

- (b) In the case of multiple environments, the accuracy and message loss rate tests can either be run in each environment, or the methodology in RTCA document DO-229E, Section 2.4.1.2.3, can be used to run an aggregate test with approximately equal time in each mode. The methodology in Section 2.4.1.2.3 must be used to identify the modes with the greatest susceptibility under which the combined accuracy and message loss rate tests are repeated in addition to the aggregate test. For example, the methodology of Section 2.4.1.2.3 is appropriate for end-use equipment that contains a high-power transmitter that operates on a large number of frequencies such that it is impractical to run a test at each frequency. This is analogous to the large number of frequencies that need to be tested during the EUROCAE ED-14 Section 19 testing on induced signal susceptibility and the Section 20 testing on radio frequency susceptibility, and this is the reason why the methodology of Section 2.4.1.2.3 was developed.
- (c) It is sufficient to identify one worst-case environment when performing acquisition and 24-hour accuracy testing.

6. SUMMARY

- (a) The manufacturer of end-use equipment that incorporates an SBAS CCA functional sensor is required to repeat the following RTCA document DO-229E Section 2.5 testing under ambient conditions (see Section 5) after installing the SBAS CCA functional sensor in the end-use equipment:
 - The Section 2.5.8 accuracy test (excluding the SBAS Tracking Bias test in 2.5.8.4) adapted per Section 2.4.1.1.1, except that the 110-% test pass threshold is used.
 - Note: Excluding the SBAS Tracking Bias test is acceptable, provided that the end-use equipment does not insert into the RF signal path any components that affect the filtering response. Otherwise, the manufacturer of the end-use equipment must repeat the SBAS Tracking Bias test as well.
 - The Section 2.5.2 message loss rate test.
 - The Section 2.5.4 initial acquisition test.
 - The Section 2.5.6 satellite reacquisition time test.
- (b) The manufacturer of the end-use equipment remains responsible for completing a full environmental qualification evaluation (ETSO Section 3.1.2) at the end-use equipment level. The manufacturer of end-use equipment that incorporates an SBAS CCA functional sensor is required to repeat the loss of navigation indication and loss of integrity indication tests as part of the environmental qualification according to RTCA document DO-229E Sections 2.4.1.1.2 and 2.4.1.1.3 respectively.

[Amdt ETSO/13]

[Amdt ETSO/16]

APPENDIX 2 TO ETSO-C145E A1 – ADDITION TO RTCA DOCUMENT DO-229E

SECTION 1

ED Decision 2020/011/R

This Appendix describes the required modifications and additions to RTCA DO-229E for compliance with this ETSO. This Appendix adds a new Section 1.8.3 and corrects a long-standing mistake in the Section 2.4 environmental requirement tables.

The new section provides information for cybersecurity and spoofing mitigation to make RTCA document DO-229E consistent with the new RTCA MOPS template and RTCA document DO-253D, Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment.

1.8.3 Cybersecurity and GNSS Spoofing Mitigation

This section contains information to address intentional interference with the GNSS. Spoofing is caused by RF waveforms that mimic true signals in some ways, but deny, degrade, disrupt, or deceive a receiver's operation when they are processed. Spoofing may be unintentional, such as effects from the signals of a GNSS repeater, or may be intentional and even malicious. There are two classes of spoofing:

- Measurement spoofing introduces RF waveforms that cause the target receiver to produce incorrect measurements of time of arrival or frequency of arrival or their rates of change;
- Data spoofing introduces incorrect digital data to the target receiver for its use in processing of signals and the calculation of positioning, navigation and timing (PNT).

Either class of spoofing can cause a range of effects, from incorrect outputs of PNT to receiver malfunction. The onset of effects can be instantaneous or delayed, and the effects can continue even after the spoofing has ended. Improperly used or installed GNSS re-radiators act like spoofers. Re-radiators replay and GNSS emulator devices can present misleading information to GNSS equipment and/or could cause lasting effects.

Equipment manufacturers should implement measures to mitigate processing of erroneous data. Cross-checks of GNSS sensor data against independent position sources and/or other detection monitors using GNSS signal metrics or data checks can be implemented in the antenna, receiver, and/or through integration with other systems at the aircraft level. Data validity checks to recognize and reject measurement and data spoofing should be implemented in the receiver. Additional guidance and best practices related to GNSS equipment can be found in the U.S. Department of Homeland Security document 'Improving the Operation and Development of Global Positioning System (GPS) Equipment Used by Critical Infrastructure'¹ and GLOBAL POSITIONING SYSTEMS DIRECTORATE SYSTEMS ENGINEERING & INTEGRATION: INTERFACE SPECIFICATION, IS-GPS-200, Navstar GPS Space Segment/Navigation User Interfaces, Revision H, IRN-IS-200H-003, 28 July 2016.

Aircraft equipment information vulnerabilities (such as cybersecurity risks) have been present for digital systems since the development of the personal computer (PC) in the late 1970s and even longer for RF systems, and the advent of internet connectivity has substantially increased those risks. Typically, access to navigation receivers has been controlled such that they are considered to be vulnerable only through RF signals and OEM and/or aircraft operator controlled processes for maintenance and updates. In some cases, aircraft GNSS receivers may be field-loadable by approved personnel, requiring physical access and physical interface to the ground receivers. However, it is

¹ [https://ics-cert.us-cert.gov/sites/default/files/documents/Improving the Operation and Development of Global Positioning System \(GPS\) Equipment Used by Critical Infrastructure S508C.pdf](https://ics-cert.us-cert.gov/sites/default/files/documents/Improving%20the%20Operation%20and%20Development%20of%20Global%20Positioning%20System%20(GPS)%20Equipment%20Used%20by%20Critical%20Infrastructure%20S508C.pdf).

expected that not all aircraft in the future will rely on such physical isolation for the security of avionics. Internet and Wi-Fi connectivity have become popular as a means for aircraft or equipment manufacturers to update installed avionics software, to update databases, or provide an alternate means of communicating with the flight crew or cabin (e.g., in-flight entertainment, weather, etc.).

In most countries, the State provides oversight of safety-of-flight systems (sometimes referred to as ‘authorised services’) which provide information to aircraft, such as ILS, VOR, GNSS, and DME, to name a few. However, the State typically does not provide oversight on ‘non-trusted’ connectivity such as the internet, Wi-Fi, or manufacturer-supplied equipment interfaces which permit the input of externally supplied data into aircraft systems. A manufacturer may expose aircraft information vulnerabilities through the design of the equipment, or the equipment may become vulnerable as a result of being connected to a common interface. Therefore, it is important for manufacturers to consider aircraft information security risk mitigation strategies in their equipment design, particularly when the equipment is responsible for an interface between the aircraft and aircraft-external systems.

Apart from any specific aircraft-information-security-related performance requirements that are contained in the MOPS, it is recommended that manufacturers consider a layered approach to aircraft information security risk mitigation that includes both technical (e.g. software, signal filtering) and physical strategies. From a technical perspective, for example, this could include signal spoofing detection capabilities or more stringent, multi-factored authentication techniques such as passwords, PINs, and digital certificates. From a physical perspective, a manufacturer could consider connectors that require special tools to remove them to prevent passenger tampering — although navigation avionics are typically located in an avionics bay inaccessible to passengers. And finally, but just as important, manufacturers should consider supply chain risk management; for example, if a manufacturer outsources the development of software code, are the contractor and its staff properly vetted?

Civil aviation authorities (CAAs) have a regulatory interest when an applicant’s design makes use of a non-trusted connection through which the installation can potentially introduce aircraft information security vulnerabilities. This requires the applicant to address not only the information security vulnerabilities and mitigation techniques for the new installation, but to also consider how vulnerability could propagate to existing downstream systems. Therefore, it is recommended that manufacturers reference their equipment aircraft information security review and mitigation strategies in the installation manual of the equipment so that the applicant can consider them in meeting the regulatory requirements of the installation.

Table 2-14 to Table 2-20

The tables incorrectly reference and label EUROCAE ED-14/RTCA document DO-160 Sections 16.5.1.2 and 16.6.1.2 regarding ‘2.1.1.7 Acquisition Time’ and ‘2.1.1.9 Reacquisition Time’. Change the table references as follows:

The MOPS initial acquisition time requirement (2.1.1.7) applies to both AC and DC equipment under abnormal operating conditions (EUROCAE ED-14/RTCA document DO-160 Sections 16.5.2 and 16.6.2) and the satellite reacquisition time requirement (2.1.1.9) applies to both AC and DC equipment under normal operating conditions (EUROCAE ED-14/RTCA document DO 160 Sections 16.5.1 and 16.6.1).

[Amdt ETSO/13]

[Amdt ETSO/16]

APPENDIX 3 TO ETSO-C145E A1

ED Decision 2020/011/R

Reserved.

[Amdt ETSO/13]

[Amdt ETSO/16]

APPENDIX 4 TO ETSO-C145E A1

ED Decision 2020/011/R

This Appendix prescribes the EASA modifications to RTCA document DO-229E, Section 2.

In Section 2.1.1.2, after the first sentence, add the following:

‘The demodulation of data from the GPS signals shall be restricted to the necessary subset of the data defined in Appendix II to IS-GPS-200D, ‘Navstar GPS Space Segment / Navigation User Interfaces’, December 2004, provided on RF link L1. The pseudo-ranging shall be performed on RF link L1 utilising the coarse/acquisition (C/A) code.’

This is to ensure that only the L1 NAV data, for which the SBAS provides corrections and integrity, is used, and that no CNAV data, which is defined in Appendix III to IS-GPS-200D, is used, for which the SBAS does not provide integrity.

[Amdt ETSO/13]

[Amdt ETSO/16]

ETSO-C146e A1

ED Decision 2020/011/R

STAND-ALONE AIRBORNE NAVIGATION EQUIPMENT USING THE GLOBAL POSITIONING SYSTEM AUGMENTED BY THE SATELLITE-BASED AUGMENTATION SYSTEM

1 Applicability

This ETSO provides the requirements which stand-alone airborne navigation equipment using the Global Positioning System (GPS) augmented by the Satellite-Based Augmentation System (SBAS) that is designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

Note: Revision A1 provides applicants with an option to use an ETSO-2C205a Class Delta circuit card assembly (CCA) functional sensor as part of their ETSO application. There is no technical MOPS change in comparison with ETSO-C146e.

2 Procedures

2.1 General

The applicable procedures are detailed in CS-ETSO, [Subpart A](#).

2.2 Specific

This section only applies to ETSO articles that use an [ETSO-2C205a](#) CCA.

Applicants that use an ETSO-2C205a CCA will need to coordinate with their CCA supplier for at least the following aspects:

2.2.1 Access to the Information on the Selected ETSO-2C205a CCA

The applicant is responsible for establishing the necessary communication channels with the ETSO-2C205a holder company. Applicants who use an ETSO-2C205a SBAS CCA will need to coordinate with their SBAS CCA supplier to obtain the documentation that supports ETSO-2C205a.

The applicant's organisation shall establish a means of communication to obtain timely notifications of design changes, open problem reports (at least the ones that impact the usage of the CCA), occurrence reports and airworthiness directives that affect or relate to the ETSO-2C205a article.

2.2.2 Assessment of Design Changes

The applicant shall perform an impact analysis of the design changes to the ETSO 2C205a article, and shall perform the necessary development life-cycle activities that are impacted by the ETSO-2C205a changes.

Note: When a major change (as assessed per point 21.A.611) is applied to the ETSO-2C205a article, which is installed into the ETSO-C146e article, it is systematically also considered to be a major change for the ETSO-C146e function.

2.2.3 Assessment and Reporting of Open Problem Reports (OPRs)

The applicant shall perform the assessment of the ETSO-2C205a CCA OPRs. The applicant shall report the resulting OPRs that affect the ETSO-C146e article.

3 Technical Conditions

3.1 Basic

3.1.1 Minimum Performance Standard

The applicable standards are those provided for functional equipment Class Gamma or Delta in RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, dated 15 December 2006, Section 2, as amended by [Appendices 2](#) and [4](#) to this ETSO.

Classes Gamma and Delta of equipment are defined in DO-229E, Section 1.4.

The test procedures are defined in DO-229E, Section 2.5.

The standards in this ETSO apply to equipment intended to accept a desired flight path and provide deviation commands keyed to that path. Pilots and autopilots will use these deviations to guide the aircraft. Except for automatic dependent surveillance with Class Gamma, these ETSO standards do not address integration issues with other avionics.

Use of an ETSO-2C205a Class Delta CCA functional sensor

Applicants for Class Delta-4 ETSO-146e have the option to use an ETSO-2C205a Delta CCA functional sensor. Applicants who choose to use an ETSO-2C205a Delta CCA can take credit for certification compliance by virtue of the ETSO-2C205a ETSOA for:

- meeting the Class Delta-4 MPS requirements in Sections 2.1.1, 2.1.5, and 2.3;
- the development assurance of the hardware/software;
- the classification of failure conditions;
- the MPS Section 2.5 performance testing (functional qualification), except that specified in Appendix 1 to this document; and
- the partial environmental testing performed on the ETSO-2C205a CCA.

After the integration of the ETSO-2C205a CCA into the ETSO-146e article, the applicant shall perform the testing described in Appendix 1. The applicant shall also complete the environmental qualification testing. The testing shall include the detailed functional test procedures delivered by the ETSO-2C205a CCA provider. This testing is required to address the paragraphs of this ETSO that are not covered by the items listed above.

Note: An end-use manufacturer that uses an ETSO-2C205a SBAS CCA functional sensor assumes full responsibility for the design and its function under their ETSO-C146e authorisation.

3.1.2 Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1. The required performance under test conditions is defined in RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, dated 15 December 2016, Section 2.4.

3.1.3 Software

See CS-ETSO, Subpart A, paragraph 2.2.

Applicants who use an ETSO-2C205a Class Delta CCA functional sensor may use the ETSO-2C205a authorisation as substantiation for compliance with the software development assurance aspects of the CCA.

3.1.4 Electronic Hardware Qualification.

See CS-ETSO, Subpart A, paragraph 2.3.

Applicants who use an ETSO-2C205a Class Delta CCA functional sensor may use the ETSO 2C205a authorisation as substantiation for compliance with the hardware development assurance aspects of the CCA.

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 of this ETSO is a:

- major failure condition for a loss of function or malfunction of en route, terminal, approach lateral navigation (LNAV), and approach LNAV/vertical navigation (VNAV) position data,
- major failure condition for a loss of function of approach localiser performance without vertical guidance (LP), and of approach localiser performance with vertical guidance (LPV) position data, and
- Hazardous failure condition for the malfunction of approach (LP and LPV) position data that results in misleading information.

Note: These failure condition classifications are considered to be the minimum classifications. Guidance for the installation of navigation systems at the aircraft level (e.g. Certification Specifications and Acceptable Means of Compliance for Airborne Communications, Navigation and Surveillance (CS-ACNS)) could require different failure condition classifications.

3.2.2 Additional Specific

If the equipment can satisfy the requirements of RTCA/DO-229E only when used with a particular antenna, the use of that antenna (by part number) shall be a requirement on the installation. This requirement shall be included in the installation manual as a limitation.

Applicants shall have all the data necessary to evaluate the geo stationary (GEO) satellite bias as defined in RTCA DO-229E, Section 2.1.4.1.5 available for review by EASA.

If the equipment uses barometric-aiding to enhance the availability of the FDE, then the equipment shall meet the requirements in RTCA DO-229E, Appendix G.

4 Marking**4.1 General**

See CS-ETSO, Subpart A, paragraph 1.2.

4.2 Specific

At least one major component shall be permanently and legibly marked with the operational equipment class as defined in Section 1.4.2 of RTCA document DO-229E (e.g. Class 2). A marking of Class 4 indicates compliance with the Delta-4 requirements. The functional equipment class defined in Section 1.4.1 of RTCA document DO-229E (e.g. Gamma, Delta) is not required to be marked.

It is sufficient to declare the proper functional equipment class in the declaration of design and performance (DDP).

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/6]

[Amdt ETSO/13]

[Amdt ETSO/16]

APPENDIX 1 TO ETSO-C146E A1– END-USE EQUIPMENT MANUFACTURER TESTS AFTER INTEGRATION OF DELTA CCA FUNCTIONAL SENSORS USED FOR NAVIGATION APPLICATIONS

ED Decision 2020/011/R

1. SCOPE

This Appendix describes the required supplementary equipment level testing, in addition to the environmental testing of RTCA document DO-229E, Section 2.4, that the manufacturer of end-use equipment is required to conduct to receive an ETSO-C146e Class Delta-4 authorisation when using an ETSO-2C205a Delta CCA functional sensor.

To perform functional tests and to measure the performance in the environment, the applicant will use the detailed functional test procedures delivered with the ETSO-2C205a CCA. These test procedures are intended to streamline and simplify the ETSO-C146e authorisation process for the manufacturer of the end-use equipment by allowing credit for the design and for selected testing performed at the Delta CCA functional sensor level. However, the manufacturer of the end-use equipment remains fully responsible for the design and control of the article per their ETSO-C146e ETSOA.

2. GENERAL PRINCIPLES

- (a) Testing methods for GPS/SBAS equipment have been standardised by RTCA document DO-229E, and serve as the basis for ETSO-C146e. RTCA document DO-229E was written to cover equipment that can be installed on aircraft. Section 2.4 specifically addresses the issues of the environment in which the equipment operates, and provides the approved test methods to validate its performance in this environment. Section 2.4 represents the RTCA consensus in identifying which RTCA document DO-229E requirements are sensitive to environmental effects. These requirements are listed in the environmental tables referenced in Section 2.4.1.
- (b) The determination that a MOPS requirement is susceptible to the environment does not depend on whether or not the implementation is a CCA installed within ETSO-C146 article. This is the same concept as an equipment enclosure that is designed to protect against a benign environment compared with one designed for a severe environment; the identification of the susceptible requirements is the same.
- (c) Therefore, this Appendix uses the tables of RTCA document DO-229E, Section 2.4.1, to identify the MOPS requirements that are susceptible to environmental conditions for a Delta CCA functional sensor in the end-use equipment. The focus is on the change in environment seen by the Delta CCA functional sensor as a result of its installation in the end-use equipment. For example, other components inside the end-use equipment may radiate RF energy that could interfere with the GPS functions; therefore, the ambient testing performed at the CCA level is not equivalent to tests performed in the end-use equipment. This is the basis for defining the RTCA document DO-229E Section 2.5 performance tests that need to be repeated by the manufacturer of the end-use equipment.

- (d) The Class Delta-4 environmental table referenced in RTCA document DO-229E, Section 2.4.1, is the prime source to determine the MOPS performance requirements that are susceptible to environmental conditions. Based on that table, Class Delta-4 has the same susceptible requirements as Class Beta, but adds two additional requirements for navigation displays and databases that are optional capabilities for Class Delta-4. Those Delta-4 requirements that are similar to those for Class Beta can be grouped in two categories: those that are susceptible to most types of environmental conditions (described in Section 3) and those that are susceptible to only a few (described in Section 4).
 - (e) The options for databases and navigation displays in Delta-4 equipment do not present any repeat MOPS testing requirements for a manufacturer who incorporates an ETSO-2C205a Delta CCA functional sensor in its ETSO-C146e article. The environmental qualification performed by the end-use equipment manufacturer according to ETSO-C146e is sufficient. The rationale is stated below.
 - (1) The database requirement testing in the environment is meant to ensure that the database storage hardware, which may be separate, is fully functional during the environmental testing. As the pass criterion for such testing is that the retrieved data is correct, the test procedures in the environment are as sensitive to hardware issues as any ambient environment test. Therefore, nothing justifies repeating the tests under ambient conditions in the end-use equipment.
 - (2) Manufacturers of end-use equipment that includes a database must perform the environmental qualification specified by ETSO-C146e and MOPS Section 2.4 irrespective of whether the database is hosted in the Delta CCA functional sensor or elsewhere in the equipment.
 - (3) It is impossible for the Delta CCA functional sensor to incorporate a display or to be a display.
3. PERFORMANCE REQUIREMENTS THAT ARE SUSCEPTIBLE TO MOST ENVIRONMENTAL CONDITIONS
- The RTCA document DO-229E requirements for accuracy (Section 2.1.5.1), and sensitivity and dynamic range (Section 2.1.1.10) are sensitive to most environmental conditions. However, these requirements are linked to the message loss rate requirement in Section 2.1.1.3.2. Sections 3.1 and 3.2 below identify the testing that manufacturers of end-use equipment are required to repeat to demonstrate that the Delta CCA functional sensor continues to meet the accuracy, dynamic range and message loss rate performance requirements after installation in the end-use equipment. All the tests shall be run under conditions in which the functions of the end-use equipment are fully enabled to create the worst-case environment.
- 3.1. RTCA document DO-229E — 2.5.8 Accuracy Test
- (a) The accuracy test described in Section 2.5.8 is actually a joint test that covers accuracy, sensitivity and dynamic range. This joint testing also applies in the environment as stated in Section 2.4.1.1.5, with the environmental adaptations as described in Section 2.4.1.1.1.
 - (b) The demonstration of accuracy is performed in accordance with Section 2.5.8.1 only for the test case with broadband external interference noise. This test must be repeated when the CCA is installed in the end-use equipment, and it is sufficient to perform it using broadband interference.

- (1) The environmental testing is limited to broadband interference, as it represents the worst-case signal-to-noise condition, which is the most sensitive to environmental effects. This applies equally to the environment for the CCA that is created by the end-use equipment.
 - (2) Section 2.5.8 contains a measurement accuracy test in Section 2.5.8.1, with the detailed test procedure in Section 2.5.8.2. The Section 2.5.8.1 test must be run under the worst-case environment identified in the section on 'Additional considerations for internal interference sources' below. The measurement accuracy testing can be combined with the message loss rate testing in Section 2.5.2.1.
 - (3) Section 2.5.8.3 is a 24-hour actual satellite accuracy test. The Section 2.5.8.3 test exposes the equipment to a variety of signal conditions and data-processing conditions over varying satellite geometries that will increase the confidence that no unforeseen interactions between the components within the end-use equipment and the Delta CCA functional sensor will go undetected. The 24-hour testing in Section 2.5.8.3 can be combined with the 24-hour message loss rate testing in Section 2.5.2.4 (see the section on 'Additional considerations for internal interference sources').
 - (4) Section 2.5.8.4 (SBAS Tracking Bias) is an analysis of the GPS hardware, and it is therefore not necessary to repeat it at the end-use equipment level provided that no extra RF components that affect the RF filtering response are inserted into the RF path. Otherwise, the manufacturer of the end-use equipment must also repeat the SBAS Tracking Bias test.
- (c) The test threshold is relaxed from 110 % to 125 % as specified in Table 2-25 of the Section 2.5.8.2.1 test procedure to shorten the duration of the test. However, the Section 2.5.8 testing (excluding the SBAS Tracking Bias test in 2.5.8.4) for the CCA in the end-use equipment shall be under ambient conditions per Section 2.5, with the 110-% test pass threshold for maximum test sensitivity.
 - (d) The Section 2.5.8 testing (excluding the SBAS Tracking Bias test in Section 2.5.8.4) should be repeated against the accuracy requirement in Section 2.1.5.1.
 - (e) Only the test case for broadband external interference noise using minimum satellite power will be executed in most cases to shorten the duration of the test. The Section 2.5.8.1 testing will be repeated for both the minimum and the maximum satellite power only for the worst-case environment.

3.2. RTCA document DO-229E — 2.5.2 Message Loss Rate Test

- (a) Section 2.5.2 specifies the message loss rate test for the 2.1.1.3.2 message loss rate requirement. This test is conducted in conjunction with the Section 2.5.8 accuracy testing. Section 2.5.2.2 defines the test procedure to collect data that verifies the SBAS message loss rate in the presence of interference using the test cases in which the SBAS satellite is at minimum power. Section 2.5.2.3 defines the pass-fail criteria.
- (b) The test in Section 2.5.2.2 will be performed during the measurement accuracy broadband interference test case described in paragraph 3.1.
- (c) The test procedure in Section 2.5.2.4.1 is run in conjunction with the 2.5.8.3 24-hour accuracy test. Section 2.5.2.4.2 defines the pass-fail criteria for the test case described in paragraph 3.1(b)(3).

4. PERFORMANCE REQUIREMENTS PARTIALLY SUSCEPTIBLE TO ENVIRONMENTAL CONDITIONS

- (a) The Class Delta-4 Table 2-20 in Section 2.4.1 of RTCA document DO-229E indicates that the requirements for initial acquisition time (2.1.1.7) and satellite reacquisition time (2.1.1.9) are sensitive to four environmental conditions: icing, lightning-induced transient susceptibility, lightning direct effects, and normal/abnormal operating conditions. The requirements for loss of navigation (Sections 2.1.1.13.2, 2.1.5.12.2, and 2.3.6.2) are sensitive to low and high operating temperatures.

Note: Class Delta-4 provides deviation guidance only during the final approach segment of an LP/LPV approach, in which a loss of integrity is treated as a loss of navigation capability.

- (b) The lightning-induced transient susceptibility, lightning direct effects or icing environmental conditions are not pertinent to the environment created by the end-use equipment relative to the Delta CCA functional sensor. However, the manufacturer of the end-use equipment remains responsible for meeting the overall environmental qualification at the end-use equipment level.
- (c) Loss of navigation indications are limited to temperature testing, and the information in RTCA DO-229E, Sections 2.4.1.1.2 and 2.4.1.1.3, is appropriate. The purpose is to ensure that the interface that is used to indicate the loss of navigation is functional under the environmental conditions that are present after the Delta CCA functional sensor is installed in the end-use equipment. Sections 2.4.1.1.2 and 2.4.1.1.3 indicate that any source that generates the indication can be used, since it is the interface, and not the detection mechanism, that is verified. The temperature testing performed at the end-use equipment level is the worst-case scenario. It is not necessary to repeat the CCA level test at room temperature in the end-use equipment since the environmental qualification adequately addresses testing for these requirements.

Note: The Class Delta table requires more than just temperature testing under environment to support the optional display component of Class Delta. Since a CCA cannot be a display or incorporate a display, the additional testing in the environment does not apply.

- (d) EUROCAE ED-14 Section 16 relates to aircraft power supplies (refer to ETSO paragraph 3.1.2 for the environmental qualification requirements). Sections 16.5.1.2 and 16.6.1.2 are for supply voltage modulation (AC)/ripple (DC). Given the potential susceptibility of the Delta CCA functional sensor to power supply noise, it is prudent to repeat the tests at the end-use equipment level on this basis.
- (e) Sections 4.1 and 4.2 identify the testing that manufacturers of end-use equipment are required to repeat to demonstrate that the Delta CCA functional sensor continues to meet the acquisition time and reacquisition time performance requirements relative to the normal/abnormal operating conditions after installation in the end-use equipment.

All tests shall be run under conditions where the functions of the end-use equipment are fully enabled to create the worst-case environment.

4.1. RTCA DO-229E — 2.5.4 Initial acquisition test procedures

The information in RTCA document DO-229E, Section 2.4.1.1.4, on the initial acquisition test in Section 2.5.4 applies. The manufacturer of the end-use equipment shall repeat the initial acquisition testing described in RTCA document DO-229E, Section 2.5.4.

4.2 RTCA DO-229E — 2.5.6 Satellite reacquisition time test

The manufacturer of the end-use equipment is required to repeat the satellite reacquisition time testing in RTCA document DO-229E, Section 2.5.6.

5. ADDITIONAL CONSIDERATIONS FOR INTERNAL INTERFERENCE SOURCES

- (a) Installing a Delta CCA functional sensor into end-use equipment that also includes other functions requires a careful evaluation of the potential internally radiated and conducted interference. The manufacturer of the end-use equipment must evaluate each operating mode to determine whether the mode changes the environment for the installed Delta CCA functional sensor. If there is only one environment or there is clearly one worst-case environment, then the accuracy and message loss rate testing in Section 3 can be run in that operating mode only. For example, if the end-use equipment includes an RF transmitter that radiates at one frequency, one could reasonably argue that setting the transmitter at full power with maximum data throughput would generate a clear worst-case environment in which to run all the testing.
- (b) In the case of multiple environments, the accuracy and message loss rate tests can either be run under each environment or the methodology in RTCA document DO-229E, Section 2.4.1.2.3, can be used to run an aggregate test with approximately equal time in each mode. The methodology in Section 2.4.1.2.3 must be used to identify the modes with the greatest susceptibility under which the combined accuracy and message loss rate tests are repeated in addition to the aggregate test. For example, the methodology of Section 2.4.1.2.3 is appropriate for end-use equipment that contains a high-power transmitter that operates on a large number of frequencies such that it is impractical to run a test at each frequency. This is analogous to the large number of frequencies that need to be tested during the EUROCAE ED-14 Section 19 testing on induced signal susceptibility and the Section 20 testing on radio frequency susceptibility, and this is the reason why the methodology of Section 2.4.1.2.3 was developed.
- (c) It is sufficient to identify one worst-case environment when performing the acquisition and 24-hour accuracy testing.

6. SUMMARY

- (a) The manufacturer of the end-use equipment that incorporates a Delta CCA functional sensor is required to repeat the following RTCA document DO-229E Section 2.5 testing under ambient conditions (see Section 5) after installing the Delta CCA functional sensor in the end-use equipment:
 - The Section 2.5.8 Accuracy testing (excluding the SBAS Tracking Bias test in 2.5.8.4) adapted per Section 2.4.1.1.1, except that the 110-% test pass threshold is used.

Note: Excluding the SBAS Tracking Bias test is acceptable, provided that the end-use equipment does not insert into the RF signal path any components that affect the filtering response. Otherwise, the manufacturer of the end-use equipment must also repeat the SBAS Tracking Bias test.
 - The Section 2.5.2 message loss rate test.
 - The Section 2.5.4 initial acquisition test.
 - The Section 2.5.6 satellite reacquisition time test.

- (b) The manufacturer of the end-use equipment remains responsible for completing a full environmental qualification evaluation (see ETSO Section 3.1.2) at the end-use equipment level. The manufacturer of end-use equipment that incorporates a Delta CCA functional sensor is required to repeat the loss of navigation indication and loss of integrity indication testing as part of the environmental qualification according to RTCA document DO-229E, Sections 2.4.1.1.2 and 2.4.1.1.3.

[Amdt ETSO/13]

[Amdt ETSO/16]

APPENDIX 2 TO ETSO-C146E A1 – ADDITION TO RTCA DOCUMENT DO-229E, SECTION 1

ED Decision 2020/011/R

This Appendix describes the required modifications and additions to RTCA document DO-229E for compliance with this ETSO. This Appendix adds a new Section 1.8.3 on cybersecurity and GNSS spoofing mitigation and additional required leg types in Section 2.2.1.3 of RTCA document DO-229E.

The new Section, 1.8.3, contains no new requirements but provides information for cybersecurity and spoofing mitigation to make RTCA document DO-229E consistent with the new RTCA MOPS template and RTCA document DO-253D, Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment.

The new 2.2.1.3 leg type requirements are applicable to Class Gamma equipment only and are necessary to properly execute published instrument procedures designed to provide maximum efficiency, flexibility, and aircraft eligibility. These instrument procedure designs may include RNAV components and/or leg types associated with conventional procedures. The modifications and additions to Section 2.2.1.3 are necessary to ensure Class Gamma equipment can properly execute current and future instrument procedure designs.

1.8.3 Cybersecurity and GNSS Spoofing Mitigation

This section contains information to address intentional interference with the GNSS. Spoofing is caused by RF waveforms that mimic true signals in some ways, but deny, degrade, disrupt, or deceive a receiver's operation when they are processed. Spoofing may be unintentional, such as effects from the signals of a GNSS repeater, or may be intentional and even malicious. There are two classes of spoofing. Measurement spoofing introduces RF waveforms that cause the target receiver to produce incorrect measurements of time of arrival or frequency of arrival or their rates of change. Data spoofing introduces incorrect digital data to the target receiver for its use in processing of signals and the calculation of PNT. Either class of spoofing can cause a range of effects, from incorrect outputs of PNT to receiver malfunction. The onset of effects can be instantaneous or delayed, and the effects can continue even after the spoofing has ended. Improperly used or installed GNSS re-radiators act like spoofers. Re-radiators, replay and GNSS emulator devices can present misleading information to GNSS equipment and/or could cause lasting effects.

Equipment manufacturers should implement measures to mitigate processing of erroneous data. Cross-checks of GNSS sensor data against independent position sources and/or other detection monitors using GNSS signal metrics or data checks can be implemented in the antenna, receiver, and/or through integration with other systems at the aircraft level. Data validity checks to recognize and reject measurement and data spoofing should be implemented in the receiver. Additional guidance and best practices related to GNSS equipment can be found in the U.S. Department of Homeland Security document 'Improving the Operation and Development of Global Positioning System (GPS) Equipment Used by Critical Infrastructure'¹ and GLOBAL POSITIONING SYSTEMS DIRECTORATE SYSTEMS ENGINEERING & INTEGRATION: INTERFACE SPECIFICATION, IS-GPS-200, Navstar GPS Space Segment/Navigation User Interfaces, Revision H, IRN-IS-200H-003 28 July 2016.

¹ [https://ics-cert.us-cert.gov/sites/default/files/documents/Improving the Operation and Development of Global Positioning System \(GPS\) Equipment Used by Critical Infrastructure S508C.pdf](https://ics-cert.us-cert.gov/sites/default/files/documents/Improving%20the%20Operation%20and%20Development%20of%20Global%20Positioning%20System%20GPS%20Equipment%20Used%20by%20Critical%20Infrastructure%20S508C.pdf)

Aircraft equipment information vulnerabilities (such as cybersecurity risks) have been present for digital systems since the development of the personal computer (PC) in the late 1970s and even longer for RF systems, and the advent of internet connectivity has substantially increased those risks. Typically, access to navigation receivers has been controlled such that they are considered to be vulnerable only through RF signals and OEM and/or aircraft operator controlled processes for maintenance and updates. In some cases, aircraft GNSS receivers may be field loadable by approved personnel, requiring physical access and physical interface to the ground receivers. However, it is expected that not all aircraft in the future will rely on such physical isolation for the security of avionics. Internet and Wi-Fi connectivity have become popular as a means for aircraft or equipment manufacturers to update installed avionics software, to update databases, or provide an alternate means of communicating with the flight crew or cabin (e.g. in-flight entertainment, weather, etc.).

In most countries, the State provides oversight of safety-of-flight systems (sometimes referred to as ‘authorised services’) which provide information to aircraft, such as ILS, VOR, GNSS, and DME, to name a few. However, the State typically does not provide oversight on ‘non-trusted’ connectivity such as the internet, Wi-Fi, or manufacturer-supplied equipment interfaces which permit the input of externally supplied data into aircraft systems. A manufacturer may expose aircraft information vulnerabilities through the design of the equipment, or the equipment may become vulnerable as a result of being connected to a common interface. Therefore, it is important for manufacturers to consider aircraft information security risk mitigation strategies in their equipment design, particularly when the equipment is responsible for an interface between the aircraft and aircraft-external systems.

Apart from any specific aircraft-information-security-related performance requirements that are contained in the MOPS, it is recommended that manufacturers consider a layered approach to aircraft information security risk mitigation that includes both technical (e.g., software, signal filtering) and physical strategies. From a technical perspective, for example, this could include signal spoofing detection capabilities or more stringent, multi-factored authentication techniques such as passwords, PINs, and digital certificates. From a physical perspective, a manufacturer could consider connectors that require special tools to remove them to prevent passenger tampering — although navigation avionics are typically located in an avionics bay inaccessible to passengers. And finally, but just as important, manufacturers should consider supply chain risk management; for example, if a manufacturer outsources the development of software code, is the contractor and its staff properly vetted?

Civil aviation authorities (CAAs) have a regulatory interest when an applicant’s design makes use of a non-trusted connection through which the installation can potentially introduce aircraft information security vulnerability. This requires the applicant to address not only the information security vulnerabilities and mitigation techniques for the new installation, but to also consider how vulnerabilities could propagate to existing downstream systems. Therefore, it is recommended that manufacturers reference their equipment aircraft information security review and mitigation strategies in the installation manual of the equipment so that the applicant can consider them in meeting the regulatory requirements of the installation.

2.2.1.3 Path Definition

Replace the list of required leg types in the first paragraph after the last sentence as shown:

The desired path shall be defined according to the following leg types:

Leg Type	Description
IF	Initial Fix
CF	Course to Fix leg
DF	Direct to Fix leg
TF	Track to Fix leg
FA	Fix to Altitude leg
FM	Fix to Manual Termination
VA	Heading to Altitude leg
VI	Heading to Intercept
VM	Heading to Manual Termination
CA	Course to Altitude Leg

Holding legs

Leg Type	Description
HA	Terminates at an altitude
HF	Terminates at a fix after one orbit
HM	Manual termination

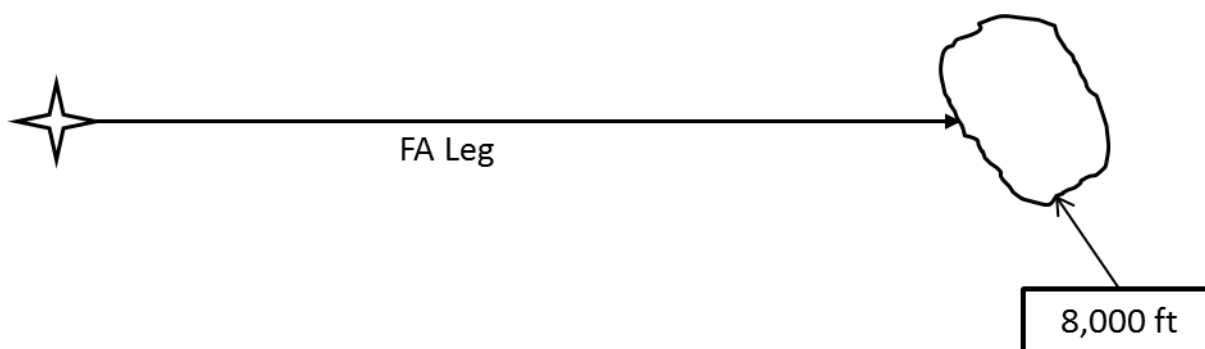
Note 1: There is no intent to require a heading or altitude source connected to the equipment to automatically execute leg types with heading or altitude components. Manual equipment inputs for heading/altitude with manual aircraft control methods are acceptable for these leg types.

Note 2: Cross-track deviation requirements are not applicable for VA, VI, and VM heading leg types.

Replace Section 2.2.1.3.6 as shown and add the following leg type descriptions. Renumber existing paragraphs (starting with 2.2.1.3.7) to account for the newly added sections:

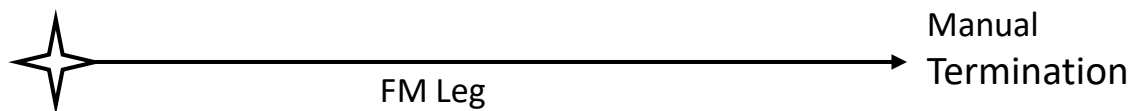
2.2.1.3.6 Fix to Altitude (FA)

An FA leg shall be defined as a specified track over the ground from a database waypoint to a specified altitude at an unspecified position.



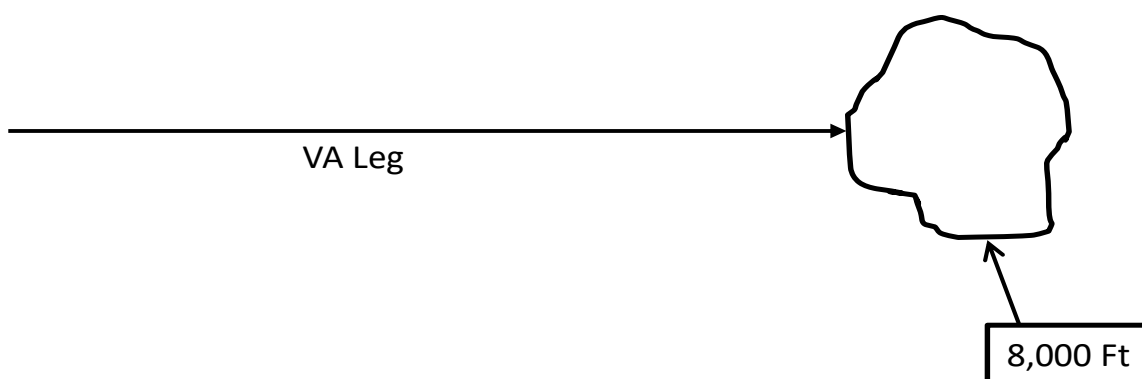
2.2.1.3.7 Fix to Manual Termination (FM)

An FM leg shall be defined as a specified track over the ground from a database fix until a manual termination of the leg.



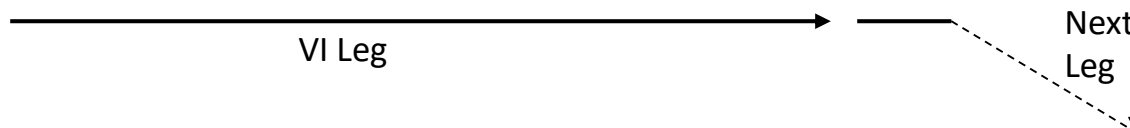
2.2.1.3.8 Heading to Altitude (VA)

A VA leg shall be defined as a specified heading to a specific altitude termination at an unspecified position. No correction is made for wind.



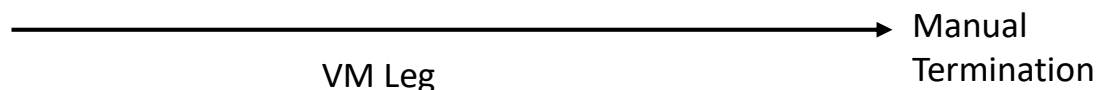
2.2.1.3.9 Heading to Intercept (VI)

A VI leg shall be defined as a specified heading to intercept a subsequent leg at an unspecified position. No correction is made for wind.



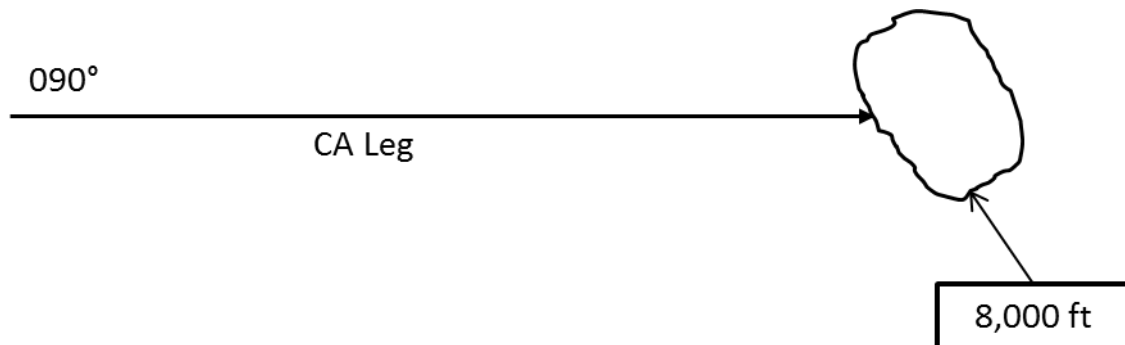
2.2.1.3.10 Heading to Manual Termination (VM)

A VM leg shall be defined as a specified heading until a manual termination of the leg. No correction is made for wind.



2.2.1.3.12 Course to Altitude (CA)

A CA leg shall be defined as a specified course to a specific altitude at an unspecified position. The course is flown making adjustment for wind.



2.2.1.3.13 Hold to Altitude (HA)

An HA leg is a holding pattern which terminates at the next crossing of the hold fix when the aircraft altitude is at or above the specified altitude. The altitude is provided by the navigation database. The source of the magnetic variation needed to convert magnetic courses to true courses is detailed in Section 2.2.1.3.12.

2.2.1.3.14 Hold to Fix (HF)

An HF leg is a holding pattern which terminates at the first crossing of the hold fix after becoming established on the inbound course. This is typically after the entry procedure is performed. The source of the magnetic variation needed to convert magnetic courses to true courses is detailed in Section 2.2.1.3.12.

2.2.1.3.14 Hold for Clearance (manual termination) (HM)

An HM leg is a holding pattern which terminates only after flight crew action. The source of the magnetic variation needed to convert magnetic courses to true courses is detailed in Section 2.2.1.3.12.

Table 2-14 to Table 2-20

The tables incorrectly reference and label EUROCAE ED-14/RTCA document DO-160 Sections 16.5.1.2 and 16.6.1.2 regarding '2.1.1.7 Acquisition Time' and '2.1.1.9 Reacquisition Time'. Change the table references as follows:

The MOPS Initial Acquisition Time requirement (2.1.1.7) applies to both AC and DC equipment under abnormal operating conditions (EUROCAE ED-14/RTCA document DO-160 Sections 16.5.2 and 16.6.2) and the satellite reacquisition time requirement (2.1.1.9) applies to both AC and DC equipment under normal operating conditions (EUROCAE ED-14/RTCA document DO-160 Sections 16.5.1 and 16.6.1).

[Amdt ETSO/13]

[Amdt ETSO/16]

APPENDIX 3 TO ETSO-C146E A1

ED Decision 2020/011/R

Reserved.

[Amdt ETSO/13]

[Amdt ETSO/16]

APPENDIX 4 TO ETSO-C146E A1

ED Decision 2020/011/R

This Appendix prescribes the EASA modifications to RTCA document DO-229E, Section 2.

At Section 2.1.1.2, after the first sentence, add the following:

‘The demodulation of data from the GPS signals shall be restricted to the necessary subset of the data defined in Appendix II to IS-GPS-200D, “Navstar GPS Space Segment/Navigation User Interfaces”, December 2004, provided on RF link L1. The pseudo-ranging shall be performed on RF link L1 utilising the coarse/acquisition (C/A) code.’

This is to ensure that only the L1 NAV data, for which the SBAS provides corrections and integrity, is used, and no CNAV data, which is defined in Appendix III to IS-GPS-200D, is used, for which the SBAS does not provide integrity.

[Amdt ETSO/13]

[Amdt ETSO/16]

ETSO-C147a

ED Decision 2016/029/R

TRAFFIC ADVISORY SYSTEM (TAS) AIRBORNE EQUIPMENT**1 Applicability**

This ETSO gives the requirements that new models of active traffic advisory system (TAS) airborne equipment that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with applicable ETSO marking.

Equipment Classes are:

- Class A. Equipment incorporating a horizontal situation display that indicates the presence and relative location of intruder aircraft, and an aural alert informing the crew of a Traffic Advisory (TA).
- Class B. Equipment incorporating an aural alert and a visual annunciation informing the crew of a TA.

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 No. RTCA/DO-197A, “Minimum Operational Performance Standards for An Active Traffic Alert and Collision Avoidance System I (ACTIVE TCAS 1),” Section Two (2) September 12, 1994, as amended by [Appendix 1](#) of this document.

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.

3.1.4 Electronic Hardware Qualification

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 Specific

None

3.2.1 Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a major failure condition for malfunctions causing the display or annunciation of hazardous misleading information in airborne aircraft.

Loss of the function defined in paragraph 3.1.1 is a minor failure condition.

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.

[Amdt ETSO/12]

APPENDIX 1 TO ETSO-C147A – CHANGES TO RTCA/DO-197A, “MINIMUM OPERATIONAL PERFORMANCE STANDARDS FOR AN ACTIVE TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM I (ACTIVE TCAS I)” APPLICABLE TO TRAFFIC ADVISORY SYSTEM (TAS) AIRBORNE EQUIPMENT

ED Decision 2016/029/R

Note: This Appendix changes several sections of DO-197A that have been modified by DO-197A Change 1. However, the below changes adopt different requirements than those contained in DO-197A Change 1.

1.0 Changes Applicable to Both Class A and Class B Equipment.

1.1 Receiver Characteristics.

1.1.1 In-band Acceptance. In lieu of paragraph 2.2.2.1 of RTCA DO-197A, substitute the following requirement:

Given a valid transponder reply signal in the absence of interference or overloads, the minimum trigger level (MTL) is defined as the input power level that results in a 90% ratio of decoded to received replies.

The MTL over the frequency range of 1,087 to 1,093 MHz shall be no greater than -70 dBm.

1.1.2 In-band Acceptance. In paragraph 2.4.2.2.1 of RTCA DO-197A, eliminate the following:

under Intruder Aircraft eliminate the last line: “Scenario C and D $\geq$ -78 dBm.

under Test Description Success:, eliminate the last sentence: For scenarios C and D, the ratio of correctly decoded intruder replies to total input replies shall not exceed 10%.

1.2 Transmission Frequency. In lieu of paragraph 2.2.3.1 of RTCA/DO-197A, substitute the following requirement:

“The transmission frequency of Mode C interrogations shall be 1,030 $\pm$ 0.2 MHz.”

1.3 Transmitter RF Output Power. In lieu of paragraph 2.2.3.2 of RTCA/DO-197A, substitute the following requirement:

When transmitting at full (unattenuated) output power, the peak RF output power delivered to a quarter wave stub antenna shall be within the following limits:

Maximum RF Power: 54 dBm (250W)

Minimum RF Power: 50 dBm (100W)

In the event that antenna gain differs from that of a quarter wave stub antenna (3 dBi), the power limits shall be adjusted accordingly. These limits are based upon range and interference limiting requirements.

Note: When transmitting at full (unattenuated) power, the RF power radiated at the pattern peak shall be within the following limits:

Maximum EIRP: 57 dBm (500W)

Minimum EIRP: 53 dBm (200W)

It is assumed that the peak gain of a typical quarter wave stub antenna is 3 dBi. EIRP = Effective Isotropic Radiated Power.

Note: As an alternative to the above, an active TAS may choose to operate as a low power system at a fixed rate power product limit of 42 Watts per second, in which case the peak RF output power delivered to a quarter wave stub antenna shall not exceed 46 dBm (40W).

- 1.4 Transmitter Pulse Characteristics. In lieu of paragraph 2.2.3.5 of RTCA/DO-197A, substitute the following requirement:

ATCRBS interrogations from active TAS shall employ the Mode C format illustrated in Figure 2-1.

The rise and decay times may be less than shown in the following table, provided the sideband radiation does not exceed the spectral limits tabulated in this standard. The amplitude of P3 shall be within 0.5 dB of the amplitude of P1.

ACTIVE TAS MODE PULSE SHAPES (All values in Microseconds)

Pulse Designator	Pulse Duration	Duration Tolerance	Rise Time		Decay Time	
			Min	Max	Min	Max
P1, P3	0.8	± 0.075	0.05	0.1	0.05	0.2

The pulse spacing tolerances shall be as follows: P1 to P3: 21 ± 0.10 microseconds

- 1.5 Mode S Broadcast Reception. In lieu of paragraph 2.2.4.2 of RTCA/DO-197A, substitute the following requirement:

The Active TAS shall have the capability to receive 1,030 MHz Mode S broadcast signals for the purpose of obtaining a count of TCAS interrogators in its vicinity. Mode S reception may reside in an associated Mode S transponder, or may be integral to the Active TAS equipment, in which case those functions necessary to receive and process Mode S broadcast signals for a TCAS count shall be implemented and tested in accordance with RTCA/DO-181A.

Note: As an alternative to the above, an active TAS may choose to operate at a fixed rate power product limit of 42W/sec, in which case the requirement to obtain a count of TCAS interrogators for the purpose of interference limiting is eliminated.

- 1.6 Interference Limiting. In lieu of paragraph 2.2.6 of RTCA/DO-197A, substitute the following requirement:

To assure that all interference effects from Active TAS equipment are kept to a low level, Active TAS equipment shall control its interrogation rate or power or both to conform to the following limits.

These limits are given in terms of:

RR = the Mode A/C reply rate of own transponder

NT = the number of airborne TCAS interrogators detected via Mode S broadcast receptions with a receiver threshold of -74 dBm.

The Minimum Active TCAS shall have the capability to monitor RR and NT and to use this information in interference limiting. Once each scan period, NT shall be updated as the number of distinct TCAS addresses received within the previous 20 second period.

The limits are as follows:

NT	K Upper Limit for $\sum P(k)$ k=1	
	If RR < 240	If RR > 240
0	250	118
1	250	113
2	250	108
3	250	103
4	250	98
5	250	94
6	250	89
7	250	84
8	250	79
9	250	74
10	245	70
11	228	65
12	210	60
13	193	55
14	175	50
15	158	45
16	144	41
17	126	36
18	109	31
19	91	26
20	74	21
21	60	17
≥22	42	12

$P(k)$ = power (watts) of the kth interrogation each second. This is the total radiated power (after all losses in cabling and antenna). If the set of powers is not the same in each 1 second period, then $\sum P(k)$ represents the average value.

K = total number of interrogations in a 1 second period.

Note 1: RR = the Mode A/C interrogation reception rate of own transponder may be used instead of RR = the Mode A/C reply rate of own transponder.

Note 2: As an alternative to the above, an active TAS may choose to operate as a low power system at a fixed rate power product limit of 42W/sec, in which case the requirement to further interference limit based on RR or IR is eliminated.

In lieu of paragraph 2.4.2.5 of RTCA/DO-197A, substitute the following:

This test verifies that Active TAS is able to monitor its own transponder reply rate and to derive a count of TCAS aircraft by listening to TCAS broadcast interrogations and, based on these values, adjust its transmit power-rate product to conform to the Active TAS interference limits.

Inputs:Active TAS

Aircraft Altitude = 8000 ft.

Altitude Rate = 0 FPM

Intruder Aircraft 1-22

Equipage = Active TCAS II

Range = Not Applicable

Relative Speed = Not Applicable

Altitude = Not Applicable

Altitude Rate = Not Applicable

TCAS Broadcast Interrogation Power = -50 dBm

ATCRBS Interrogation

Frequency = 1030 MHz

Type = ATCRBS Mode C

Power = -50 dBm

Rate

Scenario A = 230 per second

Scenario B = 250 per second

Conditions:

Active TAS initialized and operating at T = 0 seconds. Each of the 22 intruders is assigned a discrete address and transmits only TCAS broadcast interrogations and only at the following times and rates:

Intruders 1-10 every 10 sec starting at T = 30 sec.

Intruders 11-15 every 20 sec starting at T = 70 sec.

Intruders 16-22 every 20 sec starting at T = 130 sec.

The timing of the TCAS broadcast interrogations and the ATCRBS interrogations are controlled to prevent overlap of each other.

Scenario Description

The test involves use of an ATCRBS transponder which supplies reply rate information to Active TAS. The transponder is interrogated in Mode C at a 230 per second rate in Scenario A and at a 250 per second rate in Scenario B. During each scenario, the value of Total Radiated Power per second from Active TAS is measured by summing the transmitter output powers of each Active TAS interrogation over a scan period, determining the average per second value and accounting for cable and antenna losses.

Success: The Total Radiated Power per second shall not exceed the following values:

Scenario A

250 watts/sec measured at T = 20 sec

245 watts/sec measured at T = 60 sec

158 watts/sec measured at T = 120 sec

42 watts/sec measured at T = 180 sec

Scenario B

118 watts/sec measured at T = 20 sec

70 watts/sec measured at T = 60 sec

45 watts/sec measured at T = 120 sec

12 watts/sec measured at T = 180 sec

Note: For fixed rate power systems, total radiated power is constant and shall not exceed 42 watts/sec.

- 1.7 Active TAS Antenna System. In lieu of paragraph 2.2.10 of RTCA/DO-197A, substitute the following requirement:

The equipment shall transmit interrogations and receive replies from at least one directional antenna mounted on the top or bottom of the aircraft.

- 1.8 Pilot Advisory Functions. In lieu of paragraph 2.1.5 of RTCA/DO-197A, substitute the following requirement:

TAS is an airborne traffic alert system that interrogates ATC transponders in nearby aircraft and uses computer processing to identify potential and predicted collision threats. The system is designed to protect a volume of airspace around the TAS equipped aircraft. The system will provide appropriate aural and visual advisories to assist the flightcrew in visually acquiring the threat aircraft when TAS predicts a penetration of the protected airspace. Traffic advisories indicate the relative positions of intruding aircraft that meet certain range and altitude criteria and are approximately 30 seconds from closest point of approach. They assist the flightcrew in visually acquiring the intruding aircraft. The system provides a traffic display (Class A systems only) and aural and visual alerts. These indicate the relative position and altitude of ATC transponder-equipped aircraft. Traffic advisories can be generated for aircraft with operative Mode S, Mode C or Mode A (non-altitude reporting) transponders. The TAS equipment is viewed as a supplement to the pilot who, with the aid of the ATC system, has the primary responsibility for avoiding collisions. The TAS system provides no indication of aircraft without operative transponders. For Class A systems, it shall be acceptable for the TAS system to use shape as the only discriminate for traffic threat levels.

This will allow the use of a monochrome display representation of the TCAS symbology. For Class A systems, it shall also be acceptable to provide a blinking TA symbol to allow further discrimination of the traffic alert symbol.

2.0 Changes Applicable Only to Class A Equipment.

2.1 Pilot Advisory Functions, Active TCAS I Pilot Interface and Aural Alert. In lieu of paragraphs 2.1.5, 2.2.12 and 2.2.15 of RTCA/DO-197A, substitute the following requirements:

1. A traffic display shall be provided to indicate the presence and location of intruder aircraft. The traffic display may be combined with other aircraft displays. The traffic display shall provide the crew with the intruder's range, bearing, and, for altitude reporting intruders, relative altitude and vertical trend.
2. Two levels of intruder aircraft shall be displayed; those causing a TA, and other traffic. Other traffic is defined as any traffic within the selected display range and not a TA.

Note: The use of TCAS threat levels as defined in DO-197A is an acceptable alternative to the requirements defined in this section.

3. As a minimum, the traffic display shall depict the following information to aid in the visual acquisition of traffic and assist in determining the relative importance of each aircraft shown:

Note: TCAS I symbology as defined in the FAA Memorandum titled 'Interim Guidance for Airworthiness Approval and Operational Use of Traffic Alert and Collision Avoidance System (TCAS I)' dated June 16, 1995 is an acceptable alternative to the symbology requirements defined in this section.

In addition, the use of TCAS symbology with a monochrome display is also an acceptable means of depicting traffic information.

- a. Symbolic differentiation among traffic of different relative importance. TA, other traffic (see i, j, k, l, & m below).
- b. Bearing
- c. Relative altitude (for altitude reporting aircraft only)
 - (1) Above or below own aircraft (+ and - signs)
 - (2) Numerical value
- d. Vertical trend of intruder aircraft (for altitude reporting aircraft only).
- e. Range. The selected range shall be depicted.
- f. The display must be easily readable under all normal cockpit conditions and all expected ambient light conditions from total darkness to bright reflected sunlight.
- g. The display shall contain a symbol to represent own aircraft. The symbol shall be different from those used to indicate TA and other traffic. The display shall be oriented such that own aircraft heading is always up (12 o'clock).
- h. A ring shall be placed at a range of 2 NM from own aircraft symbol when a display range of 10 NM or less is selected. The ring shall have discrete markings at each of the twelve clock positions. The markings shall be of a size and shape that does not clutter the display.
- i. Symbol fill shall be used to discriminate traffic by threat levels

- j. The symbol for a TA is a filled rectangle, and, when appropriate, a data field and vertical trend arrow as described in m. & n. below.
 - k. The symbol for other traffic shall be an open rectangle, and, when appropriate, a data field and vertical trend arrow as described in m. below.
 - l. Overlapping traffic symbols should be displayed with the appropriate information overlapped. The highest priority traffic symbol should appear on top of other traffic symbols. Priority order is; 1) TA traffic in order of increasing tau, i.e., the time to closest approach and the time to coaltitude, 2) other traffic in order of increasing range.
 - M. A data field shall indicate the relative altitude, if available, of the intruder aircraft and shall consist of two digits indicating the altitude difference in hundreds of feet. For an intruder above own aircraft, the data field shall be preceded by a "+" character. For an intruder below own aircraft, the data field shall be preceded by a "-" character. For coaltitude intruders, the data field shall contain the digits "00", with no preceding "+" or "-" character. The data field shall be wholly contained within the boundaries of the rectangular traffic symbol. For TA traffic, (filled symbol), the data characters shall be depicted in a color that contrasts with the filled symbol color. For other traffic, the data field shall be the same color as the symbol. The height of the relative altitude data characters shall be no less than 0.15 inches.
 - n. A vertical arrow should be placed to the immediate right of the traffic symbol if the vertical speed of the intruder is equal to or greater than 500 fpm, with the arrow pointing up for climbing traffic and down for descending traffic. The color of the arrow shall be the same as the symbol.
 - o. Neither a data field nor a vertical arrow shall be associated with a symbol for traffic which is not reporting altitude.
 - p. The display shall be capable of depicting a minimum of three intruder aircraft simultaneously. As a minimum, the display shall be capable of displaying aircraft that are within 5 NM of own aircraft.
 - q. The display may provide for multiple crew-selectable display ranges.
 - r. When the range of the intruder causing a traffic advisory to be displayed is greater than the maximum range of the display, this shall be indicated by placing no less than one quarter of the traffic advisory symbol at the edge of the display at the proper bearing. The data field and vertical trend arrow shall be shown in their normal positions relative to the traffic symbol.
 - s. The size of the traffic symbol shall be no less than 0.2" High.
4. "No bearing" advisories shall be presented for an intruder generating a TA when the intruder's relative bearing cannot be derived. The "no bearing" advisory shall be an alphanumeric display shown in tabular form. The display shall be in the form of "TA 3.6 -05", which translates to a TA at 3.6 nautical miles, 500 feet below. "No bearing" TA's against non-altitude reporting intruders shall include the range only, e.g. "TA 2.2", which translates to a non-altitude reporting, no bearing TA at 2.2 nautical miles. The advisory shall be centered on the display below the own aircraft symbol. The display shall include provisions to display at least two "no bearing" TA's.

5. Aural Alerts. Each TAS aural alert shall be announced in a high-fidelity, distinguishable voice.
 - a. The aural alert message “Traffic-Traffic”, spoken once, shall be used to inform the crew of a TA.
 - b. All TAS aural alerts should be inhibited using the following order of precedence;
 - (1) Below 400 ± 100 feet AGL when TAS is installed on an aircraft equipped with a radio altimeter.
 - (2) For aircraft without a radio altimeter, the aural annunciations shall be inhibited when the landing gear is extended.

Note: When the TAS is installed on a fixed gear aircraft without a radio altimeter, the aural annunciations will never be inhibited.

- 2.2 Traffic Advisory Criteria. Replace the second section in paragraph 2.2.14 of RTCA/DO-197A, with the following text:

The TAS equipment shall provide two levels of advisories: Other Traffic (OT), and Traffic Advisories (TA). TAs are issued based on either tau, i.e., the time to closest approach and the time to coaltitude, or proximity to an intruder aircraft. The range tau is defined as the range divided by range rate and the vertical tau is defined as the relative altitude divided by the altitude rate.

- 2.3 Display Overload. In lieu of paragraph 2.2.17 of RTCA/DO-197A, substitute the following requirements:

If the number of targets exceeds the display capability, excess targets shall be deleted in the following order:

- a. Other traffic beginning with the intruder at the greatest range.
- b. TAs beginning with the intruder having the largest tau. Once a TA has been generated against an intruder, it cannot be removed as a TA until the TA criteria are no longer satisfied even though it may be dropped from the display.

Note: This exception does not apply when TCAS I symbology and threat levels are used.

3.0 Changes Applicable Only to Class B Equipment.

- 3.1 Pilot Advisory Functions, Active TCAS I Pilot Interface, and Aural Alert. In lieu of paragraph 2.1.5, 2.2.12, and 2.2.15 of RTCA/DO-197A, substitute the following requirements:

1. A visual “Traffic” annunciation, shall be provided for the duration of the TA.
2. Aural Alerts. For aircraft without a radio altimeter, the aural annunciations shall be inhibited when the landing gear is extended.

Note: When the TAS is installed on a fixed gear aircraft without a radio altimeter, the aural annunciation will never be inhibited.

- a. Aural alert messages shall be annunciated in threat priority sequence, greatest threat first.
 - (1) Initial aural traffic advisories shall be spontaneous and unsolicited. The unsolicited annunciations shall be as follows: “Traffic- $\langle X \rangle$ O’Clock”, spoken once, (where $\langle X \rangle$ is the clock position of the intruder, such as 1 o’clock, etc.). If surveillance bearing information is not available on the intruder, “Traffic, No Bearing”, shall be annunciated.
 - (2) The current relative bearing to intruder aircraft shall be annunciated as a traffic advisory update upon crew command. Additional information such as relative altitude, range of intruder, and vertical trend (i.e. climbing, descending) may also be annunciated.
 - (3) The acceptability of these aural annunciations must be reviewed during flight test. The following factors, at a minimum, must be evaluated for acceptability: quantity of unsolicited annunciations, duration of annunciations, annunciation clarity, and volume. This evaluation shall occur under normal cockpit workload conditions during departure, cruise, and approach and landing phases of flight and should include evaluation of suitability in a normal air traffic control voice communication environment.
 - (4) Control means shall be provided to request a traffic advisory update, mute a current aural advisory, and cancel/restore aural advisories (turning the equipment off is an acceptable means of providing the cancel aural advisories function). The default condition of the equipment at power on shall be aural advisories active.
- b. All TAS aural alerts should be inhibited using the following order of precedence;
 - (1) Below 400 ± 100 feet AGL when TAS is installed on an aircraft equipped with a radio altimeter.
 - (2) For aircraft without a radio altimeter, the aural annunciations will never be inhibited in flight but may be inhibited on the ground when the aircraft is equipped with a weight-on-wheels system.

3.2 Traffic Advisory Criteria. Replace the first and second sections in paragraph 2.2.14 of RTCA/DO-197A, with the following text:

The Active TAS equipment shall provide two levels of advisories: Other Traffic (OT), and Traffic Advisories (TA). Other traffic is defined as any traffic within the selected display range and not a TA. TAs are issued based on either tau, i.e., the time to closest approach and the time to coaltitude, or proximity to an intruder aircraft. The range tau is defined as the range divided by range rate and the vertical tau is defined as the relative altitude divided by the altitude rate.

- 3.3 Display of intruders on the ground. In lieu of paragraph 2.2.16 of RTCA/DO-197A, substitute the following requirements:

The Active TAS equipment shall provide logic to inhibit TAs of altitude reporting intruders which are on the ground. This logic shall be used when the TAS-equipped aircraft is below 1,700 feet AGL. The 1,700 foot threshold shall include hysteresis of + 50 feet.

Note: This represents a requirement for a capability within the Active TAS avionics. When Active TAS is installed on an aircraft which does not have a radio altimeter, there is not a requirement for this logic to function.

- 3.4 Display overload. In lieu of paragraph 2.2.17 of RTCA/DO-197A, substitute the following requirements:

If the number of intruders exceeds aural memory storage capacity, excess intruders shall be deleted in the following order:

- a. Other traffic beginning with the intruder at the greatest range.
- b. TAs beginning with the intruder having the largest tau. Once a TA has been generated against an intruder, it cannot be removed as a TA until the TA criteria is no longer satisfied even though it has been dropped from the list of aural warnings.

[Amdt ETSO/12]

ETSO-C151d

ED Decision 2020/011/R

TERRAIN AWARENESS AND WARNING SYSTEM (TAWS)**1 Applicability**

This ETSO provides the requirements which Terrain Awareness and Warning Systems (TAWS) intended for installation in fixed-wing aircraft that are designed and 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**

The 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**

The applicable standards are those provided in RTCA document DO-367, Minimum Operational Performance Standard (MOPS) for Terrain Awareness and Warning Systems (TAWS) Airborne Equipment, Section 2, dated 31 May 2017. Requirements for Class A, Class B and Class C equipment are provided in RTCA document DO-367 Sections 2.2.1, 2.2.2 and 2.2.3 respectively and amended as follows:

In Section 2.2.1.1.6.3.1 Aural Alert — Caution

The sentences ‘For a caution level FLTA alert due to a predicted terrain conflict, Class A Equipment shall (TAWS_MOPS_051) be capable of generating or triggering an aural message of at least one of ‘Terrain Ahead’ and ‘Caution Terrain’. The requirement does not imply that Class A Equipment must be able to support both aural messages, although it is permissible for Class A Equipment to support both messages.’

should be replaced by

‘For a caution level FLTA alert due to a predicted terrain conflict, Class A Equipment shall (TAWS_MOPS_051) be capable of generating or triggering both types of aural messages: at least one of ‘Terrain Ahead’ and ‘Caution Terrain’.

~~The requirement does not imply that Class A Equipment must be able to support both these aural messages, although it is permissible for Class A Equipment to support both messages.~~

[...]

In Section 2.2.1.1.6.3.2 Aural Alert — Warning

The sentences ‘For a warning level FLTA alert due to a predicted terrain conflict, Class A Equipment shall (TAWS_MOPS_053) be capable of generating or triggering an aural message of at least one of ‘Terrain Ahead. Pull up’ and ‘Terrain. Terrain, Pull up’.

‘The requirement does not imply that Class A Equipment must be able to support both aural messages. although it is permissible for Class A Equipment to support both messages.’

should be replaced by

‘For a warning level FLTA alert due to a predicted terrain conflict, Class A Equipment shall (TAWS_MOPS_053) be capable of generating or triggering both types of aural messages: of at least one of ‘Terrain Ahead. Pull up’ and ‘Terrain. Terrain, Pull up’.

~~‘The requirement does not imply that Class A Equipment must be able to support both these aural messages. although it is permissible for Class A Equipment to support both messages.’~~

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.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

For Class A and B ETSO articles, a failure of the function defined in paragraph 3.1.1 due to a TAWS computer malfunction resulting in false terrain warnings, an unannounced loss of function, or the presentation of hazardously misleading information is a major failure condition.

For Class C ETSO articles, a failure of the function defined in paragraph 3.1.1 due to a TAWS computer malfunction resulting in false terrain warnings, an unannounced loss of function, or the presentation of hazardously misleading information is a minor failure condition.

A loss of the function defined in paragraph 3.1.1 is a minor failure condition.

Note: Hazardously misleading information is defined as an incorrect depiction of the terrain threat relative to the aeroplane during an alert condition.

3.2.2 Operating Instructions

Operating instructions and article limitations that are sufficient to describe the operational capability of the equipment, including the coverage of the database (geographical areas and airport characteristics), should be documented and made available to the user. The operating instructions must include information on the effects of a loss of GNSS on the TAWS function if the TAWS relies on the GPS. Additionally, the instructions must contain processes for updating the terrain database.

4 Marking

4.1 General

See CS-ETSO, Subpart A, paragraph 1.2.

4.2 Specific

None.

5 Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

[Amdt ETSO/11]

[Amdt ETSO/16]

ETSO-C153a

ED Decision 2020/011/R

INTEGRATED MODULAR AVIONICS (IMA) PLATFORM AND MODULES

Note: This ETSO standard is identical to the ETSO-2C153 standard. This new revision has the purpose of aligning the ETSO Index with the published FAA TSO-C153a to reflect harmonisation. As a consequence, this standard is moved from Index 2 to Index 1 of CS-ETSO Subpart B.

1 Applicability

This ETSO provides the requirements that IMA modules, designed to be parts of an Integrated Modular Avionics (IMA) platform and manufactured on or after the date of entry into force of this ETSO, must meet in order to be identified with the applicable ETSO marking.

See Appendix 1 for an introduction to IMA and the applicable definitions.

EUROCAE ED-124 and RTCA DO-297 recognise an incremental IMA system approval by introducing intermediate acceptance steps. ETSO-C153a authorisation is an optional intermediate step to authorise an IMA platform or IMA modules (independently of the aircraft type approval). It encompasses environmental qualification, hardware development assurance, software development assurance and design approval of the intended function of resource sharing.

This ETSO refers to IMA platforms and modules which are appliances composed of hardware, core software or any embedded software module contributing to the intended function of resources sharing.

Nevertheless, if the intended function of resource sharing is implemented:

- the ‘hardware only’ module is acceptable if no further software module is needed to perform resources sharing;
- a single Line Replaceable Unit (LRU) platform (as per EUROCAE ED-124/RTCA DO-297), where the platform is limited to one LRU, is acceptable.

Hereinafter, only the term ‘IMA module’ will be used.

The following are out of the scope of this ETSO-C153a:

- IMA platforms consisting of multiple LRUs or Line Replaceable Modules (LRMs) distributed inside the aircraft that have to be addressed at installation level;
- stand-alone core software;
- configuration data which are part of the IMA system integration and installation;
- hosted applications; and
- equipment used to generate radio frequency signals for intentional transmitters.

To be eligible for an ETSO-C153a authorisation, an IMA module shall comply with common applicable requirements and shall implement at least one of the function classes below:

- CLASS RH: Rack Housing
- CLASS PR: Processing
- CLASS GP: Graphical Processing
- CLASS DS: Data Storage

- CLASS IF: Interface
- CLASS PS: Power Supply
- CLASS DH: Display Head

See [Appendix 2](#) for the common requirements and definitions of function classes.

An IMA module can also be compliant with a combination of MPS classes. In this case, the IMA module will be marked with all the classes it covers. However, if a manufacturer voluntarily applies for an ETSO-C153a authorisation, all the classes for which the intended function is implemented shall be compliant.

Example: A single LRU platform will be authorised as an 'ETSO-C153a CLASS PR + DS + IF' if the intended function of resource sharing is implemented in processing, data storage and the interfaces.

For an ETSO-C153a CLASS DH authorisation, the IMA module shall be compliant with the requirements of ETSO-C113(*) 'Airborne Multipurpose Electronic Displays'. The IMA module shall be marked with both ETSO-C153a CLASS DH and ETSO-C113.

(*) Please refer to the most recent applicable revision of ETSO-C113.

2 Procedures

2.1. General

The applicable procedures are detailed in Subpart A of CS-ETSO.

The data to be submitted to the European Union Aviation Safety Agency (EASA) (hereinafter referred to as 'the Agency') is defined in Subpart O of Annex I (Part 21) to Regulation (EU) No 748/2012 and in [Subpart A](#) of CS-ETSO.

2.2 Specific

Additional data which shall be submitted to the Agency by IMA modules manufacturers are specified in [Appendix 3](#), including the data required by ED-124 Task 1 (See paragraph 3.2.2.1 below).

3 Technical Conditions

3.1 Basic

3.1.1 Minimum Performance Standard

See [Appendix 2](#).

3.1.2 Environmental Standard

See CS-ETSO, [Subpart A](#), paragraph 2.1 and [Appendix 4](#).

3.1.3 Computer Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific

3.2.1 Failure Condition Classification

It is recognised that IMA modules may be developed independently of specific installation projects and of future hosted aircraft functions, thus preventing the possibility to define the level of the aircraft failure condition, which is out of the scope of this ETSO.

However, the module architecture and development will be driven by generic failure conditions. These can be considered as assumptions, which will contribute to determine the Development Assurance Level (DAL) allocation as per CS-ETSO [Subpart A](#), paragraph 2.4.

The assumed failure conditions and the resulting DAL are characterisation items and shall be documented in the installation manual and declaration of design and performance (DDP).

Qualitative and safety mechanisms requirements for each class are specified in the Minimum Performance Standard in [Appendix 2](#).

3.2.2 Specific Development and Installation Requirements

3.2.2.1 Development process

EUROCAE ED-124/RTCA document DO-297 'Integrated Modular Avionics (IMA) Development Guidance and Certification Considerations' contains guidance for IMA developers, application developers, integrators, certification applicants, and those involved in the approval and continuing airworthiness of IMA systems in civil certification projects.

In the frame of ETSO-C153a, the development of IMA modules or platforms shall meet the objectives of the EUROCAE ED-124/RTCA document DO-297 guidance related to Task 1 (Table A-1 'Objectives') except as constrained below:

Table A-1, Objective 8 is:

- applicable to a single LRU platform; and
- partially applicable to an IMA module for intrinsic validation and verification activities. (i.e. excluding 4.2.1 h).

Note: For Table A-1, Objective 8, the column 'doc ref' refers to 5.3 and 5.4, which provide details of objectives with applicability per Task 1 of ED-124 (See Tables 5 and 6).

3.2.2.2 Installation Considerations

An ETSO-2153 IMA module is, by definition, an incomplete system.

A definition of the activities to be performed to properly use the ETSO-C153a IMA module shall be defined for the installer. The associated test procedures to check that the authorised IMA module is properly installed shall also be documented in the installation manual in order to allow the integrator to perform integration of applications hosted on IMA platforms/modules and their installation on aircraft as per the applicable guidance.

4 Marking

4.1 General

Marking is detailed in Paragraph 1.2 of CS-ETSO, [Subpart A](#).

4.2 Specific

The part shall be permanently and legibly marked with the intended function class(es) as defined in Paragraph 1 of this ETSO. This information shall be on the ETSO nameplate or in close proximity to the nameplate.

Note: An ETSO-C153a marking does not cover IMA-hosted applications and IMA configuration management, which are software aspects not covered by this ETSO.

5 Availability of Referenced Documents

Please see paragraph 3 of CS-ETSO, [Subpart A](#).

[Amdt ETSO/10]

[Amdt ETSO/16]

APPENDIX 1 TO ETSO-C153A – INTEGRATED MODULAR AVIONICS (IMA) OVERVIEW, DEFINITION AND EXAMPLES

ED Decision 2020/011/R

This Appendix provides:

- Chapter 1: an overview of Integrated Modular Avionics (IMA);
- Chapter 2: applicable definitions;
- Chapter 3: a definition of the Minimum Performance Standard (MPS) classes; and
- Chapter 4: examples of IMA platforms using IMA modules.

Chapter 1: Integrated Modular Avionics overview

In this ETSO, Integrated Modular Avionics (IMA) is defined according to EUROCAE ED-124 (equivalent to the RTCA document DO-297):

Integrated modular avionics (IMA): is a shared set of flexible, reusable, and interoperable hardware and software resources that, when integrated, form a platform that provides services, designed and verified to meet a defined set of safety and performance requirements, to host applications performing aircraft functions.

The IMA architecture integrates many aircraft functions on the same platform. Those functions are provided by several hosted applications that have historically been contained in functionally and physically separated ‘boxes’ or LRUs.

IMA platforms are composed of modules which are designed to be reusable in order to reduce development costs and occasionally facilitate certification programmes. Some modules provide only mechanical, possibly cooling and electrical power supply functions. Others include core software and the associated computing capabilities.

IMA modules are usually both generic and configurable, therefore, the same platform could be used on different aircraft models.

Chapter 2 — Applicable definitions

Legend

- [ED-124]: Definitions from EUROCAE ED-124 (equivalent to RTCA document DO-297).
- [C153a]: Definitions provided or adjusted in the frame of the ETSO.

Aircraft function [ED-124]: The capability of the aircraft that may be provided by the hardware and software of the systems on the aircraft.

Application [ED-124]: Software and/or application-specific hardware with a defined set of interfaces that, when integrated with the platform, performs a function.

Cabinet [C153a]: Result of the integration of hardware modules mounted within one rack.

Characterisation item [C153a]: Identified module characteristics towards which the IMA module developer needs to determine the module performance, with full verification and documentation in the user guide/installation manual as appropriate.

Component [ED-124]: A self-contained hardware, software part, database or combination thereof that is configuration-controlled. A component does not provide an aircraft function by itself.

Configuration data [ED-124]: See Paragraph 3.7.1.

Core Software [ED-124]: The operating system and support software that manage resources to provide an environment in which applications can be executed. Core software is a necessary component of a platform and is typically comprised of one or more modules (such as, for example, libraries, drivers, kernel, data-loading, boot, etc.).

IMA Platform [ED-124]: A module or group of modules, including core software, which manage resources in a manner sufficient to support at least one application. IMA hardware resources and core software are designed and managed in a way that provides computational, communication and interface capabilities for hosting at least one application. Platforms by themselves do not provide any aircraft functionality. The IMA platform may be accepted independently of hosted applications.

IMA System [ED-124]: It consists of (an) IMA platform(s) and a defined set of hosted applications.

LRM (Line Replaceable Module) [C153a]: An IMA platform element identified in aircraft configuration and replaceable by aircraft line maintenance to restore the aircraft into an operational ready condition. An IMA LRM is a stand-alone item of equipment which does not provide any aircraft function until hosted applications are integrated.

LRU (Line Replaceable Unit) [C153a]: An element supporting an aircraft function identified in aircraft configuration and replaceable by aircraft line maintenance to restore the aircraft into an operational ready condition. An LRU is usually a stand-alone item of equipment such as a [radio](#), a Flight Management Computer or any kind of functional equipment.

IMA Module [C153a]: A component or collection of components that may be hardware or a combination of hardware and software, which provide resources to the IMA-hosted applications. Software application and module configuration data are not covered by this definition. Modules may be distributed across the aircraft or may be co-located.

Operating System[ED-124]:

- 1) The same as executive software.
- 2) The software kernel that services only the underlying hardware platform.
- 3) Software that directs the operations of a computer, resource allocation and data management, controlling and scheduling the execution of computer-hosted applications, managing memory, storage, input/output, and communication resources.

Rack [C153a]: A physical package able to contain at least two hardware modules, which may provide partial protection from environmental effects (shielding) and may enable installation on and removal of the mounted modules from the aircraft without physically altering other aircraft systems or equipment.

Resources/Shared resources [ED-124]: Any object (processor, memory, software, data, etc.) or component used by an IMA platform or application. A resource may be shared by multiple applications or dedicated to a specific application. A resource may be physical (a hardware device) or logical (a piece of information).

Support software [C153a]: Embedded software necessary as a complement to the operating system to provide general services such as contributing to the intended function of resources sharing, handling hardware, drivers, software loading, health monitoring, boot strap, etc.

Unit [C153a]: Set of physical components (hardware and/or software) inside an item of equipment in charge of providing a resource.

Usage Domain [C153a]: The usage domain of an IMA module is defined as an exhaustive list of conditions (such as configuration settings, usage rules etc.) to be respected by the user(s) to ensure that the IMA module continues to meet the performance characteristics and requirements of the ETSO Minimum Performance Standard. Compliance with usage domain ensures that:

- the module is compliant with its functional, performance, safety and environmental requirements specified for all implemented intended functions;
- the module characteristics documented in the User Guide (as required by Appendix 2) are guaranteed by manufacturer; and
- the module is compliant with the applicable airworthiness requirements (including continuing airworthiness aspects). (*)

(*) Note: In the context of this IMA modules/platforms ETSO standard, this last sentence refers to requirements as described in Section 2 of CS-ETSO Subpart A.

Chapter 3 — Definition of intended function classes

To apply for an ETSO-C153a authorisation, the IMA module shall comply with applicable common requirements and implement at least one Intended Function Class. If a manufacturer applies for an ETSO-C153a authorisation, all the classes for which the Intended Function is implemented shall be compliant.

CLASS RH: Rack Housing

For ETSO-C153a Class RH:

1.3.RH.1: The IMA module is a physical package able to contain at least two hardware modules that may provide protection from environmental effects (shielding, etc.) and enable the installation and removal of those module(s) from the aircraft without physically altering other aircraft systems or equipment.

1.3.RH.2: The IMA module may be a simple mechanical enclosure, or it may incorporate communication interfaces, backplanes for data and power supplies, active cooling or any combination of these features.

1.3.RH.3: The IMA module does not offer the capability to host applications unless combined with a Class PR approval.

1.3.RH.4: The IMA module may be configurable.

CLASS PR: Processing

For ETSO-C153a Class PR:

1.3.PR.1: The IMA module contains a processing component, a memory component, interface devices and the associated Core Software which constitute one or several Processing Unit(s).

Note: Containing memory components or interfaces devices does not lead automatically to having class DS and/or IF in the certification basis; DS or IF classes need to be applied for only if concurrent access to these interface or data storage resources is offered as a shared resource (as described in Class DS and IF).

1.3.PR.2: The intended function of such an IMA module is to share Processing, Data and Information between at least two hosted applications, modules and/or components.

1.3.PR.3: The IMA module offers the capability to host applications.

1.3.PR.4: The IMA module may be an association of hardware and Core Software.

- Hardware may (or may not) contain resident (not field-loadable) software to enable electronic part marking and/or future loading of Field-Loadable Software parts.
- Core Software may be resident or a Field-Loadable Software part.

1.3.PR.5: The IMA module may be configurable.

CLASS GP: Graphical Processing

For ETSO-C153a Class GP:

1.3.GP.1: The IMA module contains a graphical engine component and an optional video engine component, memories, interfaces and potentially associated Core Software which constitute one or several Graphical Unit(s).

1.3.GP.2: The intended function of such an IMA module is to share graphics and optional video signal processing between at least two hosted applications, modules and/or components.

1.3.GP.3: The IMA module does not offer the capability to host software applications unless combined with a Class PR approval.

1.3.GP.4: The IMA module may be an association of hardware and Core Software.

Hardware may (or may not) contain resident (not field-loadable) software to enable electronic part marking and/or future loading of Field-Loadable Software parts.

Core Software may be resident or a Field-Loadable Software part

1.3.GP.5: The IMA module may be configurable.

CLASS DS: Data Storage

For ETSO-C153a Class DS:

1.3.DS.1: The IMA module contains memory (volatile or non-volatile), an interface component and potentially associated Core Software which constitute one or several Data Storage Unit(s).

1.3.DS.2: The intended function of such an IMA module is to share stored data (e.g. databases, files, etc.) between several applications, modules and/or components.

1.3.DS.3: The IMA module does not offer the capability to host applications, unless combined with a Class PR approval.

1.3.DS.4: The IMA module may be an association of hardware and a Core Software.

- Hardware may (or may not) contain resident (not field-loadable) software to enable electronic part marking and/or future loading of Field-Loadable Software parts.
- Core Software may be resident or a Field-Loadable Software part.

1.3.DS.5: The IMA module may be configurable.

CLASS IF: Interface

For ETSO-C153a Class IF:

1.3.IF.1: The IMA module contains input/output component(s) and potentially associated Core Software which constitute one or several Interface Unit(s). These interfaces can be discrete, analogue, a serial interface, a digital bus, etc..

1.3.IF.2: The intended function of such an IMA module is to share information between several aircraft functions or applications.

1.3.IF.3: The IMA module does not offer the capability to host applications unless combined with a Class PR approval.

1.3.IF.4: The IMA module may be an association of hardware and a Core Software.

- Hardware may (or may not) contain resident (not field-loadable) software to enable electronic part marking and/or future loading of Field-Loadable Software parts.
- Core Software may be resident or a Field-Loadable Software part.

1.3.IF.5: The IMA module may be configurable.

CLASS PS: Power Supply

For ETSO-C153a Class PS:

1.3.PS.1: The IMA module contains a set of components (hardware and/or software) which constitute one or several Power Supply Unit(s) in charge of managing electric power.

1.3.PS.2: The intended function of such an IMA module installed into a rack (Class RH module) is to provide power supplied from an airborne electrical network to one or more hardware modules embedded into the same rack.

1.3.PS.3: The IMA module does not offer the capability to host applications unless combined with a Class PR approval.

1.3.PS.4: The IMA module may be configurable.

1.3.PS.5: The IMA module may be an association of hardware and a Core Software.

Hardware may (or may not) contain resident (not field-loadable) software to enable electronic part marking and/or future loading of Field-Loadable Software parts.

Core Software may be resident or a Field-Loadable Software part.

CLASS DH: Display Head

For ETSO-C153a Class DH:

1.3.DH.1: The IMA module contains a set of components (hardware and/or software) in charge of managing a displayed area which constitutes one or several Display Unit(s).

1.3.DH.2: The intended function of such an IMA module is to offer the capability to depict graphical information received from IMA Application(s), component(s) and/or module(s) on one Display Area.

1.3.DH.3: The IMA module does not offer the capability to host applications unless combined with a Class PR approval.

1.3.DH.4: The IMA module may be an association of hardware and a Core Software.

- Hardware may (or may not) contain resident (not field-loadable) software to enable electronic part marking and/or future loading of Field-Loadable Software parts.
- Core Software may be resident or a Field-Loadable Software part.

1.3.DH.5: The IMA module may be configurable.

Chapter 4 — Example of an IMA platform using IMA modules

EUROCAE ED-124/RTCA document DO-297 contains some examples relating to the definition of the IMA module and platform, which can be completed by some additional examples related to Chapter 3 'Definitions'.

Example 1: Single LRU platform (as per EUROCAE ED-124/RTCA document DO-297)

This example illustrates the sharing of computational and Input/Output (I/O) resources within a single Line Replaceable Unit (LRU). Such IMA system key characteristics include:

- hosting of multiple applications (not part of the IMA platform);
- platform configuration data and data loading; and
- a defined API between the IMA platform and hosted applications.

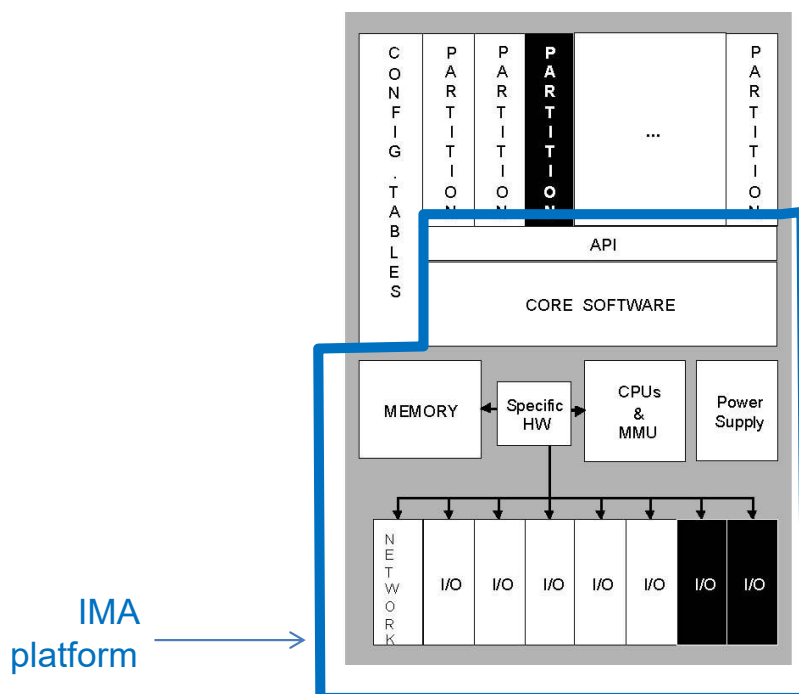


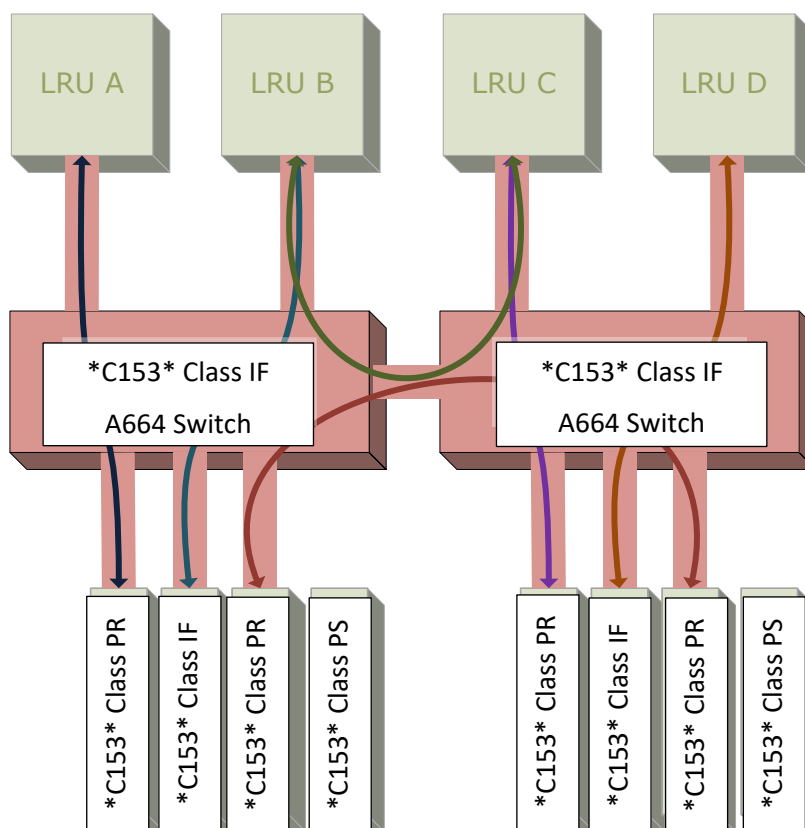
Figure 1: Single LRU platform (as per EUROCAE ED-124/RTCA DO-297)

At one level, this example illustrates a single platform providing core computational resources. At another level, it illustrates a module to be used within a larger IMA platform.

If sharing of processing, memory, and I/O resources is implemented within the LRU, such a single LRU platform will be eligible for CLASS PR, DS and IF.

Example 2: Single LRU A664 switch equipment

This example illustrates the sharing of ARINC Specification 664 I/O resources within a single Line Replaceable Unit (LRU).



Virtual link (see ARINC 664) between two subscribers, switched by the *C153* class

Figure 2: Example of an architecture based on two ETSO-*C153* class IF modules each implementing an ARINC 664 switch

Note: ETSO-*C153* is intended to identify any existing amendment of this ETSO including its first release as ETSO-2C153.

In this architecture, the two ETSO-C153a class IF modules switch A664 frames, providing each of the subscribers shared access to the network. Network subscribers can be other ETSO-C153a modules as the lower row of modules shows, or non-IMA equipment (top row) such as displays/radio transceivers.

If sharing of ARINC Specification 664 I/O resources is implemented within the LRU, such a single LRU platform shall be eligible for CLASS IF.

Example 3: IMA modules installed in a Rack Module (Line Replaceable Module)

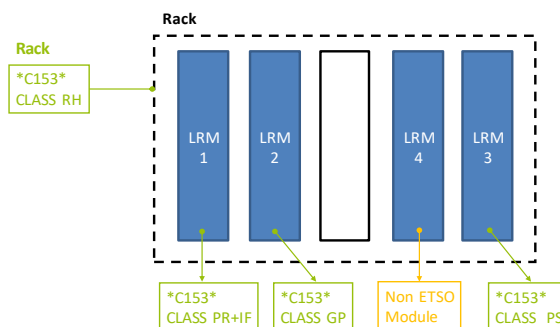


Figure 3: IMA modules installed in a Rack Module

This example illustrates the sharing of resources within several single Line Replaceable Modules (LRMs) installed in a Rack:

- a Rack is an IMA module and will be eligible for CLASS RH;
- LRM 1 provides shared Processing and Input/Output and shall be eligible for CLASS PR+IF;
- LRM 2 provides shared Graphical Processing and shall be eligible for CLASS GP;
- LRM 3 provides shared a Power Supply to LRMs embedded into the same rack, and shall be eligible for CLASS PS; and
- LRM 4 does not provide shared resources. This module shall be considered as a non-ETSO-C153a module.

All these modules are considered to be parts.

[Amdt ETSO/10]

[Amdt ETSO/16]

APPENDIX 2 TO ETSO-C153A – INTEGRATED MODULAR AVIONICS (IMA) MODULE MINIMUM PERFORMANCE STANDARD (MPS)

ED Decision 2020/011/R

This Appendix provides a Specific Minimum Performance Standard for IMA modules.

Principle

An IMA module is composed of hardware components or hardware and software components performing the intended function(s) whose minimum performance requirements are specified in this Appendix.

This Minimum Performance Standard (MPS) is structured as a common-requirements section and a set of classes specifying IMA module intended functions:

- COMMON: Minimum Performance Standard applicable whatever IMA module and whatever the implemented intended function class(es);
- CLASS RH: Rack Housing intended function;
- CLASS PR: Processing intended function;
- CLASS GP: Graphical Processing intended function;
- CLASS DS: Data Storage intended function;
- CLASS IF: Interface intended function;
- CLASS PS: Power Supply intended function; and
- CLASS DH: Display Head intended function.

To apply for an ETSO-C153s authorisation, the IMA module shall comply with a common Minimum Performance Standard and implement at least one Intended Function Class as defined in this Appendix.

When applying for an ETSO-C153a authorisation, the applicant shall include in the certification basis all classes for which the intended function is implemented in the IMA module/platform.

Naming convention

This document contains ‘shall’, ‘should’ and ‘may’ statements with the following meanings:

- the use of word ‘shall’ indicates a mandated criterion, i.e. compliance with the criterion is mandatory and no alternative may be applied;
- the use of word ‘should’ (and phrases such as ‘It is recommended that...’, etc.) indicate that though the procedure or criterion is regarded as the preferred option, alternative procedures, specifications or criteria may be applied, provided that the manufacturer, installer or tester can provide information or data to adequately support and justify the alternative;
- the use of word ‘may’ indicates that though the criterion is regarded as the preferred option, alternative criteria may be applied. In such cases, alternatives should be identified in appropriate approval plans and agreement sought from the approval authority.

Verification Procedures

For verification procedures, the following definitions and symbols are used in this Appendix:

Analysis (A)

Analysis is the method of verification which consists in comparing design with known scientific and technical principles, technical data, or procedures and practices to validate that the proposed design will meet the specified functional or performance requirements.

Demonstration (D)

Demonstration is the method of verification where qualitative versus quantitative validation of a requirement is made during a dynamic test of the system/equipment. In general, software functional requirements are verified by demonstration since their functionality must be observed through some secondary media.

Inspection (I)

Inspection is the method of verification to determine compliance with requirements and consists primarily of visual observations or mechanical measurements of the system/equipment, physical location, or technical examination of the engineering support documentation.

Test (T)

Test is the method of verification that will exercise equipment functions and measure system/equipment performance under a specific configuration and load conditions and after the controlled application of known stimuli. Quantitative values are measured, compared against previously predicated success criteria, and then evaluated to determine the degree of compliance.

Y

The test is mandated under the indicated conditions.

m/n

Either verification method 'm' or verification method 'n' may be used to verify the requirement (i.e. D/A can be verified by Demonstration or Analysis).

m+n

Both verification methods must be used to verify the requirement (i.e. D+A means that the requirement must be verified by Demonstration and Analysis).

[Amdt ETSO/10]

[Amdt ETSO/16]

APPENDIX 2.1 TO ETSO-C153A – INTEGRATED MODULAR AVIONICS (IMA) MODULE MINIMUM PERFORMANCE STANDARD (MPS)

ED Decision 2020/011/R

COMMON: Applicable to all IMA modules

1. Purpose and scope

This Appendix contains a set of Minimum Performance Standards (MPS) applicable to any IMA module and to any implemented intended function class(es).

In the following, the term ‘concurrent items’ designates the items (applications, for example) that use the shared resource of the IMA module. Depending on the module class, it means ‘processing element’ for PR class, ‘thread’ for GP, IF and DH class, ‘data storage element’ for DS class, and ‘power rail’ for PS class.

2. Requirements

2.1. Functional requirements common to all classes

CO.a) The IMA shall implement at least one Function Class.

The following requirements of this paragraph are applicable to all classes with some exception as described below:

CO.b) Except for the housing function (F1) of class RH (see Appendix 2.2, paragraph 2.1.1), the IMA module shall provide at least the following control features to react to detected failures:

- a. disable, and
- b. reset.

CO.c) Except for the Housing function (F1) of class RH (see Appendix 2.2, paragraph 2.1.1), each IMA module shall provide a health management and reporting capability.

CO.d) Except for the housing function (F1) of class RH (see Appendix 2.2, paragraph 2.1.1), the health management and reporting function shall detect, isolate, contain and report faults (in the shared resources and other resources) that could adversely affect applications using the module resources or the resources themselves.

CO.e) Except for class RH, robust partitioning (as per EUROCAE ED-124/RTCA DO-297) between ‘concurrent items’ sharing the resource shall be ensured by the IMA module.

CO.f) Except for class RH, robust partitioning shall not rely on any required behaviour of any aircraft function or hosted application (as per EUROCAE ED-124/RTCA DO-297, Section 3.5c).

CO.g) Except for class RH, the potential breaches in robust partitioning shall be identified. An appropriate process and means should be implemented to ensure that such failures which result or may result in an unsafe condition are detected and reported.

CO.h) Except for class RH, the IMA module shall implement a fault containment mechanism to prevent fault propagation between ‘concurrent items’ using the shared-resource elements and between other IMA modules.

CO.i) Reserved.

CO.j) Except for the housing function (F1) of class RH (see Appendix 2.2, paragraph 2.1.1), the interface between the ‘concurrent items’ and the shared resource should conform to the characteristics as described by a standard (ARINC specifications 653, 664, and 600, for example).

2.2. Characterisation requirements

CO.k) Each item of the characterisation shall be documented in the User Guide/Installation Manual as appropriate.

CO.l) The IMA module specification shall be characterised based on items in the table below (Figure 4: IMA module Characterisation *Categories*) and on the characterisation requirements identifying additional characterisation items specific to each functional class (defined in Appendix 2 — Class RH, PR, GP, DS, IF, PS, and DH).

CO.m) Quantifiable characterised items shall be quantified in terms of minimum, typical (when relevant) and maximum values and the associated accuracy.

Note: The influence of environmental or abnormal conditions should be considered when relevant.

CO.n) The characterisation of the IMA module shall be correct and complete. Completeness is achieved when all the shared features of the IMA module have been characterised.

CO.o) The characterisation shall identify the valid usage domain of the IMA module.

CO.p) The characterisation shall provide all constraints on the usage domain and on the installation (including limitations and activities) to be respected by the users.

CO.q) The characterisation shall provide the list of types of shared-resource elements, the associated attributes, their configurability and their performances, and their associated limit of use.

CO.r) The characterisation shall include at least the following characteristics of the core software/programmable hardware:

- a. the identification of the core software component(s)/programmable hardware (if any);
- b. the IMA module functionality, performance and safety requirements supported by the core software/programmable hardware;
- c. external interfaces and associated data coupling/control-coupling information;
- d. integration and loading procedure(s); and
- e. the development assurance level(s).

CO.s) When the IMA module offers the capability to host software, the characterisation shall provide any data needed to evaluate the worst-case execution time (WCET) of each concurrent item sharing the IMA module resource.

- CO.t) The performances of each shared-resource management mechanism including monitoring shall be characterised, in particular the range, timing aspects, transients, etc.
- CO.u) For at least the following failure modes, the failure rate shall be provided:
- a. a loss of the IMA module;
 - b. erroneous behaviour of the IMA module;
 - c. a loss of the shared-resource element; and
 - d. erroneous behaviour of the shared-resource element.
- CO.v) The characterisation shall include the monitoring coverage rate (PBIT, CBIT, etc.) for the identified failure modes of the IMA module (including shared and unshared resources, sharing mechanisms and robust partitioning mechanisms).
- CO.w) The characterisation shall address the safety aspects of bad sequencing, delay, corruption and impersonation, where applicable.
- CO.x) The following health monitoring items shall be included in the characterisation:
- a. interface rules, constraints (including limitations) to be respected by the users;
 - b. list of Health Monitoring services;
 - c. list of monitored components, monitored services, monitored interfaces;
 - d. response to each type of fault;
 - e. fault reporting attributes (reporting refers to internal logging, indication to applications using the shared resources, indication outside of the module); and
 - f. the configuration attributes, if any.
- CO.y) If the IMA module is configurable, the characterisation shall include, in addition, the following items:
- a. the authorised configuration parameters (including range, type and definition of combined parameters) in the usage domain; and
 - b. the configuration activities to be conducted (including configuration procedures, means and tools) by the user during application development (EUROCAE ED-124 — Task 2) and IMA system integration (EUROCAE ED-124 — Task 3 and 4).
- CO.z) If some tools are required for installation, these tools shall be characterised according to the following:
- a. identification;
 - b. the user's manuals of the tools;
 - c. the activities related to those tools to be conducted during application development (EUROCAE ED-124 — Task 2) and IMA system integration (EUROCAE ED-124 — Task 3 and 4);

- d. the proposed associated qualification credits that could be granted to the user of the tools;
 - e. the category of the tool and the Development Assurance Level of the tool (if any) as defined in the applicable Software Development assurance guidance (see Section 2.2 of CS-ETSO, Subpart A,); and
 - f. limitations and Open Problem Report (if any) on tools that could affect the tool qualification credit and require analysis by the user.
- CO.aa) The compatibility and mixability information between hardware, software, tools and usage domain shall be part of the characterisation. This characterisation shall address at least the following:
- a. how the authorised mixed combinations are verified;
 - b. the compatibility assessment process with authorised mixed combinations of interfacing modules (external mixability);
 - c. any preventative measures (design or procedures) to be developed by the user to prevent incorrect module combinations or software loads; and
 - d. information to be provided to maintenance personnel.
- CO.bb) The control features (disable, reset, reload, etc.) of the IMA module for reacting to detected failures shall be characterised.

Characterisation Category	Characterisation item
General Information	Power Dissipation
	Thermal characteristics
	Temperature control (e.g. cooling) characteristics
	Size and Weight
	Input and Output (I/O) Connectors (including pinout)
	Mating Connectors
	Top-level drawings and Mechanical Interfaces
	Mounting Mechanism and scheme
	Clearance characteristics
	Air Flow characteristics
	Inter-Element Interfaces (such as Backplane interface)
	Grounding and Shielding Provisions
	Separation and/or Isolation Provisions
	Module Installation and Extraction Means
	Backplane Interface
	Start-up sequence
	Different operational modes (initialisation, monitor, operational etc.)

Characterisation Category	Characterisation item
Interfaces	Analogue Input Specifications For Each Analogue Input
	Type of Analogue (e.g. differential, isolated, etc.)
	Range
	Accuracy
	Resolution
	Null and Offset
	Filtering
	Input Impedance
	Analogue-to-Digital Conversion Speed
	Steady-State Voltage Rating
	Transient Voltage Rating
	Circuit Protection Techniques
	Multiplexing
	Latency Time
	Bandwidth
	Analogue Output Specifications For Each Analogue Output
	Type of Analogue (e.g. differential, isolated, etc.)
	Range
	Accuracy
	Null
	Linearity
	Current Capacity
	Output Impedance
	Steady-State Voltage Rating
	Transient Voltage Rating
	Circuit Protection Techniques
	Multiplexing
	Latency Time
	Bandwidth
	Discrete Input Specifications For Each Discrete Input
	Trip Point
	Hysteresis
	Filtering
	Input Impedance
	Logic Sense
	Maximum Logic–High Level
	Maximum Logic–Low Level
	Minimum Logic–High Level
	Minimum Logic–Low Level
	Steady-State Voltage Rating
	Transient Voltage Rating
	Circuit Protection Techniques
	Multiplexing

Characterisation Category	Characterisation item
	Discrete Output Specifications For Each Discrete Output
	Voltage Levels
	Current Source Capacity
	Current Sink Capacity
	Output Impedance
	Circuit Protection Techniques
	Multiplexing
	Digital Communications For Each Input and Output
	Data Rates
	Integrity Checks
	Signal Levels
	Current Sink and Source
	Input Impedance
	Output Impedance
	Signal Rise and Fall Times
	Filtering
	Stub Length Limits
	Input and Output Capacitance
	Isolation
	Maximum Bit Error Rates
	Circuit Protection Techniques
	Resets
	Monitors
	Multiplexing
Processing and Memory (inc. Graphical)	Included Software Services (Core Software) and associated performances: Data loading, Health Management, Operating System
	Processing Unit (CPU, GPU, etc.), Component(s), Bus(es) and Core Clock Frequencies
	Memory Size(s), Type(s), Control of Access and Timing(s)
	Local data bus(es) Type(s) and Timings
	Start-up and Reset mechanisms and timings
Display and Rendering	
	Refer to SAE AS8034 'Minimum Performance Standard for Airborne Multipurpose Electronic Displays' (revision as defined in the applicable release of ETSO-C113)
Power Supply	Regulation
	Input Voltage and Current range
	Maximum Start-up (Input and Output Inrush) Current Rating
	Hold-up Capacity
	Restart
	Transient Immunity
	Short Circuit Management
	Power Resets and Recovery
	Circuit Protection Techniques
	Slew rate at start-up

Characterisation Category	Characterisation item

Figure 4: IMA module Characterisation Categories

The following list of terms summarises the terminology used in the characterisation items defined in Figure 4 that are applicable to this ETSO, in the development of hardware elements, and in the application of the Appendix 1 MPS development criteria. The terms are segregated into eight categories according to the performance of the appropriate hardware element.

(1) General Terms

Air Flow Characteristic: specific requirements to provide air movement into or onto a cabinet, LRU, or module (e.g. air temperature, volume rate, and pressure).

Analogue/Digital Conversion Speed: the time to perform one Analogue-to-Digital (A-to-D) conversion. Typically, this is expressed as either the time for one analogue conversion performed by the A/D converter device or the frequency at which all analogue inputs are converted.

Circuit Protection Techniques: the electrical isolation or circuitry included in inputs or outputs to protect the functional circuits from external environments (for example solutions to protect circuits from the indirect effects of lightning).

Current Source/Sink: the maximum current drawn by the output while pulling the signal to a zero-volt (ground) level.

Current Source: the maximum current supplied by the output while driving the signal to a voltage level.

Clearance Characteristics: additional spacing requirements in specific directions from the cabinet or rack beyond the outline dimensions (e.g. additional clearance is the area to allow proper airflow).

Design Assurance: all planned and systematic actions and data used to substantiate that hardware correctly performs its intended function(s) and that design errors have been identified and corrected such that the hardware satisfies the applicable certification basis.

Development Assurance: all planned and systematic actions and data used to substantiate that the system performs its intended function(s) and that development errors have been identified and corrected such that the system satisfies the applicable certification basis.

Functional Software: software applications that will be approved as part of a functional TSO authorisation or as part of a type certification effort. This software is sometimes referred to as operational software, application software, or flight software.

Functional ETSO: an ETSO with defined functionality (for example, Airborne Weather Radar, ETSO-C63). ETSO-C153a is not considered a functional ETSO, because IMA hardware elements typically do not have system-level functionality.

Grounding/Shielding Provisions: the electrical and/or mechanical details of the design which provide grounding of the element or shield connections. These are the design details usually associated with the Radio Frequency emission and susceptibility protection of the system.

Hardware element: in this ETSO, a hardware element is (1) a hardware module, or (2) cabinets or racks that host hardware modules.

Note: This definition may differ from the terminology used in other documents (e.g. ED-80/RTCA DO-254).

Inter-Element Connections: the connector type specification and connector pin assignments specified to allow modules to be installed interchangeably in the cabinets or racks.

Inter-Element Interfaces: the definition of the electrical signals, timing requirements, and protocols used to communicate among modules or elements with the cabinet or system.

Module Extraction Means: the details of the mechanical design to enable removal of the module from the cabinet.

Module Mounting Scheme: the details of the mechanical design used to secure each module into the cabinet or rack.

Mounting Mechanism: the details of the mechanical mechanism(s) used to secure the module into the cabinet or rack of the aircraft.

Multiplexing: the design technique where multiple inputs are individually switched to one receiver (for example, multiple digital communication buses switched to a serial receiver) or multiple outputs are individually supplied by the same circuit (for example, multiple analogue outputs driven by one Digital-to-Analogue converter through multiple sample-and-hold).

Separation/Isolation Provisions: the electrical and/or mechanical details of the design which provide physical or electrical means of reducing interference from one element to another.

Steady State Voltage Rating: the maximum voltage range that can be applied continuously to an input or output without resulting in damage.

Transient Voltage Rating: the maximum voltage that can be applied for a short period of time to an input or output without resulting in damage. The maximum duration of the transient must be included.

(2) Analogue Input/Output Terms

Accuracy: the degree of conformity to the true value of the signal. This is usually expressed as a percentage of the reading or a percentage of the full-scale value of the signal.

Current Capacity: the maximum amount of current that can be sunk or sourced by the circuit.

Linearity: the error from the directly proportional expected signal value as the signal values vary over the entire range.

Null: the signal value(s) for which a value of zero is identified. This is usually shown as positive and negative voltage values.

Offset: the indicated signal value (usually non-zero) when zero volts are applied.

Range: the least and greatest operating voltage extremes (full scale) of the signal; the voltage extremes between which the signal value is valid.

Resolution: the smallest measurable division of the numerical expression of the signal. This is usually identified as the number of binary bits used to express the signal value and/or the value in volts of the least significant binary bit (LSB).

(3) Discrete Input/Output Terms

Discrete Input: this is an input with only two states. Typical examples are ‘ground or open’ and ‘28-volt and open’ inputs.

Discrete Output: this is an output with only two states. Typical examples are ‘ground or open’ and ‘28-volt and open’ outputs.

(4) Input Terms

Hysteresis: the value of the input voltage lag when changing states. For example, if an input circuit has 0.2 volts of hysteresis and if the trip point is 2.0 volts, then the circuit will change state as the input voltage reaches 2.0 volts but will not revert back to the original state until the input voltage drops below 1.8 volts.

Logic Sense: this is the functional interpretation of the discrete input states. A true or positive logic sense may identify the ‘ground’ state as ‘low’ or binary ‘0’. An inverse or negative logic sense may identify a ‘ground’ state as ‘high’ or binary ‘1’.

Maximum Logic–High Level: the largest voltage value that can be applied to the input and that the circuit will interpret as ‘high’.

Maximum Logic–Low Level: the largest voltage value that can be applied to the input and that the circuit will interpret as ‘low’.

Minimum Logic–High Level: the smallest voltage value that can be applied to the input and that the circuit will interpret as ‘high’.

Minimum Logic–Low Level: the smallest voltage value that can be applied to the input and that the circuit will interpret as ‘low’.

Trip Point: this is the input voltage value at which the input circuitry changes state.

(5) Output Terms

Current Sink Capacity: the maximum current by the output while pulling the signal to a zero-volt (ground) level (current flowing in the direction from the load to the element output).

Current Source Capacity: the maximum current supplied by the output while driving the signal to a voltage level (current flowing from the element output to the load).

Voltage Levels: the minimum and maximum voltages for each state of the output. The ground point that is to be used as reference must be identified.

(6) Processor Terms

Backplane Interface: the definition of the electrical signals, buses, timing requirements, and protocols used to communicate among elements installed in a cabinet or rack.

Interrupts: the signals to the processor that stops execution of an ongoing process or application. These signals indicate that there is a higher priority request of task or that an asynchronous event is occurring.

Memory Management Unit: a specialised control circuitry, sometimes integrated within the microprocessor, which performs predictive reads of instruction (prefetch) for use by

the processor. It also may perform structured or prioritised control of specific sections of the memory.

Monitors: specific circuits which observe the normal operation of the processing system and alert the processor or user to an abnormal condition. Examples are power supply monitors, which reset the processor when a voltage is outside of its tolerance, and activity monitors, which reset the processor when the processor does not perform a prescribed sequence.

Reset Structure: the architectural details of the various signals that stop execution of an ongoing process, or software application and restarts the processor at a known state.

Central Processing Unit (CPU) Throughput: a measure of the number of processor instructions performed by the CPU per unit of time.

(7) Power Supply Terms

Hold-up Capacity: the capacity of the power supply to continue supplying output current after the input voltage drops below the minimum level. This is usually expressed as the time from the input voltage drop to the reset generated by the power supply.

Input Voltage & Current: the input voltage is specified as nominal and acceptable variation values. The input current is specified as maximum steady state current. For the peak current, please see the term ‘Maximum Start-up (Inrush) Current Rating’ below.

Maximum Start-up (Inrush) Current Rating: the maximum input current when the power supply first becomes active as a result of the input voltage increase to the minimum level.

Output Current Capacity: the continuously operating maximum current supplied for each output voltage.

Power Monitors & Status Outputs: separate circuitry which checks the output voltage levels and current loading of the power supply. This circuitry will generate one or more binary signals that may be connected to the processor to alert it to the ‘out of spec’ condition. These binary signals may also force the power supply to shut down to prevent damage to power supply components.

Power Resets: a binary signal output from the power supply that is asserted when the output voltages are outside acceptable tolerances.

Regulation: the percentage of variation of the output voltages when subjected to changes in load, changes in temperature, and all input voltage transients and deviations.

Restart: the ability of the power supply or other circuit to return to the normal operating mode when the input voltage returns to or above the minimum level or when the tripped monitor indicates that the ‘out-of-spec’ condition has ended and the operating condition is returned to normal.

Short Circuit Management: the circuitry that monitors for short circuits or overcurrent conditions in the power supply outputs. The results from this circuitry may shut down the affected output or the entire power supply.

Transient Immunity: the ability of the power supply to continue operating normally during variations in the input voltage. This is usually expressed as the length of time and voltage level of the transient.

Voltage Outputs & Tolerances: the voltage levels and tolerances of the outputs produced by the power supply.

(8) Digital Communication Terms

Data Rates: the number of data bits transmitted in a time period. This is usually expressed in thousands of bits per second (Kbps) or millions of bits per second (Mbps).

Integrity Checks: the process that uses additional data accompanying the message information to validate that the message data was received without corruption or contamination. Examples are parity checks, checksums, data validity checks, and cyclic redundancy checks.

Maximum Bit Error Rates: the largest number of bit errors allowed in a message transmission before the receiver invalidates its ability to receive data from that source.

Monitors: separate circuitry that checks either the continuing operation of a transmitter, or that the receiver responds to input data. This circuitry will generate one or more binary signals that may be connected to the processor, alerting it to the 'failed' condition.

Resets: conditions that result in the receiver or transmitter stopping operation, clearing all data, and restarting.

Signal Levels: the minimum and maximum voltages for each state of the input or output. Typically, tolerances, thresholds, and the reference ground point are also identified.

Signal Rise and Fall Times: the signal rise time is the time for the output to transition from 10 % to 90 % of the amplitude. The signal fall time is the time for the output to transition from the 90 % to the 10 % level.

Stub Length Limits: the minimum and maximum length requirements of the wiring connector from the main bus to the inputs of the element.

3. Verification requirements

CO.cc) Each requirement shall be verified.

CO.dd) Each characterisation item of IMA modules and functions, their associated attributes, their configurability and their performances shall be verified commensurately to the Development Assurance Level.

CO.ee) Each characterisation item of the IMA module shall be verified over the usage domain.

CO.ff) A set of verification procedures to demonstrate the compliance of the IMA module with the applicable MPS shall be developed and proposed as part of the certification data package.

CO.gg) There is a distinction between demonstrating the capability of sharing and demonstrating the performance of that sharing function. When demonstrating the performance of the IMA module, a subset of the characterisation items that allows the behaviour of the complete IMA module during environmental testing shall be defined and submitted together with the Qualification Test Plan.

Note that this functional subset should be detailed enough to sufficiently cover the performance of the complete IMA module.

4. Test Software representativeness

When embedded software is needed to test the IMA module, this module is authorised without the functional software (hosted applications) being installed and operating.

CO.hh) Engineering analysis performed by the design holder shall determine that the test software (not the target functional software) is representative of the overall usage domain envelope of the module and related to the verification procedures.

5. Verification procedures

The following table provides verification methods for each requirement; nevertheless, an alternative method may be proposed to the certification authority.

Requirement identifier	Verification method	Test under normal conditions	Test Functional Subset ⁽¹⁾ under environmental conditions	Comment
CO.a)	I			
CO.b)	T	Y		
CO.c)	A			
CO.d)	T(A*)	Y	Y	
CO.e)	T(A*)	Y		
CO.f)	A			
CO.g)	T	Y		
CO.h)	T(A*)	Y		
CO.i)	A			Reserved
CO.j)	T(A*)	Y		
CO.k)	I			
CO.l)	A			
CO.m)	A			
CO.n)	A			
CO.o)	T(A*)		Y ⁽²⁾	
CO.p)	A			
CO.q)	I			
CO.r)	I			
CO.s)	A			
CO.t)	A			
CO.u)	I+A			
CO.v)	I+A			
CO.w)	I+A			
CO.x)	A			
CO.y)	A			
CO.z)	A			
CO.aa)	A			
CO.bb)	A			
CO.cc)	I+A			
CO.dd)	T(A*)	Y	Y	
CO.ee)	T(A*)	Y	Y	
CO.ff)	A			
CO.gg)	A			
CO.hh)	A			

Table 1: Verification Acceptance Criteria

(A*) means that verification by the Analysis method is possible for items that cannot be tested.

Note (1): applicable for a functional subset as defined in CO.gg).

Note (2): the Usage Domain has to be taken into consideration during Environmental Qualification Testing in order to evaluate the robustness of the IMA module over the full Usage Domain (see Appendix 4, Chapter 1).

[Amdt ETSO/10]

[Amdt ETSO/16]

APPENDIX 2.2 TO ETSO-C153A – INTEGRATED MODULAR AVIONICS (IMA) PLATFORM AND MODULE MINIMUM PERFORMANCE STANDARD (MPS)

ED Decision 2020/011/R

CLASS RH: Rack Housing

1. Purpose and scope

1.1. Introduction

This Appendix contains the Minimum Performance Standards (MPS) for the CLASS RH Intended Function: Rack Housing.

These standards specify module characteristics that should be useful to designers, manufacturers, installers and users of the IMA module.

1.2. Definitions

For ETSO-C153a CLASS RH, the IMA module is a physical package able to contain at least two hardware modules, which may provide partial protection from environmental effects (shielding, etc.) and enable the installation and removal of those module(s) from the aircraft without physically altering other aircraft systems or equipment.

These IMA modules may be simple mechanical enclosures, or they may incorporate passive communication interfaces, a passive interconnection of data and power, an active or passive cooling unit or any combination of these features.

The following definitions are used:

- ‘Mounted’ refers to another hardware module, installed and fixed inside the IMA rack module, after a human operation.
- ‘Slot’ is a physical space inside the rack module, allocated to one hardware module.

These definitions are independent of the design choices made by the IMA module manufacturer.

Note:

- The IMA module compliant with ETSO-C153a CLASS RH MPS is only relevant in the case of an IMA platform architecture that uses a cabinet; and
- hardware modules mounted inside the Rack Housing will themselves be IMA modules (compliant with ETSO-C153a MPS classes other than RH) or non-IMA modules (i.e. non-IMA application specific hardware).

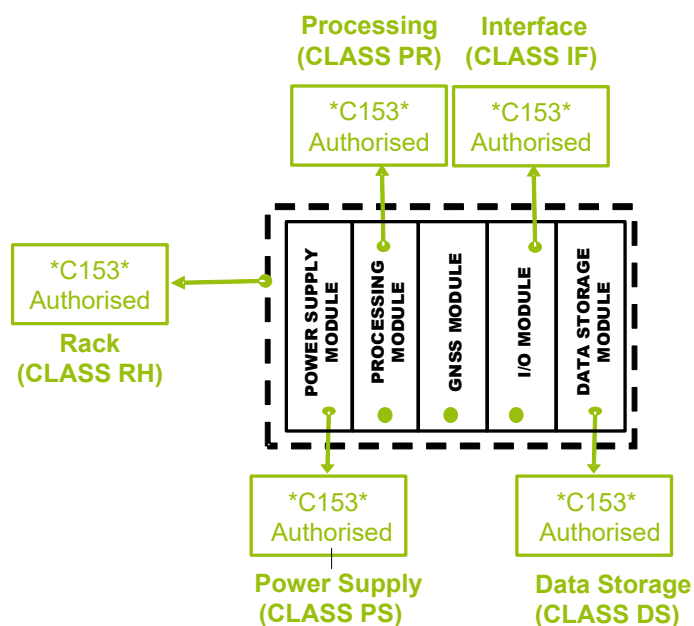


Figure 5: Illustration of the IMA platform architecture based on a cabinet

1.3. Intended Function

For ETSO-C153a CLASS RH, the intended function is to provide the capability to share some of the housing services supplied by one mechanical unit.

This intended function can be divided into 4 sub-functions:

- F1: Housing (mandatory);
- F2: Shielding (optional);
- F3: Interconnection (optional); and
- F4: Temperature control (optional).

Figure 6 provides an overview of the above-mentioned intended functions and definitions of the Rack Housing Module.

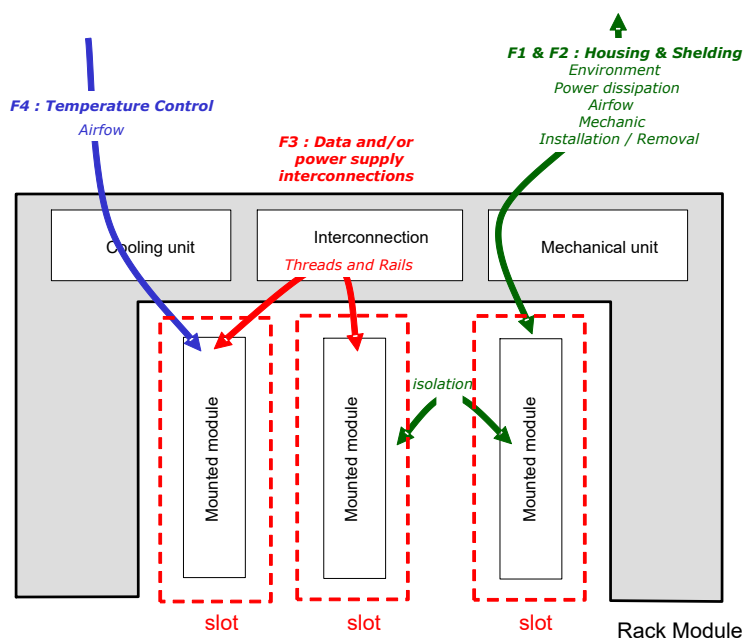


Figure 6: IMA module overview for ETSO-C153a CLASS RH

2. Requirements

2.1. Requirements for Housing (F1)

For ETSO-C153a CLASS RH, the IMA module provides shared resources for the housing needs of hardware modules. This sub-function merges:

- the capacity to host at least two hardware modules in at least two slots; and
- the capacity to mount and dismount a hardware module in its slot directly on the aircraft thanks to a human (potentially toolled) intervention.

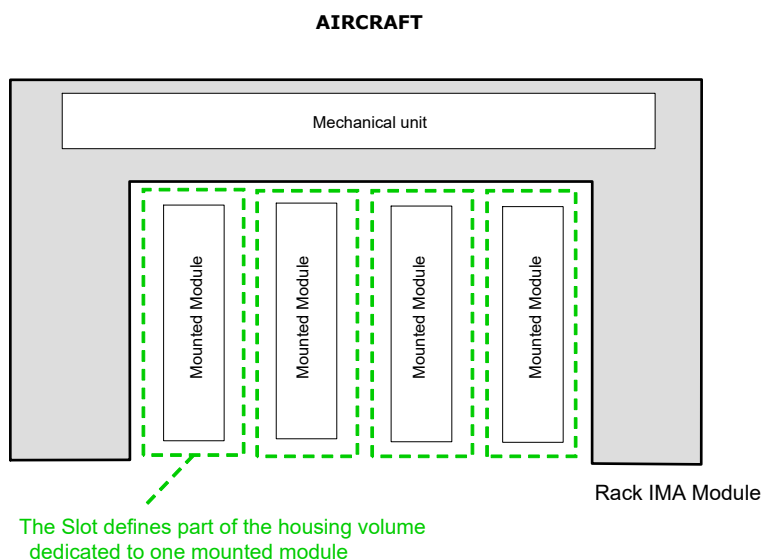


Figure 7: CLASS RH Housing function overview

2.1.1. Functional requirements for ETSO-C153a CLASS RH (F1): Housing

- RH.a) The Rack Housing shall permit the installation and attachment of at least two hardware modules to be installed and attached, one of which (at least) is an IMA module, inside its mechanical structure.
- RH.b) The Rack Housing shall ensure the physical partitioning between the different mounted hardware modules.
- RH.c) For each type of slot, a means to avoid the installation of unintended hardware modules or inappropriate installation shall be implemented (e.g. a mechanical key).
- RH.d) If compliance with the MPS requires any additional mechanical component, then if this component is separable, it shall be marked with its part number.
- RH.e) The external mechanical interface(s) of the Rack Housing module should conform to the characteristics as described by a standard (e.g. ARINC 600). Some characteristics of the slots may be configurable.

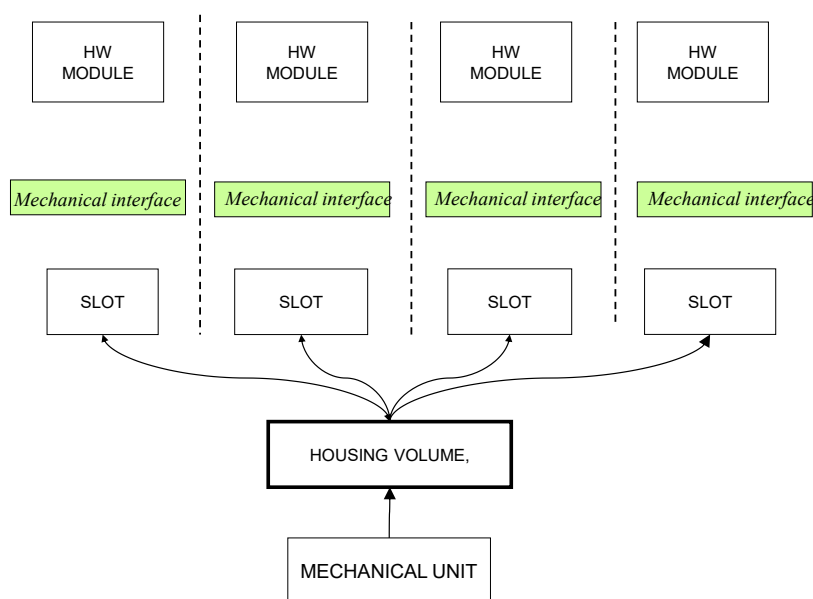


Figure 8: CLASS RH— the relationship between housing elements

2.1.2. Characterisation requirements for ETSO-C153a CLASS RH (F1): Housing

RH.f) The following housing performances or housing characteristics of the rack module shall be provided as part of the characterisation:

1. the size, mass and centre of gravity;
2. the clearance scheme;
3. the top-level drawings and mechanical interfaces;
4. the module mounting scheme;
5. the installation and extraction mechanisms;
6. the temperature control (e.g. airflow, cooling, etc.) performances if the function is implemented;
7. a list of the slots and their associated performances (physical scheme, temperature profile, connector, etc.).

Note: These characterisation requirements are additional to those applicable in Appendix 2.1 — COMMON).

RH.g) The characterisation shall include the description of the mounted hardware module installation and the extraction means and methods.

RH.h) The characterisation shall provide the list of types of slots, their associated attributes, their configurability (if any) and their sizing dimensions (drawings).

This characterisation shall include:

1. the list of authorised or predefined hardware modules (if any);
2. the list of minimum requirements that a hardware module shall comply with to be able to be inserted into the rack;
3. the slot mounting scheme (mechanical profile/drawings) and characteristics (torque, maximum number of insertions, etc.); and
4. the power dissipation and airflow profile.

RH.i) The characterisation, including the usage domain, shall be sufficiently accurate to permit specification and validation of the expected performance of the mounted hardware module.

RH.j) The characterisation shall include the configuration, weight and geometric data that are needed to evaluate the mass and centre of gravity of a populated rack and a partly populated rack.

RH.k) The characterisation shall include the installation instructions of the additional mechanical component that is necessary in order to be compliant with the MPS.

2.2. Requirements for Shielding (F2)

F2 is an optional sub-function of ETSO-C153a CLASS RH.

In this case, the IMA module provides shared resources in terms of the protection of mounted hardware modules. This sub-function merges:

- a level of protection of the mounted hardware modules from the aircraft environment (including, but not only, High Intensity Radiated Fields (HIRF) and Lightning effects); and
- a level of environmental isolation (shielding) between the mounted hardware modules inside the rack.

AIRCRAFT ENVIRONMENT

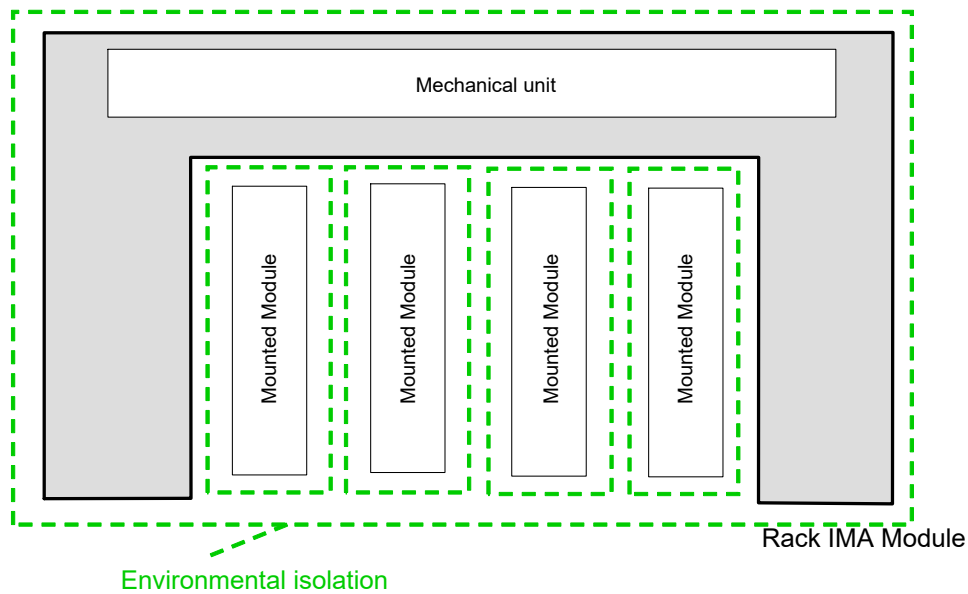


Figure 9: CLASS RH shielding function overview

2.2.1. Functional requirements for ETSO-aC153a CLASS RH (F2): Shielding

RH.l) A level of environmental protection (shielding) for each mounted hardware module shall be ensured by the Rack Housing IMA Module. This protection shall take into account the level and severity retained for the EUROCAE ED-14/RTCA DO-160 qualification of the IMA module (see Appendix 4) (outside the rack), as well as the interactions between the mounted hardware modules themselves (inside the rack).

RH.m) The protection performance of the IMA module (Rack module) shall be quantified and guaranteed for each slot and for each EUROCAE ED-14/RTCA DO-160 Section.

RH.n) Reserved

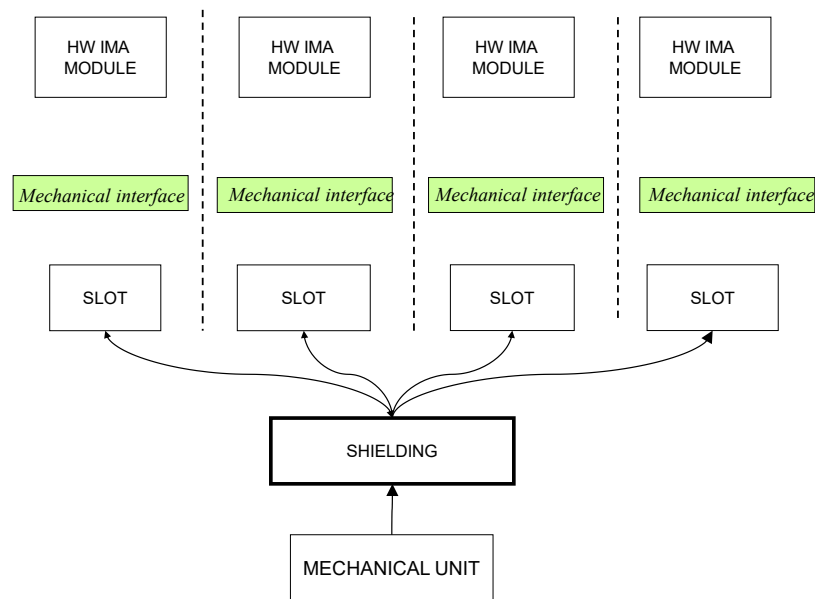


Figure 10: CLASS RH— the relationship between shielding elements

2.2.2. Characterisation requirements for ETSO-C153a CLASS RH (F2): Shielding

RH.o) The level of environmental protection (shielding) of each slot provided in Appendix 2.2, paragraph 2.1.1 shall be characterised, bounded and documented in the installation manual.

RH.p) The characterisation shall include the failure modes and rates of the protection features (such as lightning protections, etc.) to support the IMA system Safety Analysis (as per EUROCAE ED-124) at installation.

RH.q) The characterisation shall include the list of types of slots and the associated characteristics in terms of environmental protection (shielding).

This shall include:

1. the list of authorised or predefined hardware modules (if any);
2. the list of minimum requirements that a hardware module shall comply with in order to be mounted into the rack;
3. a slot Mounting Scheme (mechanical profile/isolation/drawings); and
4. the level of isolation and level of shielding per slot for each EUROCAE ED-14/RTCA DO-160 Section.

RH.r) The characterisation shall include the list of environmental tests that are used to qualify the hardware module (see Environmental Qualification Testing (EQT) in Appendix 4) mounted into the rack.

RH.s) The characterisation shall include all the possible configurations allowed for the configurable slot.

RH.t) If the 0 shielding objective is met thanks to any additional mechanical element(s), its installation shall be specified in the installation manual.

2.3. Requirements for Interconnection (F3)

F3 is an optional sub-function of ETSO-C153a CLASS RH.

In this case, the IMA module provides the capacity to interconnect hardware modules with each other inside the Rack Module. This interconnection allows the exchange of data or the distribution of power.

Note: To ensure the distribution of power to the mounted hardware modules, at least one ETSO-C153a CLASS PS module may be mounted into a slot to deliver electrical energy to the other hardware modules.

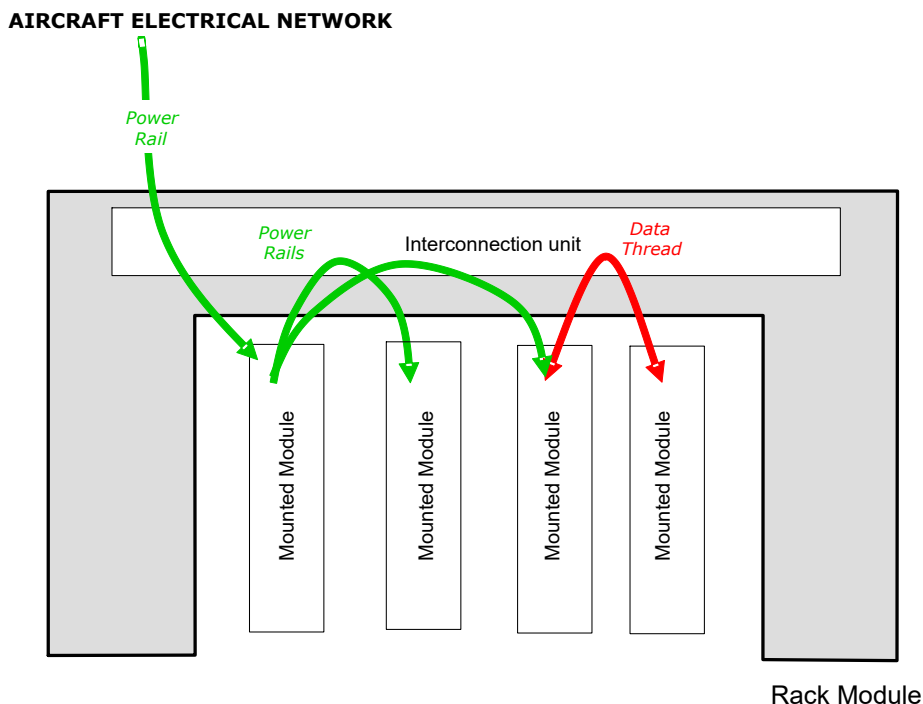


Figure 11: CLASS RH Interconnection function overview

2.3.1. Functional requirements for ETSO-C153a CLASS RH (F3): Interconnection

RH.u) The IMA module shall provide the capacity to interconnect mounted hardware modules thanks to data or power supply buses available through (an) electrical interface(s) supplied by one or several interconnection unit(s). These buses shall be dedicated to:

- a. data exchanges; and
- b. power distribution.

RH.v) If the IMA module provides more than one bus, the isolation between the buses used by mounted hardware modules shall be ensured by the IMA module. This isolation shall be substantiated by a Partitioning Analysis and by Environmental Qualification Testing.

RH.w) The interface(s) of the IMA module should conform to the characteristics as described by a standard (e.g. ARINC 600 or ARINC 664).

RH.x) The data and power supply buses shall not degrade the transmitted signals below the characterised performance.

RH.y) For ETSO-C153a CLASS RH, the IMA module shall ensure proper isolation of the interconnection function to prevent interference between signals (data, discrete I/O, power supply buses, etc.) that would affect data integrity, latency, and control.

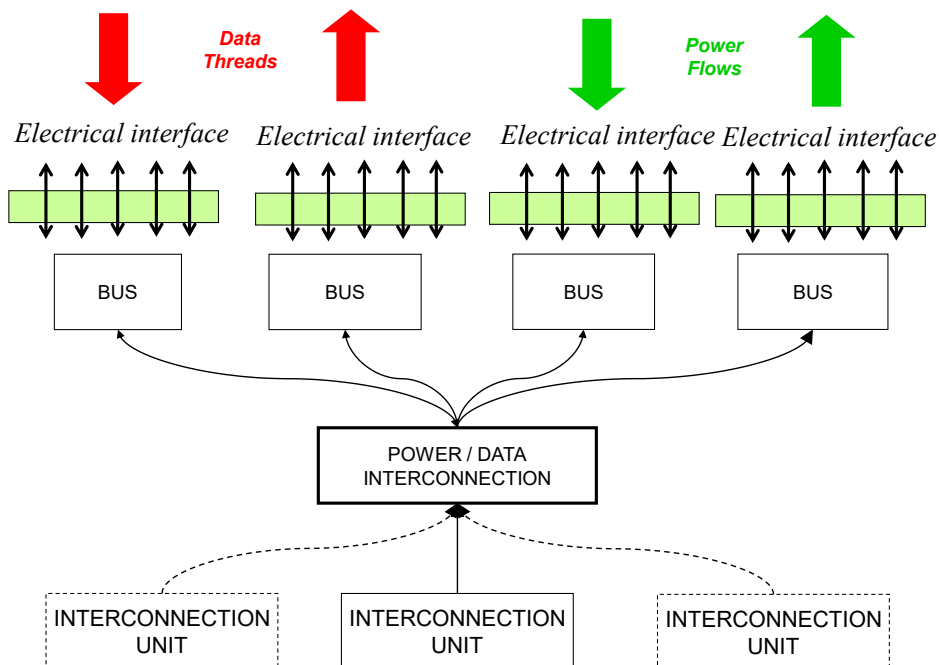


Figure 12: CLASS RH — the relationship between interconnection elements

2.3.2. Characterisation requirements for ETSO-C153a CLASS RH (F3) Interconnection

RH.z) The characterisation shall include attenuation profiles, signal integrity, cross-talk and tolerance rates. These shall be measured and guaranteed.

RH.aa) The performances of each of the types of buses provided in RH.u a) shall be characterised, quantified and guaranteed.

RH.bb) For at least the following failure modes, the failure rate shall be provided:

- a. a loss of the interconnection function; and
- b. erroneous behaviour of the interconnection function.

RH.cc) The characterisation shall address the safety aspects of sequencing, delay, corruption and impersonation.

RH.dd) The characterisation shall include the list of types of buses, their associated attributes, their configurability, and their sizing and performance.

2.4. Requirements for Temperature control (F4)

F4 is an optional sub-function of ETSO-C153a CLASS RH (F4): Temperature control

In this case, the IMA module provides the capability to control the temperature inside the rack for each mounted module.

This control may be realised by:

- distributing airflow between the aircraft environment (outside the rack) and the mounted hardware modules inside the IMA module (rack);
- enforcing airflow (convection) within the cooling generation unit;
- facilitating conduction between mounted hardware modules and the heat sinkers part of the Rack module.

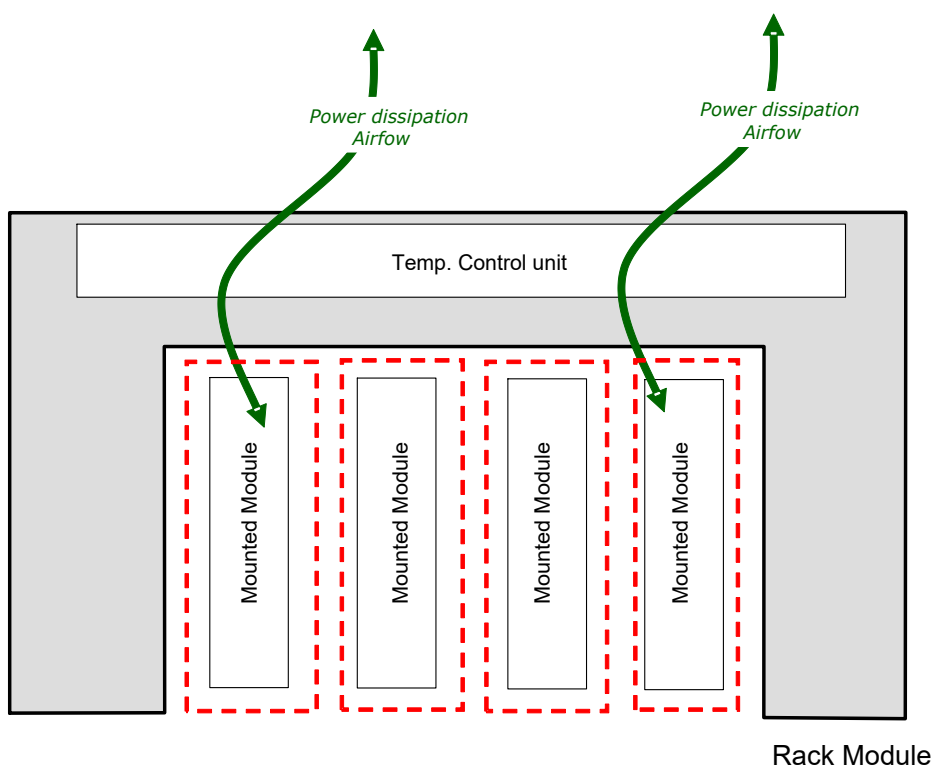


Figure 13: CLASS RH cooling function overview

2.4.1. Functional requirements for ETSO-C153a CLASS RH (F4): Temperature control

RH.ee) The IMA module shall provide regulated temperature control of the mounted hardware module. This control shall be ensured per slot in a determined temperature range.

RH.ff) The IMA module may provide an active means (temperature control unit) to control the temperature between the aircraft environment and the mounted hardware modules.

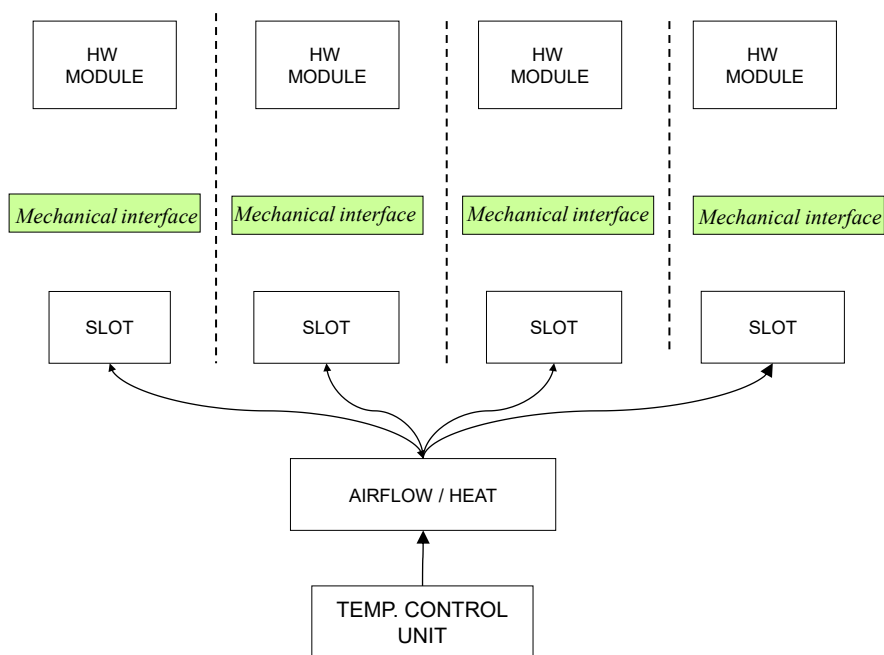


Figure 14: CLASS RH — the relationship between the cooling elements

2.4.2. Characterisation requirements for ETSO-C153a CLASS RH (F4)

RH.gg) The heat exchange performance of each slot provided shall be characterised, quantified and guaranteed in the installation manual.

RH.hh) For at least the following failure modes, the failure rate shall be provided:

- a loss of the active temperature control function; and
- erroneous behaviour of the active temperature control function.

RH.ii) Reserved

RH.jj) Reserved

3. Verification procedures

The following table gives the verification method for each MPS; nevertheless, an alternative method may be proposed to the certification authority:

Requirement identifier	Verification method	Test under normal conditions	Test under environmental conditions	Applicable ED-14/DO-160 sections
RH.a)	I+T	Y	Y ⁽²⁾	no ED-14 Section, see (2)
RH.b)	T	Y	Y	ED-14 Sections 4, 5, 7 and 8
RH.c)	I+T		Y ⁽²⁾	no ED-14 section, see (2)
RH.d)	I			
RH.e)	I/A			
RH.f)	I			
RH.g)	I			
RH.h)	I+A			
RH.i)	A			
RH.j)	I+T	Y		

Requirement identifier	Verification method	Test under normal conditions	Test under environmental conditions	Applicable ED-14/DO-160 sections
RH.k)	I			
RH.l)	I			
RH.m)	T	Y	Y	Appropriate ED-14 sections addressing the shielding characteristics and, as a minimum, Sections 18, 19, 20 and 22
RH.n)				
RH.o)	I			
RH.p)	I			
RH.q)	I+A			
RH.r)	I			
RH.s)	T	Y	Y	Appropriate ED-14 sections addressing the shielding characteristics and, as a minimum, Sections 18, 19, 20 and 22
RH.t)	I			
RH.u)	T	Y	Y ⁽¹⁾	ED-14 Sections 4, 5, 6, 7, 8, and 16 to 22
RH.v)	A+T	Y	Y	ED-14 Sections 16 to 22
RH.w)	T	Y	Y ⁽¹⁾	ED-14 Sections 4, 5, 7 and 16 to 22
RH.x)	T	Y	Y	ED-14 Sections 4, 5 and 7
RH.y)	A			
RH.z)	T(A*)	Y		
RH.aa)	T(A*)	Y ⁽¹⁾	Y ⁽¹⁾	ED-14 Sections 4, 5 and 7
RH.bb)	A	Y		
RH.cc)	T(A*)	Y ⁽¹⁾		
RH.dd)	I			
RH.ee)	T	Y	Y	ED-14 Sections 4 and 5
RH.ff)	I+T	Y	Y	ED-14 Sections 4 and 5
RH.gg)	I+T	Y	Y	ED-14 Sections 4, 5, 6 and 7
RH.hh)	A			
RH.ii)				
RH.jj)				

Table 2: Verification Acceptance Criteria

(A*) means that verification by the Analysis method is possible for the item that cannot be tested.

Note (1): applicable for a functional subset → cf. CO.gg).

Note (2): test to be completed after environmental testing.

[Amdt ETSO/10]

[Amdt ETSO/16]

APPENDIX 2.3 TO ETSO-C153A – INTEGRATED MODULAR AVIONICS (IMA) PLATFORM AND MODULE MINIMUM PERFORMANCE STANDARD (MPS)

ED Decision 2020/011/R

CLASS PR: Processing

1. Purpose and scope

1.1. Introduction

This Appendix contains the Minimum Performance Standards (MPSs) for the CLASS PR Intended Function: Processing (PR).

These standards specify characteristics that should be useful to designers, manufacturers, installers and users of the IMA module.

1.2. Definitions

For ETSO-C153a CLASS PR, the IMA module provides shared resources in terms of processing between hosted applications, modules and/or components.

The following definitions are used:

- Processing Unit: a set of physical components (hardware and/or software) in charge of carrying out the instructions of a computer programme by performing the basic arithmetical, logical, and input/output operations of the Executable Object Code.
- Executable Object Code (EUROCAE ED-12C/RTCA DO-178C): a form of code that is directly usable by the processing unit of the target computer and is, therefore, a compiled, assembled, and linked binary image, loaded into the target computing hardware.
- Processing Element: a well-defined set of instructions which is a primary form of an Executable Object Code execution and for which a level of isolation would be guaranteed by the IMA module.

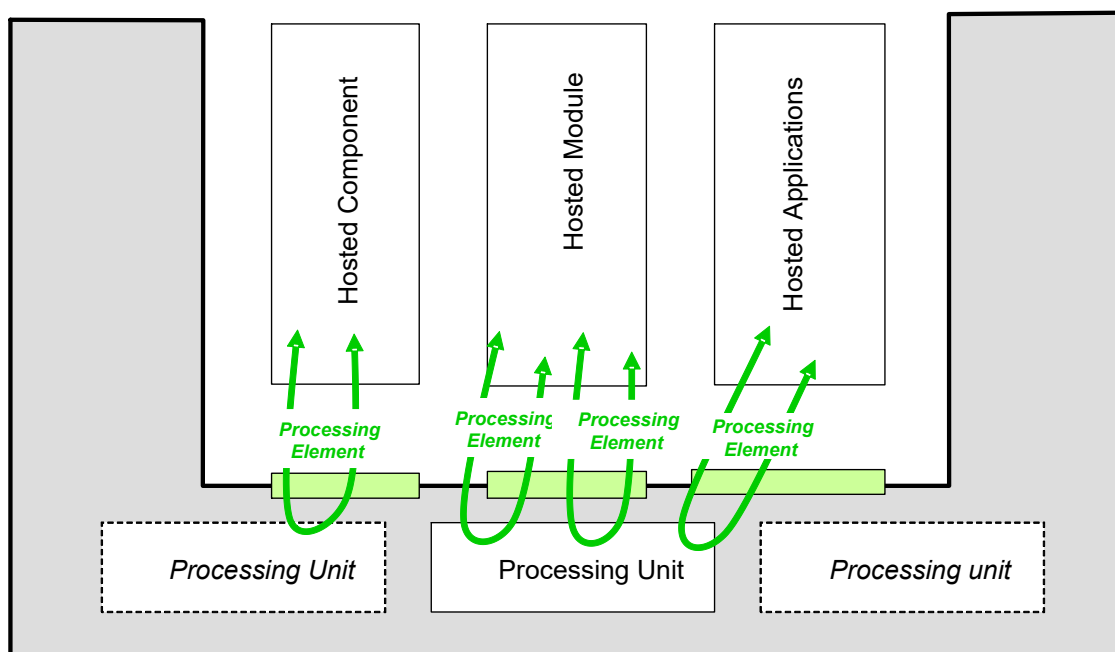
In the context of PR class, the ‘concurrent item’ defined in Appendix 2.1, paragraph 1 means ‘Processing Element’.

1.3. Intended Function

For ETSO-C153a CLASS PR, the intended function is to provide the capability to share the processing supplied by one or several processing unit(s).

The IMA module may include data storage and interfaces between hosted applications, modules and/or components; in this case, this class shall be combined with the DS and IF Classes.

The following figure provides an overview of the intended function of the above-mentioned IMA module and the associated definitions:



IMA Module

Figure 15: IMA module overview for ETSO-C153a CLASS PR

2. Requirements

2.1. Functional requirements for ETSO-C153a CLASS PR

- PR.a) The IMA module shall provide to hosted applications a Processing Resource which has the capacity to execute a set of instructions of a computer programme by performing the basic arithmetical, logical, and input/output operations of their Executable Object Code;
- PR.b) The IMA module shall be able to host applications and/or Executable Object Code(s) components.
- PR.c) The IMA module shall provide to hosted applications the capacity to share the Processing Resource thanks to Processing Elements managed through a logical interface, such as an Application Programme Interface (API).

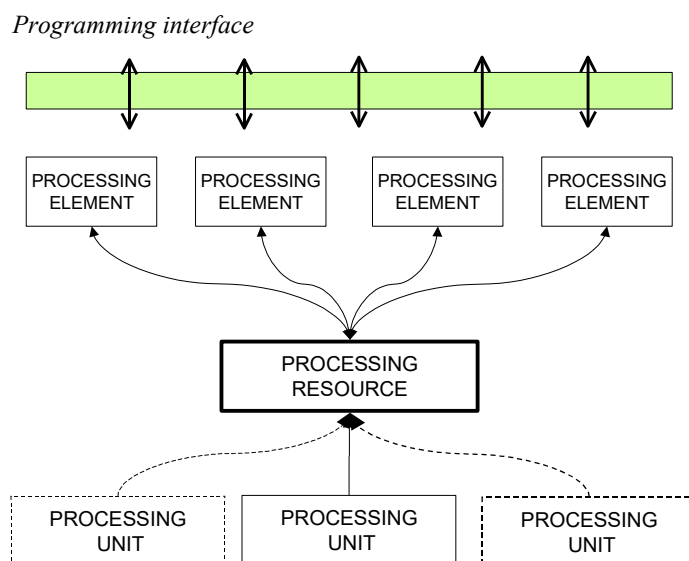


Figure 16: CLASS PR — the relationship between the processing elements

2.2. Characterisation requirements for ETSO-C153a CLASS PR

PR.d) All aspects of the processing performance of the shared Processing Unit of the IMA module shall be characterised, including, but not limited to, the following:

1. Processing Unit throughput (performance capacities and timings);
2. Performance of User Software/Software Interface (Core Software) Mechanism(s), Protocol(s), and Service(s);
3. Performance of User Hardware/Software Interface Mechanism(s), Protocol(s) and Service(s);
4. Performance of supported Processing Element Type (e.g. application, partition, process, thread, etc.);
5. Performance of Interrupt Mechanisms; and
6. Performance of Memory Management, including cache and Memory Management Unit (MMU).

Note: These performance requirements are additional to those applicable in Appendix 2.1 — COMMON.

3. Verification procedures

The following table gives the verification method for each MPS; nevertheless, an alternative method may be proposed to the certification authority:

Requirement identifier	Verification method	Test under normal conditions	Test under environmental conditions	Comment
PR.a)	T	Y	Y	
PR.b)	T	Y	Y	
PR.c)	T	Y	Y	
PR.d)	T (A*)	Y	Y ⁽¹⁾	

Table 3: Verification Acceptance Criteria

(A*) means that verification by the Analysis method is possible for the item that cannot be tested.

Note (1): applicable for a functional subset → cf. CO.gg).

[Amdt ETSO/10]

[Amdt ETSO/16]

APPENDIX 2.4 TO ETSO-C153A – INTEGRATED MODULAR AVIONICS (IMA) MODULE MINIMUM PERFORMANCE STANDARD (MPS)

ED Decision 2020/011/R

CLASS GP: Graphical Processing

1. Purpose and scope

1.1. Introduction

This Appendix contains the Minimum Performance Standard (MPS) for the CLASS GP Intended Function: Graphical Processing.

These standards specify characteristics that should be useful to designers, manufacturers, installers and users of the IMA module.

1.2. Definitions

For ETSO-C153a CLASS GP, the IMA module provides shared resources in terms of graphical conversion and graphical laying out between hosted applications, modules and/or components based on commands coming from these hosted applications, modules and/or components.

The following definitions are used:

- Graphical Thread: a set of graphical (displayable) information for which a level of isolation would be guaranteed by the IMA module.
- Data Thread: a well-defined set of data which is a primary form of the drawing directives received as input by the IMA module from hosted applications, modules and/or components.
- Command Thread: a well-defined set of command directives received as input by the IMA module from hosted applications, modules and/or components in order to change the conversion and laying out settings.
- Graphical conversion: a transformation of a set of data information that is the primary form of drawing directives (data thread) into a set of displayable basic information.
- Laying out: an operation consisting of a combination of merging or/and splitting actions of displayable basic information in order to build the final Graphical Thread to be rendered.
- Conversion Unit: a set of physical components (hardware and/or software) in charge of graphical conversion.
- Laying out Unit: a set of physical components (hardware and/or software) in charge of laying out.

Note:

- both units can be merged in one unit; and
- the final rendering of the graphical thread(s) is out of the scope of this module (refer to CLASS DH).

In the context of GP class, the ‘concurrent item’ defined in Appendix 2.1, paragraph 1 means ‘Graphical and/or Command Thread’.

1.3. Intended Function

For ETSO-C153a CLASS GP, the intended function is to provide the capability to share graphical conversion and graphical laying out supplied by one or several graphical conversion and graphical laying out unit(s).

The function of the Graphical Processing Module is to receive commands from hosted applications, modules and/or components and optionally receive video from external analogue or digital sources to process them and to generate an image to display.

This intended function is Graphical Conversion and Laying out resource sharing composed of:

- information acquisition and control;
- information conversion and laying out; and
- information forwarding & control.

The following figure provides an overview of the above-mentioned IMA module intended function and associated definitions:

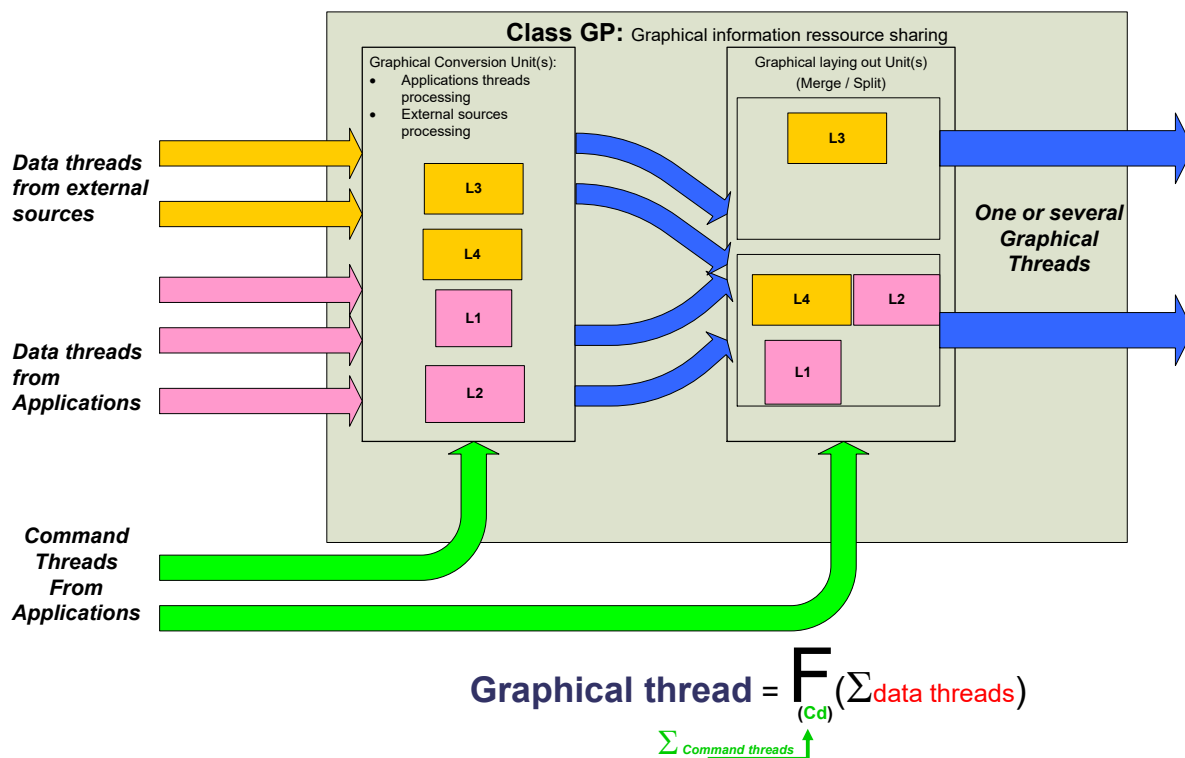


Figure 17: IMA module overview for ETSO-C153a CLASS GP

2. Requirements

2.1. Functional requirements for ETSO-C153a CLASS GP

- GP.a) The IMA module shall provide, to hosted applications, a Graphical Conversion Resource which has the capability to transform a set of drawing directives into a set of displayable basic information.
- GP.b) The IMA module shall provide, to hosted applications, a Graphical Laying out Resource which has the capability to merge or/and split displayable basic information to build the final Graphical Thread(s) to be rendered.
- GP.c) The IMA module shall provide to hosted applications, modules and/or components, the capability to change the graphical conversion and laying out settings through command threads.
- GP.d) The IMA Module shall provide to hosted applications, modules and/or components, the capability to share a Graphical Conversion Resource and a Graphical Laying out Resource based on command threads managed through (a) logical and/or physical interface(s).

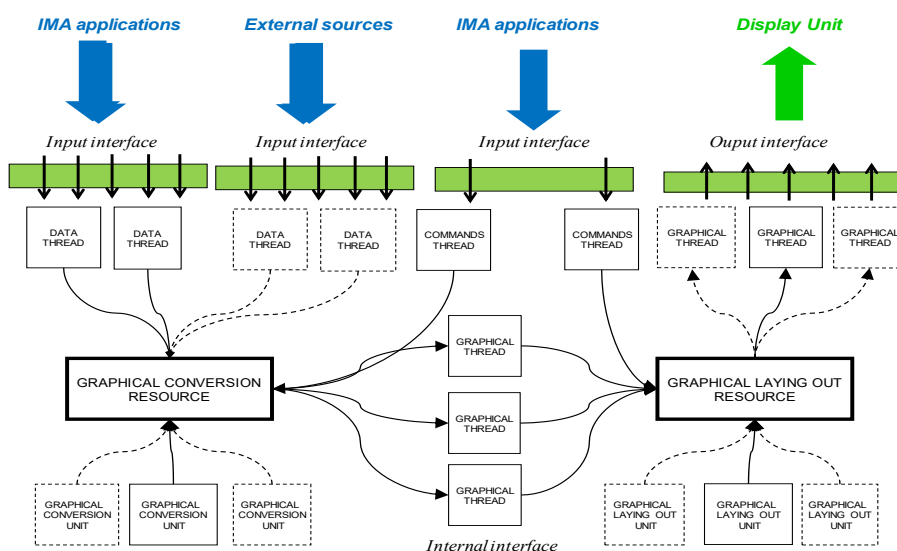


Figure 18: CLASS GP — the relationship between the Graphical Processing (GP) elements

2.2. Characterisation requirements for ETSO-C153a CLASS

- GP.e) The following aspects of the performance of the Graphical Unit(s) performance of the IMA module shall be quantified and guaranteed:
1. Graphical Unit(s) throughput (performance capacities and timings: response time, graphical update);
 2. Performances of User Software/Software Interface (Core Software) Mechanism(s), Protocol(s), and Service(s);
 3. Performance of User Hardware/Software Interface Mechanism(s), Protocol(s) and Service(s);
 4. Establishment of Worst-Case Graphical Elaboration Time;
 5. Performance of Interrupt Mechanisms;

6. Performance of supported Data Thread types;
7. Performance of supported Graphical Thread types; and
8. Performance of supported Command Thread types.

Note: These performance requirements are additional to those applicable in Appendix 2.1 — COMMON.

GP.f) In addition to the Common Requirement 0, particular emphasis shall be given to precluding or mitigating failures which could result in hazardously misleading information. Undetected loss of information or frozen information could contribute to hazardously misleading information.

Note: This is applicable to all the GP module functionality, including the implementation of image windowing, superimposition etc.

3. Verification procedures

The following table gives the verification method for each MPS; nevertheless, an alternative method may be proposed to the certification authority:

Requirement identifier	Verification method	Test under normal conditions	Test under environmental conditions	Comment
GP.a)	T	Y	Y	
GP.b)	T	Y	Y	
GP.c)	T	Y	Y	
GP.d)	T	Y	Y	
GP.e)	T(A*)	Y	Y ⁽¹⁾	
GP.f)	I			

Table 4: Verification Acceptance Criteria

(A*) means that verification by the Analysis method is possible for the item that cannot be tested.

Note (1): applicable for a functional subset → cf. CO.gg).

[Amdt ETSO/10]

[Amdt ETSO/16]

APPENDIX 2.5 TO ETSO-C153A – INTEGRATED MODULAR AVIONICS (IMA) PLATFORM AND MODULE MINIMUM PERFORMANCE STANDARD (MPS)

ED Decision 2020/011/R

CLASS DS: Data Storage (DS)

1. Purpose and scope

1.1. Introduction

This Appendix contains the Minimum Performance Standard (MPS) for the CLASS DS Intended Function: Data Storage.

These standards specify characteristics that should be useful to designers, manufacturers, installers and users of the IMA module.

1.2. Definitions

For ETSO-C153a CLASS DS, the IMA module provides shared resources in terms of data storage between hosted applications, modules and/or components.

Data Storage refers to the storage of data in a continuing and machine-readable mode. A Data Storage module that records data may access both the separate portable (removable) recording component and/or a permanent component to store and retrieve data.

The following definitions are used:

- Storage Unit: a set of physical components (hardware and/or software) in charge of supplying and managing recorded data resources (e.g. memory components and the associated interfaces, etc.)
- Data Storage Element: a completely defined set of data storage which is a primary form of recorded data and for which a level of isolation would be guaranteed by the IMA module.

In the context of DS class, the ‘concurrent item’ defined in Appendix 2.1, paragraph 1 means ‘Data Storage Element’.

1.3. Intended Function

For ETSO-C153a CLASS DS, the intended function is to provide the capability to share recorded data or data storage space supplied by one or several storage unit(s).

2. Requirements

2.1. Functional requirements for ETSO-C153a CLASS DS

DS.a) The IMA module shall provide to hosted applications, modules and/or components, a Data Storage Resource which has the capacity to record or to retrieve a set of data on/from a storage unit by performing data-retaining operations.

DS.b) The IMA module shall provide to hosted applications, modules and/or components, the capacity to use shared recorded data resources thanks to data storage elements accessible through (a) logical and/or physical interface(s).

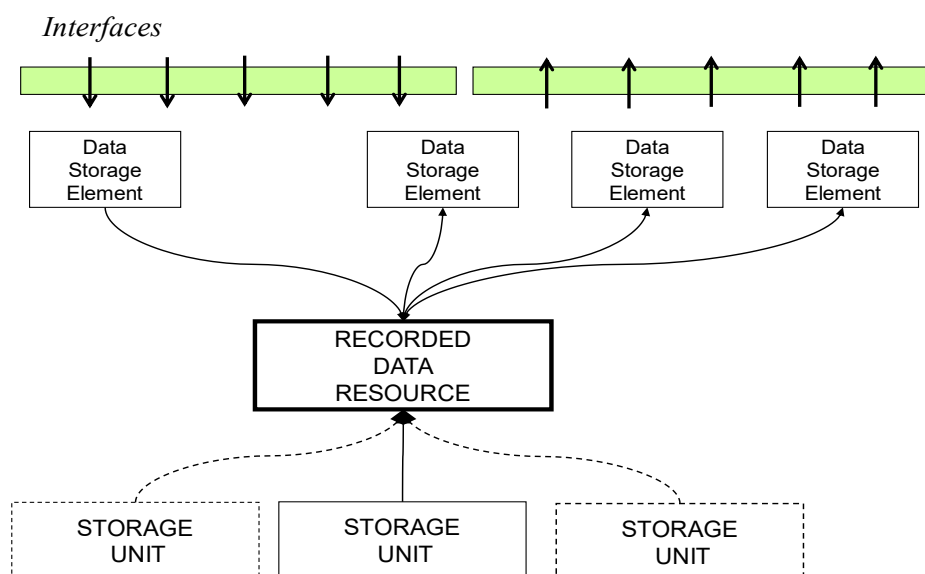


Figure 19: CLASS DS — the relationship between the data storage elements

2.2. Characterisation requirements

DS.c) All aspects of the Data Storage performance of the shared Storage Unit of the IMA module shall be characterised, including but not limited to the following:

1. performances of Memory Management functionality, including the cache and Memory Management Unit (e.g. storage capacity, cache performance, etc.);
2. performance of (a) User Interface Mechanism(s), Protocol(s) and Service(s) (e.g. access timings and throughputs, etc.); and
3. performance of a supported Data Storage Element Type (e.g. namespace, address scheme, arbitrary principles for multiple access, throughputs, timings, data space, etc.).

Note: These performance requirements are additional to those applicable in Appendix 2.1 — COMMON.

3. Verification procedures

The following table gives the verification method for each MPS; nevertheless, an alternative method may be proposed to the certification authority:

Requirement identifier	Verification method	Test under normal conditions	Test under environmental conditions	Comment
DS.a)	T	Y	Y	
DS.b)	T	Y	Y	
DS.c)	T(A*)	Y	Y ⁽¹⁾	

Table 5: Verification Acceptance Criteria

(A*) means that verification by the Analysis method is possible for the item that cannot be tested.

Note (1): applicable for a functional subset → cf. CO.gg).

[Amdt ETSO/10]

[Amdt ETSO/16]

APPENDIX 2.6 TO ETSO-C153A – INTEGRATED MODULAR AVIONICS (IMA) MODULE MINIMUM PERFORMANCE STANDARD (MPS)

ED Decision 2020/011/R

CLASS IF: Interface

1. Purpose and scope

1.1. Introduction

This Appendix contains the Minimum Performance Standards (MPS) for the CLASS IF Intended Function: Interface.

These standards specify characteristics that should be useful to designers, manufacturers, installers and users of the IMA module.

1.2. Definitions

For ETSO-C153a CLASS IF, the IMA module provides shared resources in terms of interfaces between hosted applications, modules and/or components.

The following definitions are used:

- Interface Unit: a set of hardware and/or software components in charge of supplying and managing a shared information resource.
- Data Thread: a well-defined set of data which is a primary form of information and for which a level of isolation would be guaranteed by the IMA module.

Each data thread handled by the Interface, if so wished by the applicant, may be bidirectional or symmetrical between interconnected components, modules, or hosted applications.

In the context of IF class, the ‘concurrent item’ defined in Appendix 2.1, paragraph 1 means ‘Data Thread’.

1.3. Intended Function

For ETSO-C153a CLASS IF, the intended function is to provide the capability to share information supplied by one or several interfaces units.

This intended function is Information Sharing composed of:

- information acquisition and control;
- information conversion and; and
- information forwarding and control.

The information-forwarding and control function is the means that allows sharing information between components, modules and/or hosted applications.

The following figure provides an overview of the above-mentioned intended function and the associated definitions:

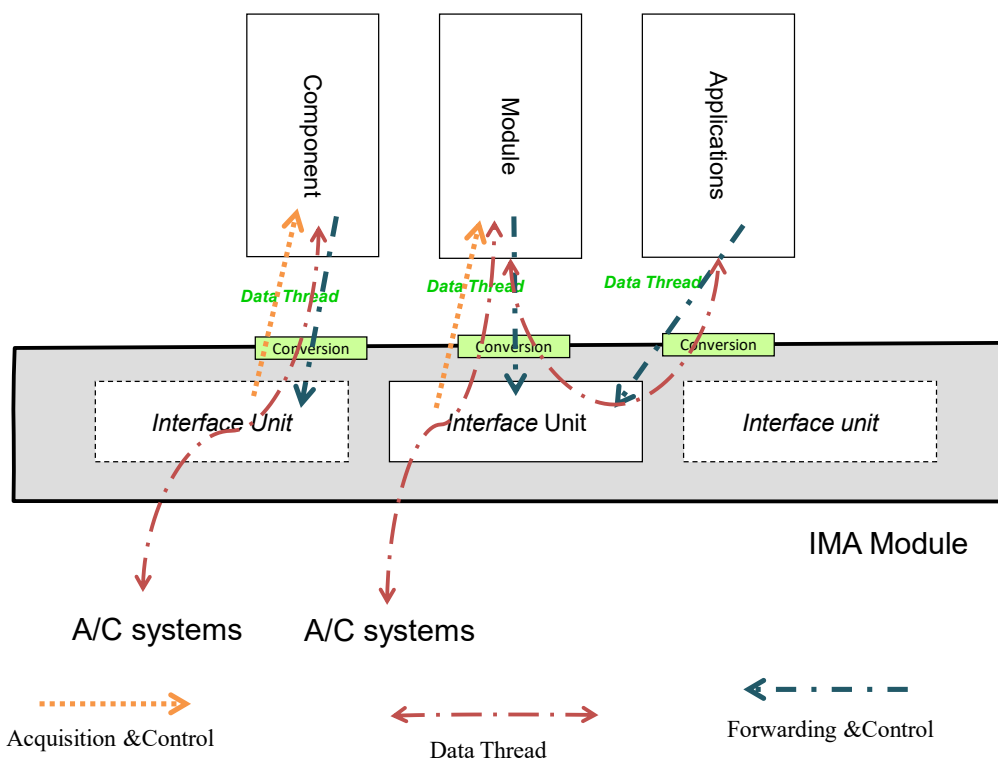


Figure 20: IMA module overview for ETSO-C153a CLASS IF

2. Requirements

For ETSO-C153a CLASS IF, the IMA module provides shared resources for the communication needs of hosted applications, modules and/or components.

2.1. Functional requirements for ETSO-C153a CLASS IF:

- IF.a) The IMA module shall provide to hosted applications, modules and/or components, an Information Resource which has the capacity to acquire from or to forward to an interface unit a set of data by performing information coding and decoding operations.
- IF.b) The IMA module shall provide to hosted applications, modules and/or components, the capacity to use shared Information Resource thanks to Data Threads handled through logical and/or physical interface(s).

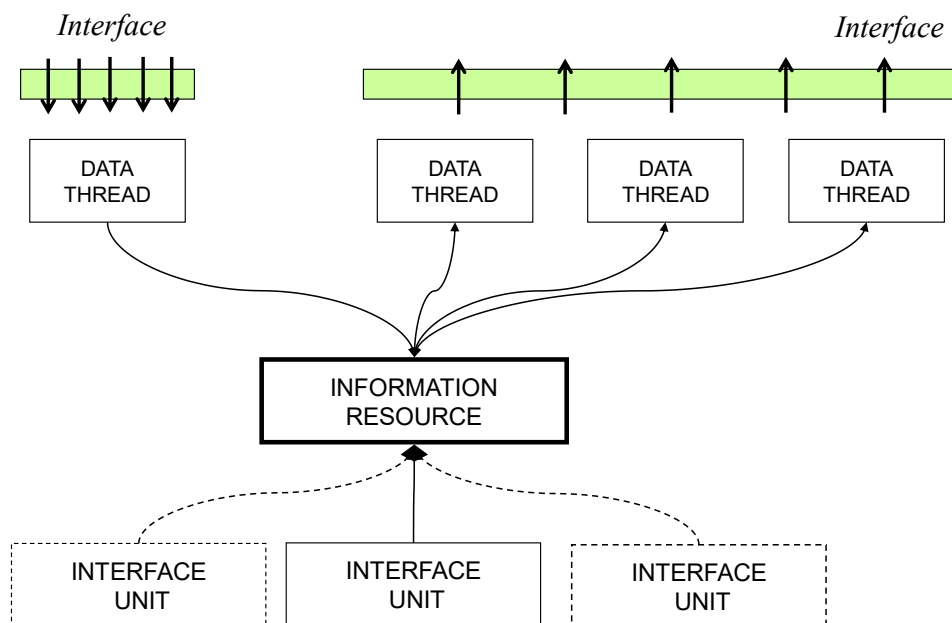


Figure 21: The relationship between CLASS IF interface (IF) elements

1.1. Characterisation requirements for ETSO-C153a CLASS IF:

IF.c) All performances of the shared Interface Unit of the IMA module shall be characterised, including but not limited to the following:

1. performance of each Interface, including its throughput, acquisition speed, forwarding speed, latency, jitter, coding rate and decoding rate;
2. performance of (a) User Interface Mechanism(s), Protocol(s) and Service(s) (e.g. socket timing, communication port timing, technological time delay, etc.); and
3. performance of supported Data Thread Type (e.g. virtual link, channel, pipe-and-filter, physical connection pin, etc.).

Note: These performance requirements are additional to those applicable in Appendix 2.1 — COMMON.

IF.d) In addition to the Common Requirement 0, the characterisation shall address the safety aspects of frozen data.

2. Verification procedures

The following table gives the verification method for each MPS; nevertheless, an alternative method may be proposed to the certification authority:

Requirement identifier	Verification method	Test under normal conditions	Test under environmental conditions	Comment
IF.a)	T	Y	Y	
IF.b)	T	Y	Y	
IF.c)	T(A*)	Y	Y ⁽¹⁾	
IF.d)	T or A*			

Table 6: Verification Acceptance Criteria

(A*) means that verification by the Analysis method is possible for the item that cannot be tested.

Note (1): applicable for a functional subset → cf. CO.gg).

[Amdt ETSO/10]

[Amdt ETSO/16]

APPENDIX 2.7 TO ETSO-C153A – INTEGRATED MODULAR AVIONICS (IMA) PLATFORM AND MODULE MINIMUM PERFORMANCE STANDARD (MPS)

ED Decision 2020/011/R

CLASS PS: Power Supply (PS)

1. Purpose and scope

1.1. Introduction

This Appendix contains the Minimum Performance Standard (MPS) for the CLASS PS Intended Function: Power Supply (PS).

These standards specify module characteristics that should be useful to designers, manufacturers, installers and users of the module.

1.2. Definitions

For ETSO-C153a CLASS PS, the IMA module is a module, mounted into a rack or the rack itself, able to supply power received from the aircraft electrical network to one or more hardware modules mounted in the same rack.

The following definitions are used:

- Power supply unit: a set of physical components (hardware and or software) in charge of managing a power supply (or a part of the power supply) resource.
- Power supply resource: obtained electrical energy from the aircraft electrical network to be distributed to electrical loads which are modules mounted into the rack.
- Power rail: a part of supplied electrical energy for which a level of isolation is guaranteed by the IMA module.
- Mounted: it refers to another hardware module installed and fixed inside the IMA Rack Module after a manual operation.
- Slot: a physical space inside the Rack Module allocated to one hardware module.
- Hold-up Capacity: The capacity of the power supply to continue supplying output current after the input voltage drops below the minimum level. This is usually expressed as the time from the input voltage drop to the reset generated by the power supply to the processor.
- Output Current Capacity: the continuously operating maximum current supplied for each output voltage.
- Power Monitors & Status Outputs: a separate circuitry which checks the output voltage levels and current loading of the power supply. This circuitry will generate one or more binary signals that may be connected to the processor to alert it to the 'out of spec' condition. These binary signals may also force the power supply to shutdown to prevent damage to power supply components.
- Power Resets: a binary signal output from the power supply that is asserted when the output voltages are outside acceptable tolerances.
- Regulation: the percentage of variation of the output voltages when subjected to changes in load, changes in temperature, and changes in all input voltage transients and deviations.

- Transient Immunity: the ability of the power supply to continue operating normally during variations in the input voltage. This is usually expressed as the time duration and the voltage level of the transient.
- Voltage Outputs and Tolerances: the voltage levels and tolerances of the outputs produced by the power supply.

In the context of PS class, the ‘concurrent item’ defined in Appendix 2.1, paragraph 1 means ‘Power Rail’.

1.3. Intended Function

For ETSO-C153a CLASS PS, the intended function is to provide the capability to share the Power Supply resource supplied by one or more Power Supply unit(s).

The following figure provides an overview of the above-mentioned intended function and definitions:

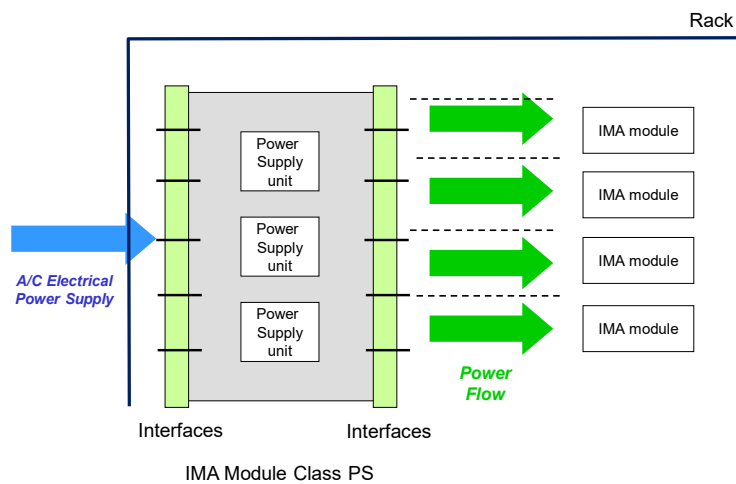


Figure 22: IMA module overview of ETSO-C153a CLASS PS

2. Requirements

2.1. Functional requirements for ETSO-C153a CLASS PS

- PS.a) The IMA module shall provide to hardware modules mounted in the same rack Power Supply Resource which has the capacity to deliver a quantity of electrical energy from power supply unit(s) to the hardware modules while performing the regulation operations.
- PS.b) The IMA module shall provide to hardware modules mounted into the same rack the capacity to share the power supply resource thanks to power rails accessible through physical interface(s).

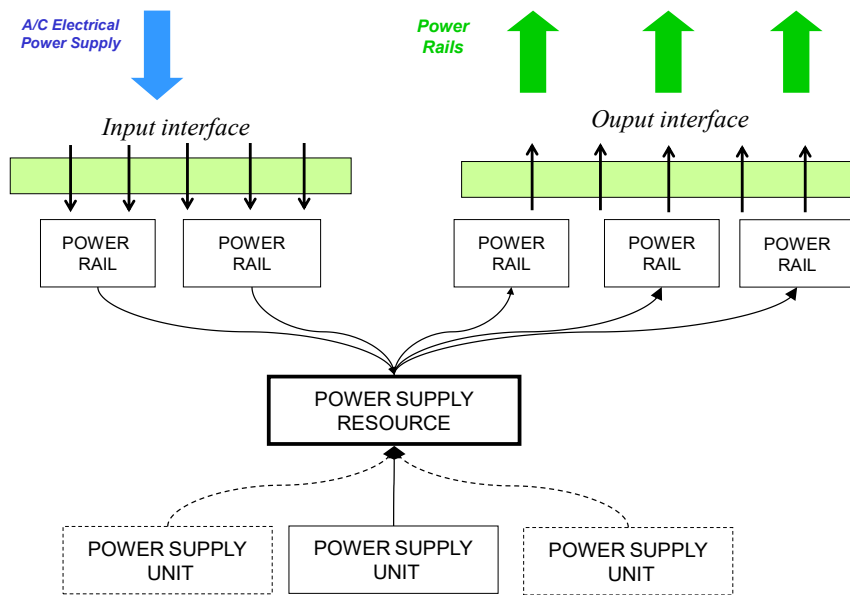


Figure 23: CLASS PS (PS) — the relationship between the elements

2.2. Characterisation requirements

PS.c) All aspects of the performance of the Power Supply of the shared Power Supply Unit of the IMA module shall be characterised, including but not limited to the following:

1. The needed input power budget characteristics (e.g. as a function of temperature and load)
2. The performance of Output Currents and Tolerances;
3. The performance of Hold-up Capacity;
4. The performance of Power Monitors and Status Outputs;
5. The performance of Power Resets;
6. The performance of Power Regulation;
7. The performance of Transient Immunity;
8. The performance of Voltage Outputs and Tolerances;
9. The performance of User Interface Mechanism(s), Protocol(s) and Service(s);
10. The performance of a supported Power Rail Type;
11. The Input and Output impedance; and
12. The capacitive load.

Note: These performance requirements are additional to those applicable to and dictated by the design of the IMA module itself (according to the 'COMMON' requirement of Appendix 2.1).

PS.d) In addition to the Common Requirement 0, the characterisation shall address the safety aspects of events such as a too low voltage or current, and a too high voltage or current. The transient, as well as permanent effects, shall also be characterised, if relevant.

PS.e) The characterisation shall provide any data needed to evaluate the power profile characteristics (e.g. Maximum Value, InRush Current) of managed power rails, and the IMA module power on/power off behaviour characteristics.

3. Verification procedures

The following table gives the verification method for each MPS; nevertheless, an alternative method may be proposed to the certification authority:

Requirement identifier	Verification method	Test under normal conditions	Test under environmental conditions	Comment
PS.a)	T	Y	Y	
PS.b)	T	Y	Y	
PS.c)	T(A*)	Y	Y ⁽¹⁾	
PS.d)	T(A*)	Y		
PS.e)	A			

Table 7: Verification Acceptance Criteria

(A*) means that verification by the Analysis method is possible for the item that cannot be tested.

Note (1): applicable for a functional subset → cf. CO.gg).

[Amdt ETSO/10]

[Amdt ETSO/16]

APPENDIX 2.8 TO ETSO-C153A – INTEGRATED MODULAR AVIONICS (IMA) PLATFORM AND MODULE MINIMUM PERFORMANCE STANDARD (MPS)

ED Decision 2020/011/R

CLASS DH: Display Head

1. Purpose and scope

1.1. Introduction

This Appendix contains the Minimum Performance Standards (MPS) for the CLASS DH Intended Function: Display Head.

These standards specify characteristics that should be useful to designers, manufacturers, installers and users of the module.

1.2. Definitions

For ETSO-C153a CLASS DH, the IMA module provides shared resources in terms of a display area between hosted applications, components and/or modules.

The following definitions are used:

- Display Unit: a set of physical components (hardware and/or software) in charge of managing a display area (or a part thereof).
- Display Area: a surface where some visual information can be depicted by one or several Display Unit(s) based on received Graphical Threads.
- Graphical Thread: a set of graphical information received as input by the Display Head from one or more IMA application(s), component(s) and/or module(s).
- Display Thread: a set of depiction information for which a level of isolation on the Display Area is guaranteed by the Display Head.

In the context of DH class, the 'concurrent item' defined in Appendix 2.1, paragraph 1 means 'Display Thread'.

1.3. Intended Function

For ETSO-C153a CLASS DH, the intended function is to provide the capability to share one display area supplied by one or several display unit(s).

The intended function of such an IMA module is to offer the capability to depict graphical information received from (an) IMA application(s), component(s) and/or module(s) on one Display Area.

The following figure provides an overview of the above-mentioned intended function and the associated interfaces:

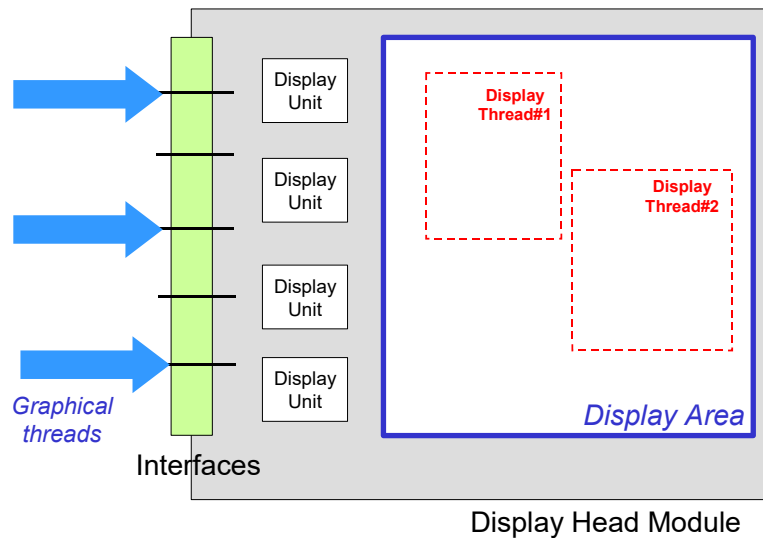


Figure 24: IMA module overview of ETSO-C153a CLASS DH

2. Requirements

2.1. Functional requirements for ETSO-C153a CLASS DH

DH.a) The IMA module shall provide to hosted applications, modules and/or components, a Display Area Resource which has the capability to render visual graphical information.

DH.b) The IMA module shall be fully or partially compliant with the MPS as from the applicable release of ETSO-C113.

Note 1: these performance requirements are additional to those applicable in Appendix 2.1 — COMMON.

Note 2: for Display Head modules without a Graphics generation function, compliance demonstration to some ETSO-C113 requirements might not be possible. In such cases, the applicant shall submit in the compliance data package the list of requirements that need further demonstration with regard to the C113 requirements providing a relevant justification.

DH.c) The IMA module shall provide to hosted applications, modules and/or components the capability to share a Display Area resource managed through a logical or physical interface.

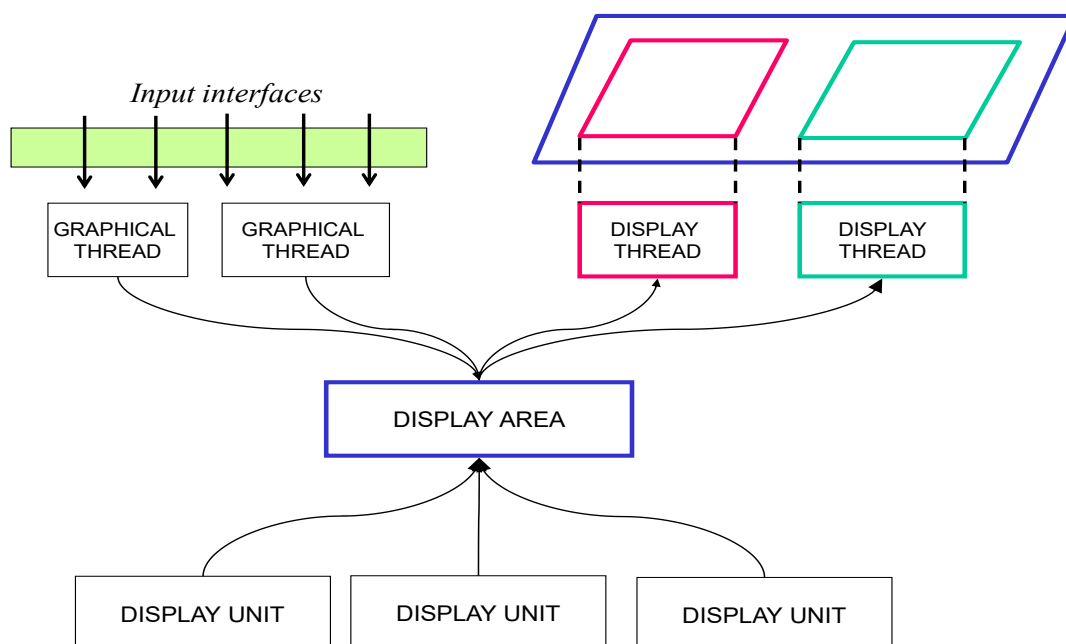


Figure 25: The relationship between CLASS DH Display Head elements

2.2. Characterisation requirements for ETSO-C153a CLASS DH

DH.d) In addition to the Common Requirement 0, the characterisation shall address the safety aspects of delay and/or frozen information.

DH.e) In addition to Common Requirement 0, the characterisation shall include any data needed to evaluate the Worst-Case Display Elaboration Time of managed threads, and the characteristics required by the applicable release of SAE AS8034 (as per the applicable revision of ETSO-C113).

DH.f) The additional activities to be performed by the user related to the applicable release of ETSO-C113 for complete compliance demonstration shall be included in the characterisation for gap identification.

3. Verification procedures

The following table gives a verification method for each MPS; nevertheless, an alternative method may be proposed to the certification authority:

Requirement identifier	Verification method	Test under normal conditions	Test under environmental conditions	Comment
DH.a)	T	Y	Y	
DH.b)	(2)	(2)	(2)	
DH.c)	T	Y	Y	
DH.d)	T/A*	Y		
DH.e)	A			
DH.f)	A			

Table 8: Verification Acceptance Criteria

(A*) means that verification by the Analysis method is possible for the item that cannot be tested.

Note (1): for the functional subset, see CO.gg).

Note (2): an applicable revision of ETSO-C113 defining the verification requirements of a display function.

[Amdt ETSO/10]

[Amdt ETSO/16]

APPENDIX 3 TO ETSO-C153A – INTEGRATED MODULAR AVIONICS (IMA) MODULE DATA REQUIREMENTS

ED Decision 2020/011/R

For an IMA module authorisation, as mentioned in paragraph 2.2 of the ETSO-C153a main body document, additional technical data shall be available or submitted. This data will be documented into a set of documents for the ETSO authorisation (qualification plans, compliance evidences, etc.) and for the IMA module users such as Application developers, Integrators or type certificate applicants (User Guide, Usage domain, etc.):

- Chapter 1 — IMA module ED-124 documentation;
- Chapter 2 — Specific User Guide and Installation Manual contents;
- Chapter 3 — Core software;
- Chapter 4 — Health management and reporting;
- Chapter 5 — Usage domain;
- Chapter 6 — Configuration;
- Chapter 7 — Tools; and
- Chapter 8 — Compatibility & mixability information.

Chapter 1 — IMA module ED-124 documentation

The IMA system approval can be made incremental by introducing some intermediate acceptance steps. An ETSO-C153a authorisation is the first intermediate step dedicated to authorising IMA platforms and/or IMA modules (independently of any specific aircraft installation).

EUROCAE ED-124/RTCA DO-297 contains guidance for Integrated Modular Avionics (IMA) developers, application developers, integrators, certification applicants, and those involved in the approval and continued airworthiness of IMA systems in civil certification projects.

As mentioned in paragraph 3.2.2.1 of the ETSO-C153a main body document, to prepare the integration of the ETSO-C153a IMA module, the development objectives are defined in the EUROCAE ED-124 guidance related to Task 1 (Table A-1 objectives).

For an ETSO-C153a approval, the following data are available (A) or submitted (S) to the competent authority:

EUROCAE ED-124 Life Cycle Data	EUROCAE ED-124 Life Cycle Section	Available (A)/Submitted (S)
Module Acceptance Plan	4.2.3	S
Module Requirements Specifications	4.2.4	A
Traceability Data	4.2.5	A
Module Design Data	4.2.4	A
Module Failure Analyses and Safety Analyses	4.2.12b	S
Module Tool Qualification Data	4.2.12c	S
Partitioning Analysis Data(1)	4.2.4i	S
V&V data (Validation and verification)	4.2.5	A
Module Acceptance Data Sheet	4.2.10	S
Interface Specifications	4.2.4f	A
Module User Guide	4.2.12e	S(2)
Module Quality Assurance (QA) Records	4.2.6	A
Module Configuration Management (CM) Records	4.2.8	A
Module Acceptance Accomplishment Summary	4.2.9	S
Module Acceptance Configuration Index	4.2.7	S
Module Open Problem Reports	4.2.11	S

Note (1): this Partitioning Analysis shall include the verification results obtained for demonstration of compliance of 0, 0, 0, and 0.

Note (2): only for User Guide content used for ETSO compliance demonstration.

Chapter 2 — Specific User Guide and Installation Manual contents

As per ED-124, the IMA module User guide shall be provided by the IMA module manufacturer to both the module users and the Airworthiness Authority.

This User Guide includes all the information for users, integrators, and certification applicants to successfully interface with or integrate the module, such as:

- guaranteed behaviour and characteristics as per CO.k);
- interfaces (incl. physical mapping of interfaces);
- limitations and Open Problem Reports (OPRs)(1) (including tools);
- the Worst-Case Execution Time (WCET) analysis elements;
- the applicable Failure Mode Effect Analysis/Failure Mode Effect Summary (extracts) necessary for higher level safety analysis;
- the Core Software (see Appendix 3, Chapter 3);
- Fault Management and Health Monitoring (see Appendix 3, Chapter 4);

- the Usage Domain (see Appendix 3, Chapter 5) ;
 - configuration aspects (see Appendix 3, Chapter 6);
 - tools aspects (see Appendix 3, Chapter 7);
 - compatibility and mixability information (see Appendix 3, Chapter 8);
 - remaining activities to be conducted by the module user to complete the IMA module qualification (environment);
 - requirements recommendations for applications (e.g. data for the qualification of the application, service available for applications, etc.); and
 - requirements recommendations for System Integration.
- (1) An explicit description of the root cause and effects of an IMA module OPR is necessary to support the IMA module user and aircraft manufacturer in their assessment of the effects of the OPR on the aircraft function.

The Installation Manual includes all the data necessary for the proper installation and use of the IMA module (including marking aspects).

Each item of the characterisation and functional requirements is addressed in the User Guide (or possibly in the Installation Manual, if appropriate).

The User Guide defines the Usage Domain for which the module acceptance data is valid.

The information includes recommendations and may also include examples of the correct use of the module. In addition, the guide highlights any warnings or limitations to integrate or to interface with the module to prevent potential incorrect or unintended use.

The User Guide may be completed by the IMA module manufacturer with:

- information on Single Event Upset (SEU) effects;
- a Validation and Integration Kit for application developers and system integrators;
- Development and In-Service support; and
- some training.

The Installation Manual includes information as required in the MPS Appendix or referenced subsequent applicable chapter of the User Guide. In this case, the User Guide chapter will be submitted to the Airworthiness Authority (see Note (*) above).

The User Guide may be included in the Installation Manual of the IMA module (e.g. Annexes) or a separated document referenced by the Installation Manual.

Chapter 3 — Core Software

As defined in Appendix 1 above, the IMA module may be an association of Hardware and Core Software.

Core Software consists of the operating system and the support software that manage resources to provide an environment in which the intended function is performed. Core software is typically comprised of one or more component(s). Core Software may be resident or a Field-Loadable Software part.

If the IMA module contains Core Software, the Core Software characteristics required by 0 of Appendix 2 are documented in the IMA module User Guide.

Chapter 4 — Health management and reporting

The data requirements related to health management and reporting are listed in 0.

Chapter 5 — IMA module usage domain

An ETSO-C153a authorisation relies on the concept of a Usage Domain (as per Chapter 2 — Definitions of Appendix 1).

The usage domain is defined at the IMA module level and used at the Application level and the IMA system level.

The definition of the usage domain includes consideration of the module functionality, performance and safety requirements, as well as of the required environmental performance of the module.

The IMA module manufactured to comply with this ETSO may be used to support other ETSOs or systems approved under CS-23, CS-25, CS-27, CS-29, CS-E or CS-P. These ETSO authorisations, IMA system approvals and aircraft level approvals, are not covered by this ETSO but will rely on the fact that compliance with the Usage Domain as documented in the User Guide, is correctly implemented.

Chapter 6 — Configuration

The IMA module may need to be configured before installation in the IMA system (EUROCAEED-124, Tasks 2, 3 and 4).

The data requirements related to configurability are listed in 0 of Appendix 2.

Chapter 7 — Tools

Some tools may need to be used during the installation of the IMA module in the IMA system (EUROCAE ED-124 Tasks 2, 3 and 4). These tools may be used by:

- application developers;
- (an) integrator(s); and
- type certificate (TC) or supplemental type certificate (STC) applicants.

These tools may address:

- software development (hosted applications);
- configuration development;
- network architecture and configuration;
- debug, data loading; and
- WCET analysis and measures.

In that case, the User Guide references each tool in the data listed in Appendix 2 0.

If qualification credit is expected from these tools (such as configuration tools), the qualification process and data requirements are defined in paragraph 2.2 of CS-ETSO Subpart A. Software standards as well as the Airborne Electronic Hardware Qualification data of paragraph 2.3 are considered to be data to be submitted to EASA in the frame of an ETSO-C153a authorisation.

Chapter 8 — Compatibility and mixability information

The IMA module manufacturer provides compatibility and mixability information between hardware, software, tools and the usage domain in the User Guide, as required per 0 of Appendix 2.

[Amdt ETSO/10]

[Amdt ETSO/16]

APPENDIX 4 TO ETSO-C153A – INTEGRATED MODULAR AVIONICS (IMA)

MODULE ENVIRONMENTAL QUALIFICATION REQUIREMENTS

ED Decision 2020/011/R

Section 2.3 of CS-ETSO Subpart A requires environmental testing to be performed according to the appropriate release of EUROCAE ED-14/RTCA DO-160.

For ETSO-C153a, some particularities have to be addressed:

- the representativeness of the Test Software;
- the Applicable Test Procedures; and
- the parameters to be monitored during the Environmental Qualification Test.

Chapter 1 — The representativeness of the Test Software

If the IMA module is qualified without the functional software installed and operating, engineering analysis from the manufacturer must determine that the Test Software (not the target functional software) is representative of the usage domain stress envelope for the environmental tests (i.e. dissipated temperature, power consumption, field radiation, etc.).

Test Software shall be developed to exercise the hardware in performing the environmental tests in the worst-case conditions and/or most sensitive configurations in order to evaluate the robustness of the IMA module over the full Usage Domain. For example, the Test Software should exercise all the physical interfaces with a maximum number of applications or inputs, and with filter values set to the domain boundary which would be the most transparent to any input electrical interference.

Chapter 2 — Applicable Test Procedures

For an ETSO-C153a authorisation, the IMA module may be a single Line Replaceable Unit (LRU) platform or may be a Line Replaceable Module (LRM) located in a Rack.

Depending on the characteristics of the IMA module, the applicant should consider one of the two following cases as appropriate:

- Case 1: the IMA module is a single LRU platform; and
- Case 2: the IMA module is a module designed to be located in a Rack at installation.

Note: The Rack Housing module is not addressed in this generic Appendix but in the relevant Appendix 2.2 — Class RH: Rack Housing.

Chapter 2.1 — The IMA module is a single LRU platform

In this case, the environmental sections defined in the Table below (Figure) are applicable to the IMA module.

The usage domain of the IMA module must be defined and maintained so that all the environmental qualification tests listed below produce a complete credit for all other functional ETSOs authorisations, or for the TC level.

Environmental Test	ED-14/DO-160 Section	Requirement for ETSO-C153a
Temperature	4.5	Mandatory
Altitude	4.6	Mandatory
Temperature Variation	5.0	Mandatory
Humidity	6.0	Mandatory
Shock (operational)	7.2	Mandatory
Shock (Crash Safety)	7.3	Optional

Environmental Test	ED-14/DO-160 Section	Requirement for ETSO-C153a
Vibration	8.0	Mandatory
Explosion Atmosphere	9.0	Optional
Waterproof	10.0	Optional
Fluids Susceptibility	11.0	Optional
Sand and Dust	12.0	Optional
Fungus Resistance	13.0	Optional
Salt Fog	14.0	Optional
Magnetic Effect	15.0	Mandatory
Power Input	16.0	Mandatory
Voltage Spike	17.0	Mandatory
Audio Frequency Conducted Susceptibility — Power Input	18.0	Mandatory
Induced-Signal Susceptibility	19.0	Mandatory
Radio Frequency Susceptibility (radiated and conducted)	20.0	Mandatory
Emission of Radio Frequency Energy	21.0	Mandatory
Lightning-Induced Transient Susceptibility	22.0	Mandatory
Lightning Direct Effects	23.0	Optional
Icing	24.0	Optional
Electrostatic Discharge (ESD)	25.0	Mandatory
Fire, Flammability	26.0	Mandatory

Figure 26 — Environmental Qualification for ETSO-C153a in the case of a single LRU platform

Chapter 2.2 — The IMA module is a module designed to be located in a Rack at installation or the rack itself.

In this type of envisioned installation, only a minimal subset of environmental conditions is applicable to the IMA module. This minimal subset is defined as mandatory in the table below (Figure 27).

Test sections identified as optional are not required for an ETSO-C153a application. Nevertheless, the IMA module can be subjected to these test conditions on a voluntary basis. When optional sections are not tested, they shall be marked with 'X'.

The Environmental Qualification Testing (EQT) will be completed after cabinet integration in the frame of some other functional ETSOs authorisation, or of a TC level.

The usage domain of the IMA module must be defined and maintained so that at least this subset of qualification tests produces some credit for other ETSOs authorisations and for the TC level.

Note: It is acceptable to perform the environmental qualification on the intended rack installation equipped with (a) mounted IMA module(s). The ETSO-C153a IMA module should be set in worst-case configurations. By doing so, the set of Qualification documents (Qualification Test Plans, Procedures and Reports) may be common to both the rack and the module ETSO-C153a authorisations. These documents should demonstrate that the considered configurations (which may differ depending on the different sections of EUROCAE ED-14/RTCA DO-160) are the worst-cases for the set of authorised modules configurations within the rack. Whatever the qualification method used, the authorised configuration should be specified in the installation manual(s).

Such documented authorised configurations include any installation limitations that are taken as hypotheses for the EQT (rack part number(s), slot number(s), blade neighbourhood(s), and temperature to be guaranteed), and need to be specified in the Installation Manual and respected by the integrator so that he/she can take credit for the EQT performed at module level.

Environmental Test	ED-14/O-160 Section	Requirement for ETSO-C153a
Temperature	4.5	Mandatory When the module performance under environmental conditions is dependent on the host rack, it is the responsibility of the applicant to adapt the ED-14/DO-160 high and low temperature values and temperature variations cycles to the intended IMA module installation context. For example, in the case of temperature testing (Section 4.0 of EUROCAE ED-14/RTCA DO-160), the temperature environment of the module (inside a rack) may be much higher or lower than the equipment level condition expressed in the aforementioned Section 4.0. Therefore, the applicant may qualify their IMA module based on a chosen intended environment, and, finally, indicate in the installation manual the temperature range for which the correct operation of the IMA module is guaranteed.
Altitude	4.6	Mandatory
Temperature Variation	5.0	Mandatory As for Section 4.5, when module performance under environmental conditions is dependent on the host rack, it is the responsibility of the applicant to adapt the ED-14/DO-160 high and low temperature values and temperature variations cycles to the intended IMA module installation context. As for Section 4.5, for example, in the case of temperature testing (Section 4.0 of EUROCAE ED-14/RTCA DO-160), where the temperature environment of the module (inside a rack) may be much higher or lower than the equipment-level condition as expressed in Section 4.0 of EUROCAE ED-14/RTCA DO-160, the applicant can qualify their IMA module based on a chosen intended environment, and, finally, indicate in the installation manual the temperature range for which the correct operation of the IMA module is guaranteed.
Humidity	6.0	Mandatory
Shock (operational)	7.2	Optional
Shock (Crash Safety)	7.3	Optional
Vibration	8.0	Optional Note: The IMA module technology should be assessed for further vibration qualification (ED-14/DO-160). This preliminary assessment could consider the IMA technology diversity of the module components, as well as the integration density and number of layers of the circuit boards within the IMA module. The assessment could be confirmed by testing on a module representative of the IMA module technology used in the product under certification. This preliminary assessment of the IMA module technology under vibration conditions does not constitute a credit for the qualification testing of the module integrated into the rack.
Explosion Atmosphere	9.0	Optional
Waterproof	10.0	Optional
Fluids Susceptibility	11.0	Optional
Sand and Dust	12.0	Optional

Environmental Test	ED-14/O-160 Section	Requirement for ETSO-C153a
Fungus Resistance	13.0	Optional
Salt Fog	14.0	Optional
Magnetic Effect	15.0	Optional
Power Input	16.0	Mandatory for IMA module interfaces directly connected to the aircraft power distribution. Note: IMA module interfaces not directly connected to the aircraft power distribution will be tested after the cabinet integration phase as part of another ETSO application or as part of a Type Certification programme.
Voltage Spike	17.0	Mandatory for IMA module interfaces directly connected to the aircraft power distribution. Note: IMA module interfaces not directly connected to the aircraft power distribution will be tested after the cabinet integration phase as part of another ETSO application or as part of a Type Certification programme.
Audio Frequency Conducted Susceptibility — Power Input	18.0	Mandatory for IMA module interfaces directly connected to the aircraft power distribution. Note: IMA module interfaces not directly connected to the aircraft power distribution will be tested after the cabinet integration phase as part of another ETSO application or as part of a Type Certification programme.
Induced-Signal Susceptibility	19.0	Mandatory for IMA module interfaces directly connected to the aircraft wiring. Note: IMA module interfaces not directly connected to the aircraft wiring will be tested after the cabinet integration phase as part of another ETSO application or as part of a Type Certification programme.
Radio Frequency Susceptibility (radiated and conducted)	20.0	Mandatory for the conducted susceptibility of IMA module interfaces directly connected to the aircraft wiring. Note: IMA module interfaces not directly connected to the aircraft wiring will be tested after the cabinet integration phase as part of another ETSO application or as part of a Type Certification programme.
Emission of Radio Frequency Energy	21.0	Mandatory for the conducted emission of IMA module interfaces directly connected to the aircraft wiring. Note: IMA module interfaces not directly connected to the aircraft wiring will be tested after the cabinet integration phase as part of another ETSO application or as part of a Type Certification programme.
Lightning-Induced Transient Susceptibility	22.0	Mandatory for IMA module interfaces directly connected to the aircraft wiring. Note: IMA module interfaces not directly connected to the aircraft wiring will be tested after the cabinet integration phase as part of another ETSO application or as part of a Type Certification programme.
Lightning Direct Effects	23.0	Optional
Icing	24.0	Optional
Electrostatic Discharge (ESD)	25.0	Mandatory for all areas subject to human contact during IMA module operation.
Fire, Flammability	26.0	Mandatory

Figure 27: Environmental Qualification Testing minimum subset for ETSO-C153a in for cabinet architectures

Chapter 3 — MPS compliance during EQT

When required by the test conditions and procedure (by the ‘DETERMINE COMPLIANCE WITH EQUIPEMENT PERFORMANCE STANDARDS’ statement), the IMA module manufacturer must determine compliance with the MPS as defined under the column ‘Test under environmental conditions’ of each individual class in Appendix 2:

MPS CLASS	MPS paragraph under Environmental Qualification Testing
All Classes (Common)	Appendix 2.1, paragraph 5
RH (Rack)	Appendix 4 is not applicable to this class. See Appendix 2.2, paragraph 3 under columns ‘Test under environmental conditions’ and ‘Applicable ED-14/DO-160 sections’.
PR (Processing)	Appendix 2.3, paragraph 3
GP (Graphical Processing)	Appendix 2.4, paragraph 3
DS (Data Storage)	Appendix 2.5, paragraph 3
IF (Interface)	Appendix 2.6, paragraph 3
PS (Power Supply)	Appendix 2.7, paragraph 3
DH (Display Head)	Appendix 2.8, paragraph 3

Figure 28 — MPS verification under environmental conditions

[Amdt ETSO/10]

[Amdt ETSO/16]

ETSO-C154c

ED Decision 2012/009/R

UNIVERSAL ACCESS TRANSCEIVER (UAT) AUTOMATIC DEPENDENT SURVEILLANCE - BROADCAST (ADS-B) EQUIPMENT OPERATING ON THE FREQUENCY OF 978 MHz

1 Applicability

This ETSO gives the requirements which Universal Access Transceiver (UAT) Automatic Dependent Surveillance - Broadcast (ADS-B) Equipment Operating on the Frequency of 978 MHz 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 Radio Technical Commission for Aeronautics (RTCA) Document DO-282B, Minimum Operational Performance Standards for Universal Access Transceiver (UAT) Automatic Dependent Surveillance Broadcast (ADS-B), dated 02/12/2009.

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.

3.1.4 Electronic Hardware Qualification

See CS-ETSO [Subpart A](#) paragraph 2.3.

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO [Subpart A](#) paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a major failure condition.

4 Marking

4.1 General

Marking as detailed in CS-ETSO [Subpart A](#) paragraph 1.2.

4.2 Specific

Transmitting and receiving components must be permanently and legibly marked. The following table explains how to mark components. Find the equipment class in RTCA/DO-282B, Section 2.1.11.

If component can:	Mark it with:	Sample marking pattern:
Transmit and receive	Equipment class it supports	Class A1H or Class A3
Transmit, but not receive	Equipment class it supports	Class B1 or Class A3 - Transmit Only
Receive, but not transmit	Equipment class it supports	Class A2 - Receive Only
Perform the optional frequency diplexer function developed under this ETSO	The words "UAT Diplexer," Maximum amplitude attenuation between the antenna port (A) and UAT port (U) of the diplexer, and Maximum amplitude attenuation between the antenna port (A) and transponder port (T) of the diplexer	UAT Diplexer A/U -0.x dB A/T -0.x dB

5 Availability of Referenced Document

See CS-ETSO [Subpart A](#) paragraph 3.

[Amdt ETSO/7]

ETSO-C155b

ED Decision 2018/002/R

RECORDER INDEPENDENT POWER SUPPLY**1 Applicability**

This ETSO provides the requirements which recorder independent power supplies (RIPSs), that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

ETSOs that may be used in conjunction with this ETSO are those covering:

- rechargeable lithium cells and lithium batteries,
- digital flight data recorders,
- cockpit voice recorders,
- data link recorders,
- cockpit image recorders.

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 5-2, 5-3, 5-4 and 5-5 of EUROCAE ED-112A, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, with the following changes:

- in paragraph 5-2.1.1:
‘b. The intent of the RIPS is to allow for continued operation for 10 or more minutes applied in all cases when aircraft power to the recorder is removed.’
- in paragraph 5-2.2:
the following sentence ‘The RIPS shall detect and report any internal failures, if maintenance is required, and of any conditions affecting the ability of the RIPS to perform its intended function.’
shall be replaced by
‘The RIPS shall detect and report internal failures, whether maintenance is required, and any conditions affecting the ability of the RIPS to perform its intended function.’

- in paragraph 5-3.2.1:

‘The backup time shall be at least 9 minutes and not exceed 30 minutes’.

Other ED-112A requirements related to installation, flight testing, and aircraft maintenance are excluded from this ETSO.

3.1.2 Environmental standard

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 Airborne electronic hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 Specific

The applicant shall declare the rated performance of the equipment associated to the time of recording (Output power, rated capacity, as applicable ...).

If any battery is used in the RIPS, it must meet the requirements of the applicable ETSO related to the battery type or any other battery standards acceptable to EASA.

3.2.1 Failure condition classification

See CS-ETSO, Subpart A, paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 of this ETSO is a minor failure condition.

Loss of the function defined in paragraph 3.1.1 of this ETSO is a minor failure condition.

The applicant must develop the system to at least the development assurance level commensurate with these failure conditions.

Note: The failure classification is driven by the use of recorders in accident investigations.

4 Marking

4.1 General

Marking as 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.

[Amdt ETSO/6]

[Amdt ETSO/8]

[Amdt ETSO/13]

ETSO-C157b

ED Decision 2016/029/R

FLIGHT INFORMATION SERVICES-BROADCAST (FIS-B) EQUIPMENT

1 Applicability

This ETSO gives the requirements which Aircraft Flight Information Services-Broadcast (FIS-B) Data Link Systems and Equipment that are designed and 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

This standard apply to equipment intended to display weather and other non-air traffic control-related flight advisory information to pilots in a manner that will enhance their awareness of the flight conditions.

Standards set forth in the Radio Technical Commission for Aeronautics (RTCA), Inc Document DO-267A, Minimum Aviation System Performance Standards (MASPS) for Flight Information Services-Broadcast (FIS-B) Data Link, Rev. A dated 29 April 2004 or DO-358, inimum Operational Performance Standards (MOPS) for Flight Information Services-Broadcast (FIS-B) with Universal Access Transceiver (UAT), dated March 24, 2015 defined in the following table 1.

Demonstrate the required functional performance under the test conditions as specified in table 1.

Equipment Class	Equipment Name	Functionality	Test conditions
1	FIS-B Equipment using Universal Access Transceiver (UAT) and Interoperable with the Surveillance and Broadcast Services (SBS) Provider	RTCA/DO358 Sections 2.2.	RTCA/DO-358, Sections 2.3 and 2.4.
2	FIS-B Equipment not Interoperable with the SBS Provider	RTCA/DO-267A Section 2 (except 2.1.4; 2.2.12; and 2.2.13) and Section 3.8.	RTCA/DO-267A, Section 4.

Table 1. Equipment Classes for FIS-B

Note: This ETSO is intended for equipment used in the US National Airspace System. UAT is not intended to be operated in European Airspace.

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.

3.1.4 Electronic Hardware Qualification

See CS-ETSO Subpart A paragraph 2.3.

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO Subpart A paragraph 2.4.

Failure of the function defined in paragraph 3.11 resulting in misleading weather or flight information is a minor failure condition.

Loss of the function defined in paragraph 3.1.1 is a minor failure condition.

3.2.2 Manual

The applicant shall produce a manual including operating instructions and equipment limitations. This manual must state the following:

‘FIS-B information may be used for pilot planning decisions focused on updating the pilot’s awareness of the dynamic flight environment; including avoiding areas of inclement weather that are beyond visual range and pilot near-term decisions where poor visibility precludes visual acquisition of inclement weather. FIS-B weather and NAS status information may be used as follows:

- (a) To promote pilot awareness of ownship location with respect to reported weather, including hazardous meteorological conditions; NAS status indicators to enhance pilot planning decisions; and pilot near-term decision-making.*
- (b) To cue the pilot to communicate with Air Traffic Control, Flight Service Station specialist, operator dispatch, or airline operations control center for general and mission critical meteorological information, NAS status conditions, or both. FIS-B information, including weather information, NOTAMs, and TFR areas, are intended for the sole purpose of assisting in long-/near-term planning and decision making. The system lacks sufficient resolution and updating capability necessary for aerial maneuvering associated with immediate decisions. In particular, in extreme scenarios, the oldest weather radar data on the display can be up to 15 to 20 minutes older than the display’s age indication for that weather radar data. Therefore, do not attempt to use FIS-B weather information to maneuver the aircraft at minimum safe distances from hazardous weather. FIS-B information must not be used in lieu of a standard preflight briefing.’*

In addition to the above operating instructions and equipment limitations, the following paragraph should be added for FIS-B Class 1 equipment only.

- (c) *‘FIS-B uplink is an FAA approved source for METAR , TAF, WINDS, PIREPs, NEXRAD, AIRMET, SIGMET, and TFR information subject to the range limits for the broadcast of these products. FIS-B uplink is not an FAA approved source for NOTAMs.’*

In addition to the above operating instructions and equipment limitations, the following paragraph should be added for FIS-B Class 2 equipment only.

- (d) *‘This FIS-B Class 2 equipment is not interoperable with the FAA SBS provider.’*

4 Marking

4.1 General

Marking as 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.

[Amdt ETSO/7]

[Amdt ETSO/12]

ETSO-C158

ED Decision 2012/009/R

AERONAUTICAL MOBILE HIGH FREQUENCY DATA LINK (HF DL) EQUIPMENT**1 Applicability**

This ETSO gives the requirements which Aeronautical Mobile High Frequency Data Link (HF DL) Equipment 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 Radio Technical Commission for Aeronautics (RTCA) Document DO-265, Minimum Operational Performance Standards for Aeronautical Mobile High Frequency Data Link (HF DL)", dated 14/12/2000.

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.

3.1.4 Electronic Hardware Qualification

See CS-ETSO [Subpart A](#) paragraph 2.3.

3.2 Specific**3.2.1 Failure Condition Classification**

See CS-ETSO [Subpart A](#) paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a minor failure condition.

4 Marking**4.1 General**

Marking as 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.

[Amdt ETSO/7]

ETSO-C159d

ED Decision 2020/011/R

NEXT GENERATION SATELLITE SYSTEMS (NGSS) EQUIPMENT**1 Applicability**

This ETSO provides the requirements which next generation satellite systems (NGSS) equipment that is designed and 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**

The 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**

The standards are those provided in EUROCAE ED-243 ‘Minimum Operational Performance Standards for Avionics Supporting Next Generation Satellite Systems (NGSS)’, dated April, 2017.

Note: *There are no MPS security requirements for NGSS equipment. However, a security risk assessment may be required at the time of installation, and if needed, security controls may be implemented in connected aircraft systems or addressed by flight crew procedures.*

3.1.2 Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 Specific

The MPS allows for different equipment classes and subclasses as defined by EUROCAE ED-243. There are 6 applicable equipment classes and 11 equipment subclass components identified as shown in Tables 1A, 1B and Tables 2A, 2B of this ETSO. Tables 1A and 2A show the requirements for satellite communication (short burst data) (SATCOM (SBD)) equipment classes and subclass components, and Tables 1B and 2B show the requirements for satellite communication (swift Broadband) (SATCOM (SBB)) equipment classes and subclass components. The manufacturer must declare the equipment class requirements from those identified in the applicable table of this ETSO. The equipment configuration shall satisfy the relevant requirements of the EUROCAE ED-243 minimum operational performance standards (MOPS) as identified in Tables 1A and 1B and 2A and 2B of this ETSO.

Table 1A — Equipment Class Identifiers supporting SATCOM (SBD)

Equipment Class Identifier	Description	Requirement
AES1	AES using a single channel Satellite Data Unit (SDU) that contains one transceiver for data only applications. AES1 is a Short Burst Data (SBD)-only transceiver and cannot support voice calling. A passive Low Gain Antenna (LGA) is required for use with the AES1.	Appendix D, Section 2.2.1.1 and Section 2.4 for the applicable test requirements
AES2	AES2 is capable of multiple services using a single or dual channel SDU that contains one or two transceivers for data and/or voice applications. A passive LGA is required for use with the AES2.	Appendix D, Section 2.2.1.2 and Section 2.4 for the applicable test requirements
AES3	AES using two or more transceivers for multiple data and/or voice applications. A passive LGA is required for use with the AES3.	Appendix D, Section 2.2.1.3 and Section 2.4 for the applicable test requirements

Table 1B — Equipment Class Identifiers supporting SATCOM (SBB)

Equipment Class Identifier	Description	Requirement
AES4	AES using an enhanced Low Gain Antenna (ELGA). AES4 configured as a complete system.	Appendix E, Section 2.2.1.1.1 and Section 2.4 for the applicable test requirements
AES6	AES using a High Gain Antenna (HGA), transceiver, and Diplexer Low Noise Amplifier (DLNA).	Appendix E, Section 2.2.1.1.2 and Section 2.4 for the applicable test requirements
AES7	AES using an Intermediate Gain Antenna (IGA), transceiver, and DLNA.	Appendix E, Section 2.2.1.1.3 and Section 2.4 for the applicable test requirements

Table 2A — Equipment Subclass Identifiers supporting SATCOM (SBD)

Subclass Identifier	Description	Requirement
LGA	Passive LGA for use with AES1, AES2 or AES3.	Appendix D, Section 2.2.3.1.1

Table 2B — Equipment Subclass Identifiers supporting SATCOM (SBB)

Subclass Identifier	Description	Requirement
HGA	HGA for AES6.	Appendix E, Section 2.2.3.1.2
IGA	IGA for AES7.	Appendix E, Section 2.2.3.1.2
6MA	Transceiver, SDU Configuration Module (SCM), SDU, Modified Type A (DMA) Diplexer Low Noise Amplifier (DLNA), and HGA for use with AES6.	Appendix E, Section 2.2.1.1.4
7MA	Transceiver, SDU, SCM, DMA DLNA, and IGA for use with AES7.	Appendix E, Section 2.2.1.1.6

6D	Transceiver and DLNA combination includes SDU, High-Power Amplifier (HPA), DLNA, SCM, and HGA functions for use with AES6.	Appendix E, Section 2.2.1.1.8
7D	Transceiver and DLNA combination includes SDU, HPA, DLNA, SCM, and IGA functions for use with AES7.	Appendix E, Section 2.2.1.1.9
6F	Transceiver and Type F (DF) DLNA includes SDU, HPA, SCM, and HGA functions for use with AES6.	Appendix E, Section 2.2.1.1.5
7F	Transceiver and DF DLNA includes SDU, HPA, SCM, and IGA functions for use with AES7.	Appendix E, Section 2.2.1.1.7
DMA	DLNA with standard Transmitter (Tx) filter configures with 6MA transceiver and HGA for use with AES6, or 7MA transceiver and IGA for use with AES7.	Appendix E, Section 2.2.1.1.10
DF	DLNA with enhanced Tx filter configures with 6MA or 6F transceiver and HGA for use with AES6, or with 7MA or 7F transceiver and IGA for use with AES7.	Appendix E, Section 2.2.1.1.11

This ETSO standard applies to equipment intended for long-range communication services, procedural and continental communication services, aeronautical mobile satellite (route) services (AMS(R)S) by means of satellite communications between AES, corresponding satellites, and ground earth stations (GES). The NGSS supports voice and data communications between aircraft users and ground-based users, such as air navigation service providers (ANSPs) and aircraft operators.

The functionality of an NGSS supports four categories of communication service in the aircraft control domain (ACD) and/or aircraft information services domain (AISD). Two are safety of flight communication used for air traffic services (ATS) and aeronautical operational control (AOC) communication. The other two are aeronautical administrative communication (AAC) and special-purpose aeronautical passenger communication (APC) under the physical or virtual access control of the flight crew.

EUROCAE ED-243, Normative Appendix E, also contains provisions for supporting a non-priority communications service known as passenger information and entertainment services (PIES). EUROCAE ED-243, Normative Appendix E, states that non-priority services are outside the scope of that Appendix. However, PIES communications, if supported, must be partitioned from communications in the ACD and AISD for security reasons. Therefore, PIES communications are non-ETSO functions, and equipment that supports shared ACD and PIES communications must provide security partitioning of the PIES functionality from priority communications services in the ACD and AISD in accordance with this ETSO.

See paragraphs 3.1.3, 3.1.4 and 3.2.1 of this ETSO for specific additional data, design/security assurance and verification requirements related to the required security

partitioning for equipment intended to support shared ACD/AISD and PIES communications.

NGSS equipment is intended for procedural/continental airspace area operations. The failure conditions specified in paragraph 3.2.1 of this ETSO have been determined based on NGSS equipment that supplements or complements primary HF/VHF voice or data communications in procedural/continental airspace area operations, and on equipment that provides ‘Segregation & arbitration’ as described in EUROCAE ED-243, Appendix E, Section 1.3.4, or the equivalent functionality. Use of NGSS equipment in other operating environments (for example, high-density terminal/en route airspace) may impact equipment performance and safety considerations.

3.2.1 Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

A loss or malfunction of the security partitioning required by paragraph 3.2 of this ETSO that enables unauthorised or inadvertent access to ACD or AISD communications from outside the ACD or AISD is a major failure condition.

A loss or malfunction of the functions defined in paragraph 3.1.1 of this ETSO, except for a loss or malfunction of the security partitioning required by paragraph 3.2 of this ETSO, is a minor failure condition.

Note: The use of NGSS equipment as the sole means of routine ATS communication may change the classification of the failure conditions.

4 Marking

4.1 General

See CS-ETSO, Subpart A, paragraph 1.2.

4.2 Specific

For valid combinations of system component markings, see Table 3 below.

Table 3 – Valid Combinations of System Components

Valid Combinations		EUROCAE ED-243 Normative Appendix	Transceiver						Transceiver & DLNA		DLNA		Antenna			Complete System
			SBD	LBT	6MA	6F	7MA	7F	6D	7D	DMA	DF	LGA (passive)	HGA	IGA	
AES1	1	D														x
	2	D	x										x			
AES2	3	D														x
	4	D		x									x			
AES3	5	D														x
	6	D	x	x									x			
AES4	1	E														x
AES6	2	E			x						x			x		
	3	E				x						x		x		
	4	E							x					x		
	5	E			x							x		x		
	6	E														x
	7	E					x				x				x	
AES7	8	E						x				x			x	
	9	E								x					x	
	10	E					x					x			x	
	11	E														x

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/11]

[Amdt ETSO/13]

[Amdt ETSO/16]

ETSO-C160a A1

ED Decision 2020/011/R

VDL MODE 2 COMMUNICATIONS EQUIPMENT**1 Applicability**

This ETSO provides the requirements which VDL Mode 2 Communications equipment that is designed and 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**

The 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**

The applicable standards are those provided in EUROCAE ED-92B, Minimum Operational Performance Standards for Aircraft VDL Mode 2 Physical, Link, and Network Layer, dated 21 March 2012, or in EUROCAE ED-92C, Minimum Operational Performance Standards for an Airborne VDL Mode-2 System Operating in the Frequency Range 118-136.975 MHz, dated September 2018. ED-92B is identical to RTCA DO-281B. ED-92C is identical to RTCA DO-281C.

Compliance shall be demonstrated entirely with one of the versions of the applicable minimum operational performance standards.

3.1.2 Environmental Standard

See CS-ETSO, [Subpart A](#), paragraph 2.1.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific**3.2.1 Failure Condition Classification**

See CS-ETSO, [Subpart A](#), paragraph 2.4.

A failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a minor failure condition.

4 Marking

4.1 General

See CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

None.

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/8]

[Amdt ETSO/16]

ETSO-C161a

ED Decision 2012/009/R

GROUND BASED AUGMENTATION SYSTEM POSITIONING AND NAVIGATION EQUIPMENT

1 Applicability

This ETSO gives the requirements which 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 Radio Technical Commission for Aeronautics (RTCA) Document DO-253C, Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment, dated 16/12/2008, section 2 as modified by appendices 1 and 2 of this ETSO for airborne equipment class (AEC) C to support Category I precision approach. These standards also apply to equipment that implements the optional GBAS positioning service. This ETSO does not apply to AEC D equipment as the additional requirements to support the GBAS Approach Service Type D and Category III precision approaches have not been validated. A new ETSO or a revision to this ETSO for AEC D equipment will be issued once these additional requirements are validated.

This TSO's standards apply to equipment intended to output deviations relative to a precision approach path using GBAS, and to provide position information to an ETSO-C161a navigation management unit that outputs deviation commands referenced to a desired flight path. These standards do not address integration issues with other avionics except for automatic dependent surveillance. The positioning and navigation functions are defined in section 2.3 of RTCA/DO-253C. In accordance with section 2.1 of RTCA/DO-253C, equipment obtaining this ETSOA must also comply with the position, velocity and time (PVT) output requirements of either, [ETSO-C145c](#), [ETSO-C146c](#) or [ETSO-C196a](#).

Note: [ETSO-C196a](#), which is based on RTCA/DO-316, Minimum Operational Performance Standards for Global Positioning System/Aircraft Based Augmentation System Airborne Equipment, is not referenced in RTCA DO-253C. RTCA/DO-316 was published after the publication of DO-253C. ETSO-C129a is not applicable to this ETSO.

3.1.2 Environmental Standard

See CS-ETSO [Subpart A](#) paragraph 2.1. The required performance is defined in RTCA/DO253C section 2.4.

3.1.3 Computer Software

See CS-ETSO [Subpart A](#) paragraph 2.2.

3.1.4 - Electronic Hardware Qualification

See CS-ETSO [Subpart A](#) paragraph 2.3.

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO [Subpart A](#) paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a major failure condition for the malfunction of position data and a hazardous failure condition for the malfunction of precision approach navigation data.

Failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a minor failure condition for the loss of position data and a minor failure condition for the loss of precision approach navigation data.

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

[Amdt ETSO/3]

[Amdt ETSO/7]

APPENDIX 1 TO ETSO-C161A – MINIMUM PERFORMANCE SPECIFICATION FOR GROUND BASED AUGMENTATION SYSTEM POSITIONING AND NAVIGATION EQUIPMENT

ED Decision 2012/009/R

This Appendix prescribes the minimum performance standards (MPS) for GBAS equipment for airborne equipment class (AEC) C and equipment using the GBAS Positioning Service. The applicable standard is RTCA/DO-253C, Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment, dated 16/12/2008, section 2. The applicable standard is modified as follows:

1. Except as modified by appendix 2 of this ETSO, for all RTCA/DO-253C references to RTCA/DO 246(), use RTCA/DO-246B, GNSS-Based Precision Approach Local Area Augmentation System (LAAS) Signal-In-Space Interface Control Document (ICD), dated 28/11/2001.
2. Page 35, section 2.3.6.4.1, *modify* Table 2-7 and the note under the table as highlighted below (rest of section unchanged):

Table 2-7 GPS Tracking Constraints for DD DLL Discriminators

Region (see Figure 2-3)	3 dB Pre-correlation bandwidth, BW	Average Correlator Spacing (d_1 and $2d_1$) [C/A chips]	Instantaneous Correlator Spacing (d_1 and $2d_1$) [C/A chips]	Differential Group Delay	Applicable AEC
1	$(-50 \times x) + 12 < BW \leq 7 \text{ MHz}$	0.1-0.2	0.09-0.22	$\leq 600 \text{ ns} - D_A - D_C$	C
	$2 < BW \leq 7 \text{ MHz}$	0.2-0.6	0.18-0.65		
2	$(-50 \times x) + 12 < BW \leq (133.33 \times x) + 2.667 \text{ MHz}$	0.07-0.085	0.063-0.094	$\leq 150 \text{ ns} - D_A - D_C$	C & D
	$(-50 \times x) + 12 < BW \leq 14 \text{ MHz}$	0.085-0.1	0.077-0.11		
	$7 < BW \leq 14 \text{ MHz}$	0.1-0.24	0.09-0.26		
3	$14 < BW \leq 16 \text{ MHz}$	0.1-0.24	0.09-0.26	$\leq 150 \text{ ns} - D_A - D_C$	C & D
	$(133.33 \times x) + 2.667 < BW \leq 16 \text{ MHz}$	0.085-0.1	0.077-0.11		

Note (1): D_A is the differential group delay contribution of the antenna through the output of the pre-amp. D_C is the differential group delay contribution of the installation specific connection between the antenna and the PAN equipment.

Note (2): x denotes the average correlator spacing for d_1 in C/A chips.

3. Page 49, section 2.3.8.1.3, *add* a new paragraph g. to the list of conditions as follows:
 - g) The distance (slant range) between the aircraft and the GBAS reference point is less than the maximum GBAS usable distance, if the maximum GBAS usable distance ($D_{\max}$) is provided in the Type 2 message being used [LAAS-281].
4. Page 57, section 2.3.9.5, *replace* the differential correction magnitude check, δPR_i equation as follows:

$$\delta PR_i = PRC_i + RRC_i^*(t - t_{zcount}) + TC_i$$

5. Page A-6, *replace* the Maximum Use Distance ($D_{\max}$) definition as follows:

Maximum Use Distance ($D_{\max}$) – the maximum distance from the GBAS reference point for which the integrity is assured.

6. If a manufacturer elects to provide the authentication capability in its equipment as specified in section 2.3.7.3 of RTCA/DO-253C, the equipment shall also perform the differential correction magnitude check in section 2.3.9.5.

NOTE: There are additional sections of RTCA DO-246D that are applicable when VDB authentication is implemented. These are specified in [appendix 2](#).

7. Summary of ETSO changes relative to DO-253C.

LAAS Requirement Designator [LAAS-xxx]	Change Status from DO-253C
093	Changed
123	Changed
281	Added
351 and 352	New application (see item 6 above)

[Amdt ETSO/7]

APPENDIX 2 TO ETSO-C161A – MINIMUM PERFORMANCE SPECIFICATION FOR GNSS-BASED PRECISION APPROACH LOCAL AREA AUGMENTATION SYSTEM (LAAS) SIGNAL-IN-SPACE INTERFACE CONTROL DOCUMENT (ICD)

ED Decision 2012/009/R

This Appendix prescribes the interface control document for GBAS as it applies to AEC C for this ETSO. The applicable standard is RTCA/DO-246B, GNSS-Based Precision Approach Local Area Augmentation System (LAAS) Signal-in-Space Interface Control Document, dated 28 November 2001. The applicable standard is modified as follows:

1. Page 22, replace the ephemeris CRC bit order of transmission in section 2.4.3.2. Message Type 1 parameters, with the updated definition in the latest revision, RTCA/DO-246D, dated December 16, 2008, section 2.4.3.2.

NOTE: This change reorders the bits of the ephemeris CRC from their previous transmission order of r1, r2, r3, r4 ... r16, where r1 is the least significant bit and bit r16 is the most significant bit, to r9, r10, r11 ... r16, followed by r1, r2, ... r8, where r9 and r1 are the first bits of each bite into the bit scrambler. This change is not backwards compatible with the existing standard. The change was adopted for compatibility with a significant number of current implementations of ground equipment and avionics. This change affects [LAAS-107], [LAAS-117], [LAAS-118], and [LAAS-214]. Other changes to RTCA/DO-246B, reflected in RTCA/DO-246D, to support the newly incorporated GBAS Approach Service Type D are not relevant for this ETSO and should not be implemented.

2. Appendix A, *replace* appendix A, Cyclic Redundancy Checks (CRCs), *with* RTCA/DO-246D, Appendix A.
3. Page B-2, *replace* Table B-1 Example of Type 1 Message, *with* RTCA/DO-246D, Table B-1.
4. Page B-4, *replace* Table B-2 Example of Type 1 and Type 2 Messages in One Burst *with* RTCA/DO-246D, Table B-2.
5. Page B-7, *replace* Table B-3 Example of Type 4 Message *with* RTCA/DO-246D, Table B-4 as modified below for the runway number valid range.
The valid range for runway number is 1-36.
6. Page B-10, *replace* Table B-4 Example of Type 5 Message *with* RTCA/DO-246D, appendix B, Table B-6, Example of Type 5 Message.
7. If a manufacturer elects to provide the authentication capability in its equipment as specified in section 2.3.7.3 of RTCA/DO-253C, the following paragraphs from RTCA/DO-246D, dated 16/12/2008 are applicable:
 - a. Message Type 2, Additional Data Block 4, VDB Authentication Parameters description and Table 2-16 in DO-246D, section 2.4.4.1, pages 33 and 35.
 - b. Message Type 3 – Null Message and Table 2-17 Format of Message Type 3 in DO-246D, section 2.4.5, page 37.
 - c. Reference Path Identifier in DO-246D, section 2.4.6.4, page 53.

8. Summary of RTCA/DO-253C requirements affected by these modifications to DO-246B.

Appendix 2 Item number	LAAS Requirement Designator [LAAS-xxx]
1	107, 117, 118, 214
2	Editorial
3	Editorial
4	Editorial
5	Editorial
6	Editorial
7	328, 329, 330 and 331

[Amdt ETSO/7]

ETSO-C162a

ED Decision 2012/009/R

GROUND BASED AUGMENTATION SYSTEM VERY HIGH FREQUENCY DATA BROADCAST EQUIPMENT

1 Applicability

This ETSO gives the requirements which Ground Based Augmentation System Very High Frequency Data Broadcast Equipment 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 Radio Technical Commission for Aeronautics (RTCA) Document DO-253C, Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment, dated 16/12/2008.

NOTE: All RTCA/DO-253C references to RTCA/DO 246() apply to RTCA/DO-246B, GNSS-Based Precision Approach Local Area Augmentation System (LAAS) Signal-In-Space Interface Control Document (ICD), dated November 28, 2001. Modifications to these references are noted in [appendix 2](#) of ETSO-C161a.

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.

3.1.4 Electronic Hardware Qualification

See CS-ETSO [Subpart A](#) paragraph 2.3.

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO [Subpart A](#) paragraph 2.4.

Failure or loss of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a minor failure condition.

4 Marking**4.1 General**

Marking as 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.

[Amdt ETSO/7]

ETSO-C164

ED Decision 2013/012/R

NIGHT VISION GOGGLES (NVG)**1 Applicability**

This ETSO gives the requirements which Night Vision Goggles (NVG) 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 RTCA DO-275, Minimum Operational Performance Standards for Integrated Night Vision Imaging System Equipment, dated 12/10/2001.

3.1.2 Environmental standard

See CS-ETSO, [Subpart A](#), paragraph 2.1.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne electronic hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific**3.2.1 Failure condition classification**

See CS-ETSO, [Subpart A](#), paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a major failure condition.

4 Marking**4.1 General**

Marking as detailed in CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

If the night vision goggle includes airborne software, then the part number must include hardware and software identification. Or, you can use a separate part number for hardware and software. Either way, you must include a means for showing the modification status.

5 Availability of referenced document

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/8]

ETSO-C165b

ED Decision 2020/011/R

ELECTRONIC MAP SYSTEMS FOR GRAPHICAL DEPICTION OF AIRCRAFT POSITION**1 Applicability**

This ETSO provides the requirements that any electronic map system for the graphical depiction of aircraft position (own-ship), designed and manufactured on or after the date of this ETSO, must meet in order to be identified with the applicable ETSO marking.

This ETSO applies to equipment that is intended to provide graphical depiction of advisory information on a display (e.g. navigation, traffic, weather, obstacles, graphical taxi routing, etc.). The system is intended to improve flight crew positional awareness of the aircraft own-ship position relative to other items depicted on the display.

2 Procedures**2.1 General**

The applicable procedures are detailed in CS-ETSO [Subpart A](#).

2.2 Specific

Applications to certify only the software without certifying the hardware and/or the operating system will be accepted. Nevertheless, the applicant has to specify the requirements for the hardware and/or the operating system to be used, the tests to be performed once the software is integrated into the final system, and the environment which has been used to demonstrate functionality of the system.

2.3 Databases

If the article includes database(s), each database must be processed in accordance with the requirements in EUROCAE ED-76A, Standards For Processing Aeronautical Data, dated June 2015, or RTCA DO-200B, Standards for Processing Aeronautical Data, dated 18 June 2015.

3 Technical Conditions**3.1 Basic****3.1.1 Minimum Performance Standard (MPS)**

The applicable are those provided in Section 2 of RTCA document DO-257B, 'Minimum Operational Performance Standards for the Depiction of Navigational Information on Electronic Maps', dated 22 March 2018.

Electronic map systems may include displays, controls, and processing equipment that is intended to provide a graphical depiction of navigation information on the display (e.g. flight plans, fixes, nav aids, electronic charts, terrain, weather, obstacles, aerodrome surfaces, graphical taxi routing, etc.). The electronic map system improves flight crew positional awareness of the aircraft relative to other items depicted on the display. The standards were updated to support required navigation performance (RNP) systems, specifically when the in-flight (plan view) and vertical situation display (VSD) maps are displaying defined paths that are generated by the RNP system.

Table 1 provides the RTCA DO-257B requirements that are applicable to each specific function of the electronic map systems.

	Applicable Requirements Sections in RTCA DO-257B				
Electronic Map System functional description	2.1	2.2	2.3	2.4	2.5
In flight (Plan View Display)	X	X	X		
Aerodrome Moving Map (AMM)	X	X		X	
Vertical Situation Display (VSD)	X	X			X

Table 1

Displays that are part of the electronic map system must also be approved in accordance with ETSO-C113().

3.1.2 Environmental Standard

See CS-ETSO, [Subpart A](#), paragraph 2.1.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4. RTCA DO-257B Section 2.1.8 defines the minimum failure condition classifications for the specific electronic map system functions that are summarised in Table 1, except for the loss of the aerodrome moving map display, which is a minor failure condition.

Failure of the functions defined in paragraph 3.1.1 of this ETSO for Electronic Map Systems used in flight and VSD equipment (airborne applications) have been determined to be a major failure condition for malfunctions causing the incorrect depiction of aircraft position (own-ship).

3.2.2 Documentation

Installation procedures and limitations must include:

- a description of the intended function of the electronic map system;
- a description of the data quality characteristics that are necessary for the electronic map system to perform its intended function (reference EUROCAE ED-76A Standards For Processing Aeronautical Data, dated June 2015, Section 2.3, or RTCA DO-200B, Standards for Processing Aeronautical Data, dated 18 June 2015, Section 2.3);
- a requirement to interface the electronic map system with a TSO or ETSO-approved global navigation satellite system (GNSS) sensor, which is the source of position input data;

- if applicable, a description of how the electronic map system with AMM meets the total system accuracy requirements of RTCA DO-257B, Section 2.4.1.1; and
- a requirement stating that the aeronautical database(s) associated with the electronic map system, whether internal or external to the electronic map system, must demonstrate compliance with EUROCAE ED-76A/RTCA DO-200B, or its subsequent revisions as required in paragraph 2.3 of this ETSO.

4 Marking

4.1 General

See CS-ETSO, [Subpart A](#), paragraph 1.2

4.2 Specific

None.

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3

[Amdt ETSO/6]

[Amdt ETSO/9]

[Amdt ETSO/16]

ETSO-C166b A3

ED Decision 2018/002/R

EXTENDED SQUITTER AUTOMATIC DEPENDENT SURVEILLANCE-BROADCAST (ADS-B) AND TRAFFIC INFORMATION SERVICES-BROADCAST (TIS-B) EQUIPMENT OPERATING ON THE RADIO FREQUENCY OF 1090 MEGAHERTZ (MHz)

1 Applicability

This ETSO provides the requirements which Extended Squitter Automatic Dependent Surveillance-Broadcast (ADS-B) and Traffic Information Services-Broadcast (TIS-B) Equipment Operating on the Radio Frequency of 1090 Megahertz (MHz) that are designed and 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 EUROCAE ED-102A, Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance-Broadcast (ADS-B) and Traffic Information Services-Broadcast (TIS-B), dated December 2009, section 2. EUROCAE ED-102A Corrigendum 1 dated January 2012 is also acceptable.

This ETSO supports two major classes of 1090 MHz ADS-B and TIS-B equipment:

- (a) Class A equipment, consisting of transmit and receive subsystems; and
- (b) Class B equipment, containing a transmit subsystem only.

Class A equipment includes Classes A0, A1, A1S, A2 and A3. This standard requires 1090 MHz airborne Class A equipment to include the capability of receiving both ADS-B and TIS-B messages and delivering both ADS-B and TIS-B reports, as well as transmitting ADS-B messages. A receive-only Class of equipment is allowed.

Class B equipment includes Classes B0, B1, and B1S. Classes B0, B1, and B1S are the same as A0, A1, and A1S, except they do not have receive subsystems. Note that Classes B2 and B3 are not for aircraft use.

3.1.2 Environmental standard

See CS-ETSO, [Subpart A](#), paragraph 2.1. The required performance under test conditions is defined in EUROCAE ED-102A, section 2.4.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne electronic hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific

3.2.1 Failure condition classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 of this ETSO resulting in misleading information is a major failure condition.

Failure of the function defined in paragraph 3.1.1 of this ETSO resulting in loss of function is a minor failure condition at equipment level.

Note: The major failure condition for transmission of incorrect ADS-B messages is based on the use of the data by other aircraft or Air Traffic Control for separation services.

Note: COMMISSION IMPLEMENTING REGULATION (EU) No 1207/2011 of 22 November 2011 laying down requirements for the performance and the interoperability of surveillance for the single European sky requires that the probability of discontinuity of the transmit function defined in paragraph 3.1.1 of this ETSO at aircraft level shall be equal to or less than $2 \cdot 10^{-4}$ per flight hour.

4 Marking

4.1 General

Marking as detailed in CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

Transmitting and receiving components must be permanently and legibly marked.

The following table explains how to mark components.

EUROCAE ED-102A provides the equipment class in Section 2.1.11, and the receiving equipment type in Section 2.2.6.

<i>If the component can:</i>	<i>Mark it with the:</i>	<i>Sample marking pattern:</i>
Transmit and receive	Equipment class it supports, and Receiving equipment type	Class A0/Type 1
Transmit, but not receive	Equipment class it supports	Class B1, or Class A3-Transmitting only
Receive, but not transmit	Equipment class it supports, and Receiving equipment type	Class A2/Type 2-Receiving only

5 Availability of referenced document

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/11]

[Amdt ETSO/13]

ETSO-C168

ED Decision 2020/011/R

AVIATION VISUAL DISTRESS SIGNALS**1 Applicability**

This ETSO provides the requirements which aviation visual distress signals that are designed and 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**

The 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**

For handheld, high-intensity, stroboscopic light sources that can be added to aviation survival kits to supplement pyrotechnic devices, the standards are those provided in SAE International's Aerospace Standard AS5134A, Aviation Distress Signal, dated 27 September 2007.

3.1.2 Environmental Standard

See CS-ETSO, [Subpart A](#), paragraph 2.1.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific**3.2.1 Failure Condition Classification**

See CS-ETSO, [Subpart A](#), paragraph 2.4.

3.2.2 Others

These light sources must:

- eliminate the significant potential equipment and personnel hazards that are posed by untrained personnel using pyrotechnics in inflatable life rafts; and
- provide an equivalent level of safety to pyrotechnics that aid in locating and rescuing aviation accident survivors.

4 Marking**4.1 General**

See CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

None.

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/16]

ETSO-C170

ED Decision 2012/009/R

HIGH FREQUENCY (HF) RADIO COMMUNICATIONS TRANSCEIVER EQUIPMENT OPERATING WITHIN THE RADIO FREQUENCY 1.5 TO 30 MEGAHERTZ

1 Applicability

This ETSO gives the requirements which High Frequency (HF) Radio Communications Transceiver Equipment Operating Within the Radio Frequency 1.5 to 30 Megahertz that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

This ETSO cancels ETSO-C31d “High Frequency (HF) Radio Communications Transmitting Equipment Operating within the Radio Frequency Range 1.5-30 Megahertz” and ETSO-C32d “High Frequency (HF) Radio Communications Receiving Equipment Operating within the Radio Frequency Range 1.5-30 Megahertz”.

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 Radio Technical Commission for Aeronautics (RTCA) Document DO-163, Minimum Operational Performance Standards - Airborne HF Radio Communications Transmitting and Receiving Equipment Operating within the Radio-Frequency Range of 1.5 to 30 MHz, dated 09/03/1976.

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.

3.1.4 Electronic Hardware Qualification

See CS-ETSO [Subpart A](#) paragraph 2.3.

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO [Subpart A](#) paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a minor failure condition.

4 Marking**4.1 General**

Marking as 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.

[Amdt ETSO/7]

ETSO-C172a

ED Decision 2016/029/R

CARGO RESTRAINT STRAP ASSEMBLIES**1 Applicability**

This ETSO gives the requirements which Cargo Restraint Strap Assemblies that are designed and 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 AS 5385C, Cargo Restraint Straps - Design Criteria and Testing Methods, dated January 2007, as amended by [Appendix 1](#) of this ETSO.

3.1.2 Environmental Standard

Cargo restraint strap assemblies must meet the minimum performance requirements of this ETSO at any time during the service life.

- (1) The environmental degradation due to aging, ultra-violet (UV) exposure, weathering, etc. shall be determined, for any non-metallic materials used in the construction of cargo restraint strap assemblies.
- (2) For textile performance, refer to SAE Aerospace Information Report (AIR) 1490B, Environmental Degradation of Textiles, dated December 2007, for available data when exposed to environmental factors. It shall be determined when the environmental effects of degradation on cargo restraint strap assemblies commensurate with the expected storage and service life become unacceptable for the minimum performance requirements.

NOTE: Environmental degradation data other than that documented in AIR1490B may be used if it can be substantiated and considered acceptable for the ETSO authorisation.

3.1.3 Computer Software

None.

3.1.4 Electronic Hardware Qualification

None.

3.2 Specific**3.2.1 Failure Condition Classification**

N/A

4 Marking**4.1 General**

Marking as detailed in CS-ETSO [Subpart A](#) paragraph 1.2. In addition, each Cargo Restraint Strap Assemblies shall be legibly and permanently marked in accordance with SAE AS 5385C, section 7.3 with the following:

- (i) dates of manufacture and expiration per SAE AS 5385C, section 4.5.2. Format the dates per SAE AS 5385C, section 7.2.
- (ii) the rated ultimate load in daN and lbf.
- (iii) a unique identifier if required by SAE AS 5385C, section 4.5.2(b).

Also mark permanently and legibly, with at least the manufacturer's name, subassembly part number, and the ETSO number:

- (1) each component that is easily removable (without hand tool), and
- (2) each subassembly of the article that may be interchangeable.

NOTE 1: any extra information listed in SAE AS 5385C, section 7, not specifically required in this paragraph, may be marked.

NOTE 2: Compliance with this ETSO does not necessarily indicate compliance with SAE AS 5385C. To make the cargo strap assembly as complying with SAE AS 5385C, the cargo strap assembly must be shown to meet the requirements of SAE AS 5385C in conformance with SAE AS 5385C, Para 7.1 and Note 8.

4.2 Specific

None

5 Availability of Referenced Document

See CS-ETSO [Subpart A](#) paragraph 3.

[Amdt ETSO/7]

[Amdt ETSO/12]

APPENDIX 1 TO ETSO-C172A – MINIMUM PERFORMANCE STANDARD FOR CARGO RESTRAINT STRAP ASSEMBLIES

ED Decision 2016/029/R

This Appendix prescribes the MPS for cargo restraint strap assemblies. The applicable standard is SAE AS 5385C “Cargo Restraint Straps – Design Criteria and Testing Methods”, dated January 2007 modified as follows:

AS5385C Section	Action
1	Disregard
2	Modify Paragraph 2. “REFERENCES” by disregarding the last sentence.
3	Modify Paragraph 3.6 to omit reference to D6 in the first sentence. Modify Figure 1. to disregard D6 end fitting Disregard 3.14
4	Modify 4.4 to read as follows: The webbing, as used in the restraint strap assembly, i.e., including sewing and any treatment, shall meet the flammability test criteria of CS-25 Appendix F, Part I, paragraph (a)(1)(iv): it may not have a burn rate greater than 63.5 mm (2.5 in) per minute when tested horizontally with the apparatus and test procedures required in Appendix F, Part I, paragraph (b)(5) (see 5.8). Disregard 4.5.4 and 4.9.1 Modify 4.5.1 by adding the following note: “NOTE: Environmental degradation data other than that documented in AIR490B may be used if substantiated by the Applicant and approved by the Agency.”
5	Disregard 5.9, 5.10 and 5.11 Modify 5.1 by adding the following note: “NOTE: Equivalent alternate methods must be approved by the Agency”.
6	Disregard
7	Apply per Paragraph 4 of this ETSO
8	Disregard
9	Disregard
10	Disregard

[Amdt ETSO/7]

[Amdt. ETSO/12]

ETSO-C173a

ED Decision 2016/013/R

NICKEL-CADMIUM, NICKEL METAL-HYDRIDE, AND LEAD-ACID BATTERIES**1 Applicability**

This ETSO provides the requirements which Nickel-Cadmium, Nickel Metal-Hydride, and Lead-Acid Batteries that are designed and manufactured on or after the applicability 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 RTCA DO-293A, Minimum Operational Performance Standards (MPS) for Nickel-Cadmium, Nickel Metal-Hydride, and Lead-Acid Batteries, dated 12/2/2009, as amended according to [Appendix 1](#) to this ETSO.

3.1.2 Environmental Standard

Nickel-Cadmium, Nickel Metal-Hydride, and Lead-Acid Batteries shall be tested according to the conditions specified in RTCA DO-293A.

Where the RTCA DO-293A quotes the RTCA DO-160 standard, the applicable DO-160 standard revision is defined in CS-ETSO, [Subpart A](#), paragraph 2.1.

3.1.3 Computer Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Electronic Hardware Qualification

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific

None.

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

4 Marking**4.1 General**

Marking as detailed in CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

At least one major component shall be marked permanently and legibly with all the information in RTCA DO-293A, section 1.10, as modified by [Appendix 1](#).

5 Availability of Referenced Document

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/11]

APPENDIX 1 TO ETSO-C173A – MINIMUM PERFORMANCE STANDARD FOR NICKEL-CADMIUM, NICKEL METAL-HYDRIDE, AND LEAD-ACID BATTERIES AMENDMENT TO RTCA DO-293A REQUIREMENTS

ED Decision 2016/013/R

RTCA/DO-293A section and title:	Amendment:
1.10.1, Battery Marking	It shall be added to the bottom of the list of Manufacturer's markings: 11. End Point Voltage (EPV)
2.3.1, Rapid Discharge Capacity at 23 °C	It shall be deleted at the end of the paragraph and the Test Method: 'or the manufacturer recommended cutoff voltage'
2.3.2, Rapid Discharge Capacity at – 30 °C	It shall be deleted at the end of the paragraph and the Test Method: 'or the manufacturer recommended cutoff voltage'
3.12, Electrolyte Resistance	It shall be applied ONLY to heater blankets of this section the following: Testing method and evaluation criteria of MIL-PRF-8565 can be utilised in lieu of the testing method and evaluation criteria stipulated in paragraph 3.12 of RTCA /DO-293A.

[Amdt ETSO/11]

ETSO-C174 A1

ED Decision 2013/012/R

BATTERY-BASED EMERGENCY POWER UNIT (BEPU)**1 Applicability**

This ETSO gives the requirements which Battery based Emergency Power Units (BEPU) that are manufactured on or after the date of this ETSO must meet in order to be identified with 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 are given in [Appendix 1](#).

Note: The battery used in the BEPU must meet the requirements of [ETSO-C173](#) "Nickel-Cadmium and Lead Acid Batteries" or any other battery standards acceptable to the Agency.

3.1.2 Environmental standard

As stated in [Appendix 1](#), chapter 2, of this ETSO.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne electronic hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific**3.2.1 Failure condition classification**

See CS-ETSO, [Subpart A](#), paragraph 2.4.

4 Marking**4.1 General**

Marking is detailed in CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

Product label shall indicate:

- battery capacity (e.g. 20 Amp-Hour (Ah)),
- nominal voltage,
- battery chemistry.

5 Availability of referenced document

See CS-ETSO, [Subpart A](#), paragraph 3

[Amdt ETSO/3]

[Amdt ETSO/8]

APPENDIX 1 TO ETSO-C174 A1 – MINIMUM PERFORMANCE STANDARD FOR BATTERY-BASED EMERGENCY POWER UNIT (BEPU)

ED Decision 2013/012/R

CHAPTER 1: MINIMUM PERFORMANCE STANDARD UNDER STANDARD CONDITIONS

1 PURPOSE

These are the requirements under standard conditions for a Battery-based Emergency Power Units (BEPU) to meet the Minimum Performance Standard for this ETSO. The performance of specific equipment may be enhanced, depending on its intended application and configuration.

2 GENERAL REQUIREMENTS

The BEPU must meet the power quality requirements of MIL-STD-704F, Aircraft Electrical Power Characteristics, dated March 12, 2004, and maintain the rated values and functionality according to its specification data sheet, unless otherwise specified in this ETSO.

- (a) Design the BEPU to minimize the risk of causing or spreading a fire.
- (b) Storage batteries must be designed and installed as follows: Safe cell temperatures and pressures must be maintained during any probable charging or discharging condition. No uncontrolled increase in cell temperature may result when the battery is recharged (after previous complete discharge):
 - at maximum regulated voltage or power,
 - during a flight of maximum duration, and,
 - under the most adverse cooling condition likely to occur in service.
- (c) Demonstrate the above conditions by test, unless your experience with similar batteries and installations has shown that maintaining safe cell temperatures and pressures do not present a problem.
- (d) Systems like electronic circuits installed in the BEPU must be compatible with the battery chemistry.
- (e) During a failure of the normal power source to the emergency electrical bus, the BEPU supplies emergency electrical bus loads without intervention by the flight crew. After re-establishment of the normal power source, the emergency bus loads revert automatically from the BEPU to the normal power source, and the BEPU automatically returns to charging mode. To prevent inadvertent recharging of the BEPU from the aircraft battery when a normal power source is not available, the BEPU shall not enter the recharge mode when the BEPU input (source) voltage is below 24VDC.
- (f) Specify the value of voltage spikes occurring when the BEPU is switched on and off and between modes (if applicable).
- (g) Any single component failure within the BEPU (either open or short) cannot result in an over voltage condition on the battery.
- (h) The BEPU will not have any protection/provision that results in automatic removal of power from the emergency load.
- (i) The BEPU will not discharge through the input side of the BEPU.

- (j) If the BEPU provides backup power to multiple loads, equip the BEPU with protection provisions that allow for the isolation and removal of excess load on any of its output feeders that draw more than its pre-determined maximum current. This will protect remaining loads in case of a load short circuit.
- (k) The BEPU should not drain its battery power when the aircraft power is off.
- (l) Charge fully the battery before installation. Charge the battery every time the aircraft is powered up, regardless of cockpit switch position.
- (m) The charging time from 20 % to 80 % capacity will be less than 3 hours.
- (n) Specify the nominal current and the short time maximum current.
- (o) Design the BEPU in such a way so that separation devices placed between input, output, and battery will enable the current flow from input to output, even when there is a malfunction with other BEPU components. The separation devices will prevent current flow in the direction from output (respectively the battery) to input, and from output to battery. See Figure A-2 at the end of this appendix. The minimum current rating of the separation devices must be greater than three times the continuous rated output current of the BEPU. Unless provided in the aircraft, design the BEPU to prevent output current greater than 30 milliamperes (mA) from flowing back to battery. The loss (breakdown) of voltage of such separation devices will exceed three times the BEPU rated voltage.
- (p) The maximum output voltage ripple cannot exceed the limits stated in MIL-STD-704F. Note this limit does not include the ripple already on the input line into the BEPU. (See Figure A-3 at the end of this appendix.)
- (q) To preclude catastrophic effects of excess temperature, the BEPU will monitor battery temperature during battery-charging cycles, and remove power when over temperature limits are reached. Applications where excessive battery temperature cannot cause catastrophic events do not require monitoring.
- (r) If the BEPU contains a battery heater device, a single-fault failure redundancy protection is required to prevent heater runaway.

3 CAPACITY AND RELATED PARAMETERS

The parameters listed in this section under environmentally benign and ground benign conditions at 25°C must be provided. Considered nominal conditions follow.

- (a) BEPU capacity. Specify the value for the nominal capacity in Amp-Hours (Ah) based on a constant discharge current for 1.0 hour. During capacity testing the output voltage cannot degrade below 20VDC.
- (b) BEPU output voltage excursions. Provide graphs of output voltage versus time for the following conditions:
 - complete discharge to low voltage dropout point after being fully charged;
 - complete discharge to low voltage dropout point after being charged to 72% capacity. This (72% capacity) represents a BEPU at the end of its life and 90% state of charge.
- (c) BEPU life. Declare the expected battery life based on the number of 100% discharge cycles on the battery nameplate. Battery life is expired when 80% of the capacity stated on the nameplate is reached.

- (d) BEPU maximum current consumption. Specify the maximum current consumption (excluding external loads) of the BEPU. Maximum current includes charging, heating, and other functionalities performed by electronic circuits.
- (e) BEPU output current. Specify the nominal current that can be delivered by the BEPU related to the nominal Ah rating specified in paragraph 3.a of this Chapter 1 "CAPACITY AND RELATED PARAMETERS", and the short time maximum current versus time, if necessary.

4 MONITOR AND CONTROL

- (a) Instrumentation, data read-outs, and controls can be provided by support equipment instead of the BEPU.
- (b) Design all instrumentation and data read-outs for easy interpretation to avoid misunderstandings.
- (c) The BEPU can have (but is not limited to) the following optional controls:
 - BEPU Off: Battery power is disconnected from all loads;
 - BEPU Arm: Ready to engage power to the loads if aircraft power is lost. The BEPU should be in "charging mode" unless there is a failure of the emergency bus;
 - BEPU On/Engage: Causes the battery to be applied to the loads. The BEPU should be in "charging code" unless during failure of the emergency bus.
- (d) Provide a test function for pre-flight check, showing the system function and battery status. The battery is considered good with 80% state of charge. We recommend an in-flight low battery warning indication. Perform a lamp test where the checked segments are lighted.

CHAPTER 2: MINIMUM PERFORMANCE STANDARD UNDER ENVIRONMENTAL TEST CONDITIONS

1 GENERAL

Unless otherwise specified, applicable test procedures are defined in CS-ETSO, Subpart A paragraph 2.1.

2 PERFORMANCE TESTS

The following environmental tests verify BEPU operations based on manufacturer specifications and requirements under extreme environmental conditions. If the manufacturer's specifications during these tests are different than those recorded under benign environmental conditions as specified in paragraph 3 of Chapter 1 of this Appendix, the manufacturer will specify the modified rating and under what condition such ratings would occur. For the following tests, determine compliance of the BEPU with the manufacturer's nominal ratings (unless otherwise specified) as referenced in paragraph 3 of Chapter 1 of this Appendix except when otherwise noted, charge the batteries to at least 80 % of manufacturers rated capacity before conducting these tests:

- BEPU capacity using nominal current discharge;
- BEPU output voltage excursion;
- BEPU current consumption.

For the applicable environmental test requirements see ETSO, Subpart A, paragraph 2.1:

- (a) Section 4, Temperature and Altitude.
 - Operating Low Temperature Test. You may use an internal battery heater for this test.
 - Operating High Temperature Test
 - Altitude Test
 - Decompression Test
 - Overpressure Test
- (b) Section 5, Temperature Variation. Combine this test with Section 4 Testing Requirements.
- (c) Section 6, Humidity.
- (d) Section 7, Operational Shocks and Crash Safety. After this test, the equipment must remain in its mounting with no part of the equipment or its mounting becoming detached and free on the shock test table. Measure and record the BEPU capacity after completion.

Note: These tests may damage the equipment. Therefore, these tests may be conducted last.

- (e) Section 8, Vibration. While the equipment is subjected to this test, ensure that all mechanical devices operate satisfactorily and that the mechanical construction remains undamaged.
- (f) Section 9, Explosion Proofness. Required only if the BEPU contains components that are known to cause inductive arcing.
- (g) Section 10, Water Proofness (if required).
- (h) Section 11 Fluids Susceptibility (if required). Not mandatory for ETSO approval.
- (i) Section 12, Sand and Dust (if required).
- (j) Section 13, Fungus Resistance (if required). Compliance by analysis is acceptable.
- (k) Section 15, Magnetic Effect.
- (l) Section 16, Power Input.
- (m) Section 17, Voltage Spike. During and after this test, no failed parts must exist, including any degradation on component voltage and current ratings. No parasitic or transient mode switching can result from this test.
- (n) Section 18, Audio Frequency Conducted Susceptibility – Power Inputs. Conduct by charging the BEPU when its capacity is between 0% and 75%. No parasitic or transient mode switching can result from this test.
- (o) Section 19, Induced Signal Susceptibility. No parasitic or transient mode switching can result from this test.
- (p) Section 20, RF Susceptibility. No parasitic or transient mode switching can result from this test.
- (q) Section 21, Emission of RF Energy. Conduct while BEPU is being charged. Charge must be between 0% and 75% of capacity during this test.
- (r) Section 22, Lightning Induced Transient Susceptibility. No parasitic or transient mode switching can result from this test.

- (s) Section 23, Lightning Direct Effects. Not mandatory for this ETSO approval. If you conduct this test, no failed parts may exist during and after the test. Failed parts include any degradation on component voltage and current ratings. No parasitic or transient mode switching should result during this test.
- (t) Section 24, Icing. Not mandatory for this ETSO approval. If you conduct this test, no failed parts may exist during and after the test. Failed parts include any degradation on component voltage and current ratings.
- (u) Section 25, Electrical Discharge.

CHAPTER 3: ELECTRICAL TEST PROCEDURES

1 GENERAL

Electrical test procedures covered under environmental test conditions in Chapter 2 of this Appendix are conducted according to the test procedures are outlined below.

2 GENERAL TEST CONDITIONS

Unless otherwise specified, the following test conditions apply:

- (a) Conduct all tests under conditions of ambient room temperature (except sections 4, 5 and 6) and ambient pressure and humidity as outlined in Section 1, Paragraph 3.
- (b) Unless otherwise specified, the input supply voltage will be within 10 % of the nominal value the BEPU is designed to operate.
- (c) A reasonable warm-up period for stabilization is permissible. Battery nominal capacity is defined at 25 °C.

3 SPECIFIC TEST CONDITIONS

(Per paragraph 4 “MONITOR and CONTROL” of the Chapter 1 of this document)

- (a) Lamp test: All segments lighted.
- (b) Check load segment on when load is applied.

4 ALIGNMENT, ADJUSTMENT AND CALIBRATION PRIOR TO TEST

If necessary, perform alignment, adjustment and calibration before testing.

5 TEST EQUIPMENT

Calibrate the test equipment you use to verify final test results traceable to the National Bureau of Standards. Test equipment accuracy will be at least 2 %.

CHAPTER 4: DESCRIPTION OF A BEPU

1 GENERAL

A BEPU supplies power for a specified time period to an emergency power bus (output) in case of main or emergency bus failure.

2 PARTS OF A BEPU

The BEPU consists of a remote unit or panel-mounted device containing a rechargeable battery pack (accumulator) and means for providing charging, monitoring of battery temperature,

battery state, current, as well as system testing and related functions. The batteries are kept fully charged during normal operation regardless of surrounding temperature.

- (a) An indicator/test switch gives information on the battery status of the BEPU before commencing flight.
- (b) Figure A-1 block diagram illustrates the description of the BEPU functionality. It does not define a requirement.
- (c) Figure A-2 depicts an example BEPU current flow.
- (d) Figure A-3 depicts a recommended measurement of BEPU output voltage ripple.

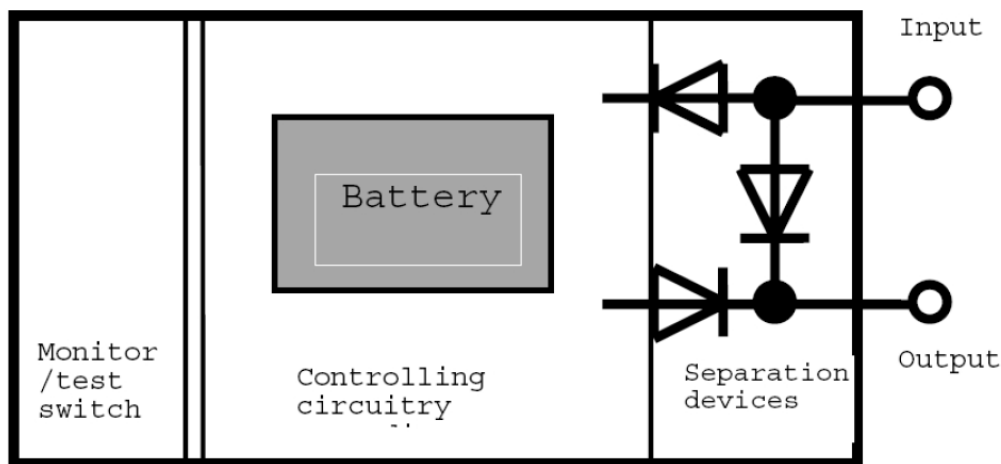


Figure A-1: BEPU Block Diagram

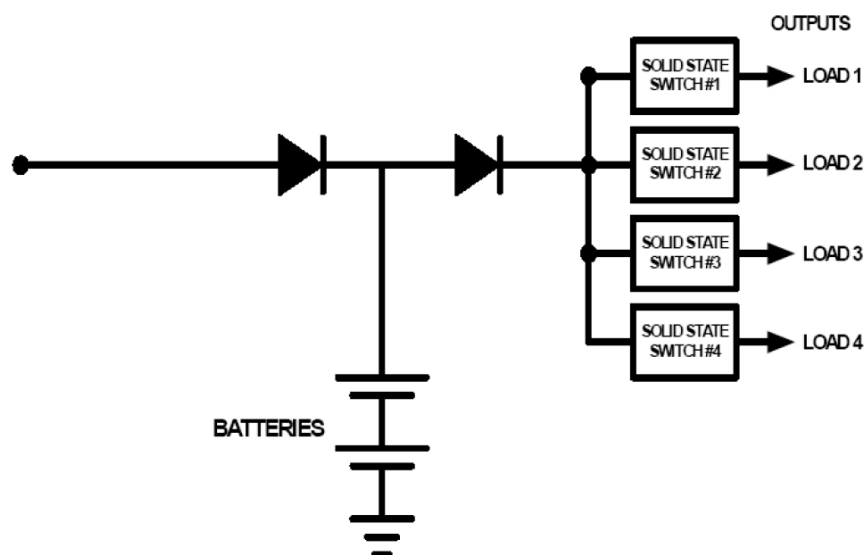


Figure A-2: An example BEPU Current Flow

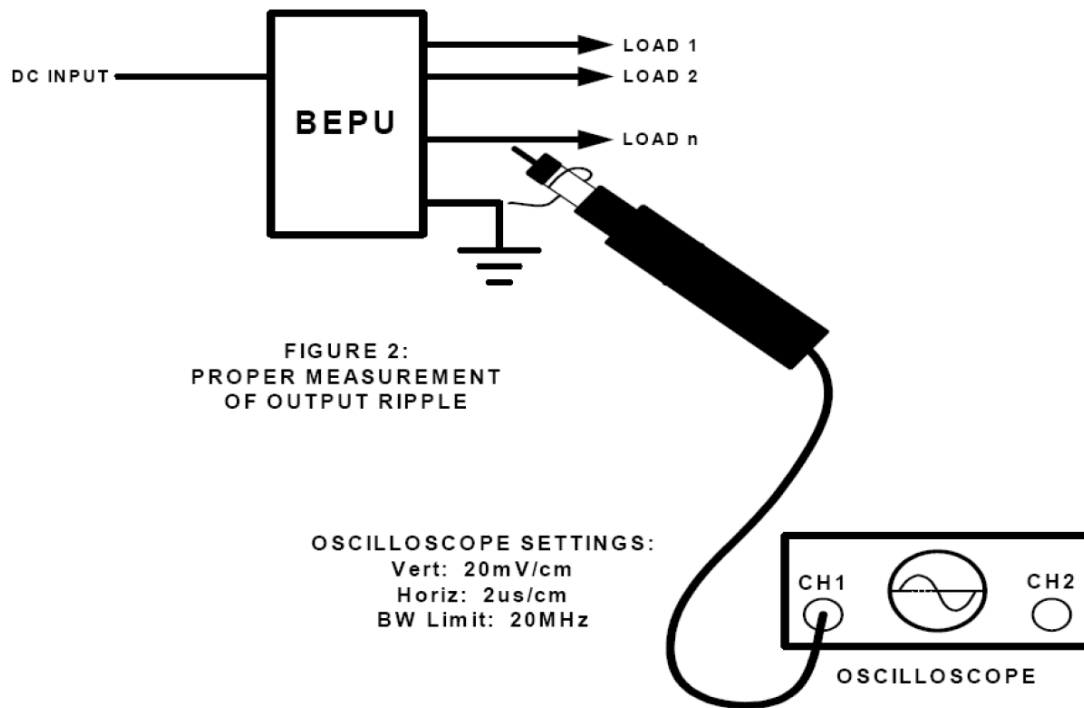


Figure A-3: Recommended Measurement of BEPU Output Voltage Ripple

[Amdt ETSO/3]

[Amdt ETSO/8]

ETSO-C175

ED Decision 2008/012/R

GALLEY CART, CONTAINERS AND ASSOCIATED COMPONENTS**1 Applicability**

This ETSO gives the requirements which Galley Cart, Containers and Associated Components that are manufactured on or after the effective 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**

SAE AS 8056 "Minimum Design and Performance of Airplane Galley In-Flight Carts, Containers, and Associated Components" from November 2004, as amended by [Appendix 1](#) of this ETSO.

3.2 Specific

None

4 Marking**4.1 General**

Marking is detailed in CS-ETSO [Subpart A](#) paragraph 1.2.

4.2 Specific

Each manufactured Galley Cart, Containers and Associated Components must be permanently and legibly marked according to information provided in SAE AS 8056 paragraph 3.7

5 Availability of Referenced Document

Refer to CS-ETSO [Subpart A](#) paragraph 3.

[Amdt ETSO/3]

APPENDIX 1 TO ETSO-C175 – MPS FOR GALLEY CART, CONTAINERS AND ASSOCIATED COMPONENTS

ED Decision 2008/012/R

This ETSO's standards are set forth in the industry standard, SAE AS 8056, Minimum Design and Performance of Airplane Galley In-Flight Carts, Containers, and Associated Components, dated November 2004 modified as follows:

Modifications to SAE AS 8056

AS 8056 section:	Action:
3.2.1, Materials and Materials Control	TO DELETE "...or experience."
3.2.1.2, Materials	TO CHANGE ALL TO: "Each batch, roll or sheet of non-metallic materials or finished metal (including finishes or decorative surfaces applied to the materials) shall meet the applicable test criteria prescribed in 14 CFR part 25, Appendix F, parts I, IV, V and VI."
3.2.5, Interface Clearances	TO ADD AT END: "...and shall account for the equipment and aircraft tolerances."
3.3.5, Material Strength Properties and Material Variability	TO ADD after first paragraph: "The applicable specifications are Metallic Materials Process Development and Standardization (MMPDS, formerly MIL Handbook-5) and MIL Handbook- 17."
3.5, Fire Properties	TO ADD new sub section after 3.5.2: "Flame Propagation: thermal /acoustic insulation material installed on the equipment shall meet the flame propagation requirements of 14 CFR § 25.856(a) when tested per Appendix F, part VI or other Agency approved equivalent test requirements. This requirement does not apply to "small parts" as defined in 14 CFR part25, Appendix F part I."
3.6, Fire Containment	TO CHANGE 14 CFR 25.853 to 14 CFR § 25.853(h).
4.1, General	ADD after 1st paragraph: "ETSO Applicants are encouraged to validate finite element models based on critical testing when such an approach is taken to substantiate design changes to ensure compliance with 14 CFR § 25.307."
4.2, Structural	TO ADD between the 2nd and 3rd paragraph: "In order to maintain a maximum door deflection of 50 mm, the allowable retaining device envelope and the minimum retaining device engagement area shown in Figures 4 and 5 shall be developed by testing for both the primary and secondary retaining devices acting independently."
4.5, Fire Properties	TO ADD new subsection after 4.5.2, Flame Propagation: "Thermal/Acoustic insulation materials shall be demonstrated to comply with the flame propagation requirements of 3.5."
AS 8056 section:	Action:
4.6, Fire Containment	TO ADD between the 6th and 7th paragraph: "For air chilled carts, the test procedure step that reads "Place the cart into the galley structure so that it is connected or attached to the chilled air distribution ducts with the designed airflow volume. Circulate air through the cart at the designated airflow rate" may be substituted as follows: "Simulate the galley seal at the cart/galley interface and circulate air through one of the cart air openings at a flow rate of 30.7 l/s (+0/ - 4.72) (65 (+0, -10) cf/m) and ambient temperature of 22.22deg C (+5.55 / -5.55) (72 deg F (+10, - 10)). It is acceptable to

	increase the airflow rate as necessary to meet a manufacturer's requirements.”
5.1, Interface Control Drawing	TO ADD AT END: “For air-chilled carts, identify the flow rate of air (e.g., 47.2 l/s or 100 cf/m) circulated through the cart during the fire containment test.”

[Amdt ETSO/3]

ETSO-C178

ED Decision 2013/012/R

SINGLE PHASE 115 VAC, 400 Hz ARC FAULT CIRCUIT BREAKERS**1 Applicability**

This ETSO gives the requirements which Single Phase 115 VAC, 400 Hz Arc Fault Circuit Breakers 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 AS 5692, Arc Fault Circuit Breaker (AFCB), Aircraft, Trip-Free Single Phase 115 Vac, 400 Hz – Constant Frequency, dated October 2004. AFCBs may have separate indication of thermal and arcing faults to assist in fault isolation and performing proper repairs.

3.1.2 Environmental standard

See CS-ETSO, [Subpart A](#), paragraph 2.1.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne electronic hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific**3.2.1 Failure condition classification**

See CS-ETSO, [Subpart A](#), paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a major failure condition.

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.

[Amdt ETSO/8]

ETSO-C179b

ED Decision 2020/011/R

RECHARGEABLE LITHIUM CELLS, BATTERIES, AND BATTERY SYSTEMS**1 Applicability**

This ETSO provides the requirements which rechargeable lithium cells, batteries, and battery systems that are designed and 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**

The 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**

For equipment with rechargeable lithium cells, lithium batteries and battery systems that are intended to provide power for aircraft equipment, including emergency systems, the applicable standards are those provided in RTCA document DO-311A, Minimum Operational Performance Standards for Rechargeable Lithium Batteries and Battery Systems, dated 19 December 2017. However, the demonstration of compliance with this ETSO may not rely on Appendix C to DO-311A.

3.1.2 Environmental Standard

Test the equipment according to Section 3 of RTCA document DO-311A, Minimum Operational Performance Standards for Rechargeable Lithium Batteries and Battery Systems, dated 19 December 2017.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific**3.2.1 Failure Condition Classification**

See CS-ETSO, [Subpart A](#), paragraph 2.4.

4 Marking

4.1 General

See CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

The specific marking requirements are detailed in Section 2.1.3 of RTCA document DO-311A, Minimum Operational Performance Standards for Rechargeable Lithium Battery Batteries and Systems document, dated 19 December 2017.

In addition, the article must be marked with:

- its serial number;
- ‘ETSO-C179b-CLASS A-XY’ or ‘ETSO C179b-CLASS B-XY’ as shown below (where X stands for the energy category and Y stands for the venting category as listed in the table below and defined in RTCA document DO-311A Sections 1.4.1 and 1.4.2):
 - ETSO-C179b CLASS A — During the RTCA document DO-311A Section 2.4.5.5 Battery Thermal Runaway Containment Test, all the cells within the battery must undergo thermal runaways.
 - ETSO-C179b CLASS B — During the RTCA document DO-311A Section 2.4.5.5 Battery Thermal Runaway Containment Test, not all the cells within the battery must undergo thermal runaways.

Energy Category (X)	Venting Category (Y)
1	A
1	B
1	C
2	A
2	B
2	C
3	A
3	B
3	C
4	A
4	B
4	C

(For example: ETSO-C179b CLASS B-1A would be a rechargeable lithium battery and battery system that is of energy category 1 and a venting category of A, and not all the cells underwent thermal runaways during the RTCA document DO-311A Section 2.4.5.5 testing.)

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/7]

[Amdt ETSO/16]

ETSO-C184

ED Decision 2012/009/R

AIRPLANE GALLEY INSERT EQUIPMENT, ELECTRICAL/PRESSURISED**1 Applicability**

This ETSO gives the requirements which Airplane Galley Insert Equipment, Electrical/Pressurised 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 Society of Automotive Engineers (SAE) Aerospace Standard (AS) 8057, Minimum Design and Performance of Airplane Galley Insert Equipment, Electrical/Pressurized, issued July, 2008 as modified by Appendix 1 of this document.

3.1.2 Environmental Standard

See AS 8057, paragraph 3.17 as modified by [appendix 1](#) of this document.

3.1.3 Computer Software

See CS-ETSO [Subpart A](#) paragraph 2.2.

3.1.4 Electronic Hardware Qualification

See CS-ETSO [Subpart A](#) paragraph 2.3.

3.2 Specific**3.2.1 Failure Condition Classification**

See CS-ETSO [Subpart A](#) paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a minor failure condition.

4 Marking**4.1 General**

Marking as 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.

[Amdt ETSO/7]

APPENDIX 1 TO ETSO-C184 – MINIMUM PERFORMANCE STANDARD FOR AIRPLANE GALLEY INSERT EQUIPMENT, ELECTRICAL/PRESSURIZED

ED Decision 2012/009/R

This Appendix prescribes the minimum performance standards (MPS) for airplane galley insert equipment. The applicable standard is SAE AS 8057, Minimum Design and Performance of Airplane Galley Insert Equipment, Electrical/Pressurized, issued July, 2008. EASA did revise it as follows:

1. Page 5, replace paragraph 1.3.b. with:
“The word “should” indicates a criterion for which an alternative, including non-compliance, may be applied.”
2. Page 8, disregard paragraph 2.2 Definitions: “ACCEPTANCE TEST”, “ASSOCIATED COMPONENTS”, “DETRIMENTAL PERMANENT DEFORMATION”, and “FAILSAFE”.
3. Page 8, replace paragraph 2.2 Definitions: “FAILURE” with: “FAILURE: is a failure to meet the Minimum Performance Standard of the ETSO. The standard ensures a level of safety that is acceptable.
4. Page 9, replace paragraph 2.2 Definitions: INTERCHANGEABILITY with:
“INTERCHANGEABILITY: That quality which allows an assembly or part to substitute or be substituted for another and to meet all physical, functional, and structural requirements of the original.”
5. Page 9, replace paragraph 2.2 Definitions: MAXIMUM NORMAL OPERATING PRESSURE (MNOP) with: “MAXIMUM NORMAL OPERATING PRESSURE (MNOP):
The maximum attainable pressure of the equipment’s pressure system when all the equipment’s components are functioning normally.”
6. Page 9, replace paragraph 2.2 Definitions: OPTION with
“OPTION: A function capable of being included as part of equipment. It shall be fully developed and able to be incorporated without adverse effects to meeting the performance requirements of this AS included in this ETSO.”
7. Page 9, disregard paragraph 2.2 Definitions: “PERIODIC TESTING”.
8. Page 10, disregard paragraph 2.2 Definitions: “PROCESS SPECIFICATION”
9. Page 10, replace paragraph 3.1 with:
“Table 1 identifies applicable requirements for typical galley insert equipment designs. Novel designs may require compliance to additional requirements, or requirements in Table 1 not identified by a bullet. To use the table, find the equipment in question along the top row, and then read down that column; the row in which a bullet appears indicates requirements that shall be addressed. A bullet in brackets indicates that the requirements are applicable for only a part of the equipment in question.”
10. Page 11, disregard paragraphs 3.2.1 and 3.2.1.1.
11. Page 12, disregard paragraph 3.2.1.2.a.
12. Page 12, replace paragraph 3.2.1.2.c with:
“Aluminium honeycomb core shall be finished for corrosion resistance.”

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13. Page 12, disregard paragraphs 3.2.1.4. through 3.2.1.6.
 14. Page 12, replace paragraph 3.2.1.8 with:

“Components shall be protected against deterioration or loss of strength in service due to environmental causes. Selection and finishing of material (including fasteners), where dissimilar metals may be placed in contact, shall be per MIL-STD-889 or equivalent. Material not inherently corrosion resistant shall be finished with a protective treatment or coating. Magnesium alloys shall not be used.”
 15. Page 13, disregard paragraphs 3.2.1.9. through 3.2.2.3.
 16. Page 14, replace paragraph 3.2.2.4 with:

“Bonded joints shall not be loaded primarily in tension”

Disregard paragraphs 3.2.2.4.a through d.
 17. Page 14, disregard paragraph 3.2.2.5.
 18. Page 14, replace paragraph 3.2.3 with:

“Construction for Trash Compactors

Trash compactors shall be constructed of fire-resistant materials capable of containing fire (see 3.10) under the conditions expected to result in service.”

Note: Fire-resistant, with respect to sheet or structural members, means the capacity to withstand the heat associated with fire at least as well as aluminium alloy in dimensions appropriate for the purpose for which they are used.
 19. Page 15, disregard paragraph 3.2.4.
 20. Page 15, replace paragraph 3.2.5 with:

“Interface clearances between equipment and the surrounding galley or structure required for ventilation, heat dissipation, installation, loading, etc. shall be clearly defined and included in the application data for this ETSO.”
 21. Page 15, replace paragraph 3.2.6 with:

“Equipment shall comply with US Food and Drug Administration (FDA) requirements for sanitary construction in Sections 1, 2, 4, and 6 of Attachment 3 Guidelines for Sanitary Construction of Aircraft Galleys and Galley Equipment, to FDA document, Guide to Inspections of Interstate Carriers and Support Facilities, (Reference 2.1.5).”
 22. Page 15, disregard paragraph 3.2.7.
 23. Page 16, disregard paragraph 3.2.8.
 24. Page 16, replace paragraph 3.3.1.a. with:

“Equipment shall be designed to meet the structural loading as specified in 4.2.1.”
 25. Page 16, replace paragraph 3.3.2.a. with:

“The structure of equipment shall address the load case in each direction and be verified according to 4.2.1.”
 26. Page 16, replace paragraph 3.3.2.b with:

“The loading conditions shall be determined by assuming installation of equipment around the z-axis of the airplane (see Figure 1).”

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27. Page 16, disregard paragraph 3.3.2.c.
28. Page 16, replace paragraph 3.3.2.d. with:
“Failure shall not occur under ultimate load cases. All permanent deformation that occurs under ultimate or limit load cases shall be reported in the data furnished with each article.”
Disregard “NOTE” following paragraph 3.3.2.d.
29. Page 16, replace paragraph 3.3.3 with:
“A local attachment factor of 1.33 shall be applied in addition to the design load factors for attachments (such as door hinges, latches and retaining devices).”
30. Page 16, replace paragraph 3.3.4 with:
“Material strength properties shall be based on tests of material meeting industry specifications to establish design values on a statistical basis. Design values shall be chosen to minimize the probability of structural failure due to material variability. The applicable specifications are Metallic Materials Process Development and Standardization (MMPDS, formerly MIL-Handbook-5) and the Composite Materials Handbook (CMH-17, formerly MIL-Handbook-17).
Analytical substantiation of material strength shall be based on material design values shown to be statistically reliable by repeated structural testing. Strength substantiation shown by full scale testing shall account for the variability of the materials and processes used to fabricate the parts by applying an appropriate overload factor. See chapter 2 in General Aviation Manufacturer's Association (GAMA) document Publication 13 for guidance in determining the appropriate overload factor.”
31. Page 18, replace paragraph 3.3.5.i. with:
“Forces generated by the conditions tested in 3.17, 4.2.1., or the weight of the retaining device itself, shall not cause the retaining device to release.”
32. Page 18, replace paragraph 3.3.5.m. with:
“Equipment with a stowage compartment (e.g., trash compactors, ovens, refrigerators and freezers, wine chillers) shall be designed such that the stowage compartment completely encloses its contents.”
33. Page 18, correct 3.3.6.b.2. to read:
“maximum wet weight, including associated components used for normal operation of the equipment (with the exception of attached hoses, tubes, pipes and/or electrical conduit), maximum amount of water in the equipment plumbing system and including water in tank, beverage in server, soaked pillow pack (if applicable).”
34. Page 19, disregard paragraph 3.3.8.
35. Page 19, disregard paragraph 3.3.9.
36. Page 19, replace paragraph 3.4.1.a. with:
“Equipment shall be designed for the primary power levels typically found in aircraft (e.g., 28VDC, and/or 115 VAC (Constant frequency (CF) or Wide variable frequency (WF), or 230 VAC (CF) or (WF)).”

37. Page 20, replace paragraph 3.4.4 with:

“Equipment shall be designed to be capable of withstanding over-voltage events without arcing, sparking, smoke or fire. Equipment shall be designed to pass the following dielectric tests: (Note: Components (filters, protection diodes) normally not capable of withstanding the dielectric withstanding voltage test without damage may be disconnected or individually disabled (e.g., short circuited) for these tests. The dielectric withstanding voltage test shall be run prior to the insulation resistance test.)” Paragraphs 3.4.4.a and b. remain unchanged.

38. Page 21, replace paragraph 3.4.7. with:

“In addition to the requirements of this document, microwave ovens shall meet the provisions of the U.S.A. Code of Federal Regulation 21 CFR § 1030.10, Performance Standards for Microwave and Radio Frequency Emitting Products.”

39. Page 21, replace paragraph 3.4.8.a. with:

“Equipment shall be designed to minimize the generation of or susceptibility to electromagnetic interference.”

40. Page 21, disregard paragraph 3.4.8.b.

41. Page 22, replace paragraph 3.4.9.b. with:

“Hidden installed equipment (e.g., remote water heater, air chiller) may have a separate control module capable of being installed on the front of the galley for the following functions:” Information in bullets remains unchanged.

42. Page 23, replace paragraph 3.6.2.a. with:

“Show the complete equipment plumbing interface in the application data for this ETSO.”

43. Page 23, disregard paragraphs 3.6.2.c and 3.6.2.d.

44. Page 23, replace paragraph 3.6.3 with:

“Equipment, capable of being connected to the potable water system of an airplane, that heats and stores water shall incorporate a feature for sensing a low water condition. Indication of low water shall both illuminate a warning light and interrupt power to the equipment heating elements.”

45. Page 23, replace paragraph 3.6.4.a. with:

“Equipment capable of being connected to an airplane potable water system shall incorporate a self-venting device.”

46. Page 23, replace paragraph 3.6.4.b. with:

“Equipment capable of being connected to an airplane potable water system shall be self-draining.”

47. Page 24, replace paragraph 3.6.6.a. with:

“Demonstrate equipment proof and burst pressure values by test and provide pressure values in the application data for this ETSO.”

48. Page 25, replace paragraph 3.6.7.b. with:

“Water taps/faucets shall be self-closing unless the application data for this ETSO specify this equipment is intended for installation above a sink in the galley monument.”

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49. Page 25, revise paragraph 3.8.c. first sentence with:
- “External surfaces that have to be heated directly to meet the equipment purpose (e.g., toaster slot, skillet surface, heating plates of a sandwich press, warmer pad for beverage server) are excluded from 3.8.a. and 3.8.b.
50. Page 25, replace paragraph 3.9 with:
- “Materials (including finishes or decorative surfaces applied to the materials) shall comply with the appropriate paragraphs of CS-25, App. F, as follows:”
51. Page 25, replace paragraph 3.9.1.a. with:
- “Equipment shall comply with the appropriate flammability requirements of CS-25 when tested per Appendix F, Part I.”
52. Page 25, replace paragraph 3.9.1.b. with:
- “Thermal and acoustic insulation material and components (batting, cover foil, foam, etc.) shall comply with the flame propagation requirements of CS-25, Appendix F, Part
- VI. Consult Advisory Circular AC 25.856-1, Thermal/Acoustic Insulation Flame Propagation Test Method Details, for appropriate guidance.”
53. Page 26, replace paragraph 3.9.2. with:
- “Exposed surfaces of equipment, when stowed, shall meet the heat release and smoke density requirements of CS-25, Appendix F, Parts IV and V.”
54. Page 26, replace paragraph 3.10.a. with:
- “Equipment dedicated to, or that may be used for, waste stowage (e.g., trash compactors) shall meet AC 25-17A Transport Airplane Cabin Interiors Crashworthiness Handbook Appendix 8 Fire Containment Test Methods, Sections 4.2 CARTS and 5.2 ACCEPTANCE CRITERIA.”
55. Page 26, replace paragraph 3.11. with:
- “Equipment shall be marked using materials and/or processes that will ensure legibility during its lifespan. Markings shall be conspicuous and worded in mandatory “command” English. Non-English language marking is acceptable, in addition to English. Non-English marking may be used alone when airworthiness requirements are not involved. Marking location, style and wording should be consistent. Weight placards shall include both English and metric units. The location and wording of placards shall be shown in the application data for this ETSO.”
56. Page 26, replace paragraph 3.11.3.a. with:
- ““No Cigarette Disposal” shall be placed on or near each waste receptacle disposal door (e.g., the waste disposal flap of a trash compactor).”
57. Page 27, disregard paragraphs 3.14.a, 3.14.b, and 3.14.c.
58. Page 27, disregard paragraph 3.17 Note #1 on Pass/Fail criteria at bottom of Table 2 and replace Note #2 with:
- “(2) Equipment shall comply with the performance requirements of this ETSO in each instance RTCA/DO-160 reads ‘DETERMINE COMPLIANCE WITH APPLICABLE EQUIPMENT PERFORMANCE STANDARDS’. The equipment shall also comply with the performance standards of this ETSO after DO-160 testing.

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59. Page 30, replace paragraph 3.18.1 with:
“The power consumption of the equipment shall be defined in the application data for this ETSO.”
60. Page 32, replace paragraph 3.19. with:
“A Failure Mode and Effects Analysis (FMEA) shall be performed at the equipment level independent of the aircraft. The analysis shall include typical and hidden failure modes throughout the entire operating range and include the effects of mishandling.”
61. Page 33, replace paragraph 4.2.1 Table 3 Note (2) with:
“(2) Load factors may be increased to meet aircraft flight and ground cases. If increased factors are used, they shall be provided in a manual, containing operating instructions and equipment limitations sufficient to describe the equipment’s operational capability, as part of the application data for this ETSO.”
62. Page 33, replace paragraph 4.2.1 Table 3 Note (5) with:
“(5) For equipment with a stowage compartment, maximum door deflections shall meet 3.3.5.n.
63. Page 34, replace paragraph 4.2.4.a. with:
“Proof Pressure Test: The qualification unit shall have its pressurized components tested to the required proof pressure; this pressure shall be held for five minutes. The equipment shall not be damaged nor leak as a result of the test.”
64. Page 35, replace paragraph 4.2.6.2.b. with:
“The top, sides and front surfaces of equipment shall be tested per CS-25, Appendix F, Parts IV and V.”
65. Page 35, correct 4.2.7. to read:
“Trash compactors used to receive combustible material shall comply with the fire containment requirements of 3.10, when substantiated per AS 8056, 4.6.”
66. Page 35, disregard section 4.2.9.
67. Page 37, replace paragraph 4.2.15. with:
“Conduct and prepare the FMEA in accordance with ARP 4761 at the equipment level independent from the aircraft.”
68. Page 38, disregard section 4.3.
69. Page 39, replace paragraph 5.1.b.12 with:
“Maximum amount of discharge air emitted by equipment, if applicable.”
70. Page 40, disregard section 5.2.
71. Page 41, disregard section 6.

[Amdt ETSO/7]

ETSO-C190

ED Decision 2010/010/R

ACTIVE AIRBORNE GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)**1 Applicability**

This ETSO gives the requirements for new models of Active Airborne Global Navigation Satellite System (GNSS) Antenna that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

This ETSO apply to equipment intended to receive and provide signals to global positioning system (GPS)/satellite based augmentation system (SBAS) sensors or systems of all operational classes, and GPS/ground based augmentation system (GBAS) sensors or systems that will provide flight path deviation commands to the pilot or autopilot. These standards do not address the use of the signals received through this antenna for other applications. GPS/SBAS receiver operational classes are defined in RTCA document DO-229D “Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment” dated December 13, 2006, Section 1.4.2.

Note: For Passive Airborne Global Navigation Satellite System (GNSS) Antenna, see [ETSO-C144a](#)

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 RTCA document DO-301 “Minimum Operational Performance Standards for Global Navigation Satellite System (GNSS) Airborne Active Antenna Equipment for the L1 Frequency Band” dated December 13, 2006, Section 2.

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

3.1.4 Electronic Hardware Qualification.

See CS-ETSO [Subpart A](#) paragraph 2.3

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO [Subpart A](#) paragraph 2.4

Failure of the function defined in paragraphs 3.1.1 of this ETSO constitutes a loss of navigation which is a major failure condition.

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

[Amdt ETSO/6]

ETSO-C194

ED Decision 2012/009/R

HELICOPTER TERRAIN AWARENESS AND WARNING SYSTEM (HTAWS)**1 Applicability**

This ETSO gives the requirements which Helicopter Terrain Awareness and Warning System (HTAWS) 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 Radio Technical Commission for Aeronautics (RTCA) Document DO-309, Minimum Operational Performance Standards (MOPS) for Helicopter Terrain Awareness and Warning System (HTAWS) Airborne Equipment, dated 13/03/2008.

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.

3.1.4 Electronic Hardware Qualification

See CS-ETSO [Subpart A](#) paragraph 2.3.

3.2 Specific**3.2.1 Failure Condition Classification**

See CS-ETSO [Subpart A](#) paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a major failure condition.

4 Marking**4.1 General**

Marking as 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.

[Amdt ETSO/7]

ETSO-C195b

ED Decision 2016/029/R

AVIONICS SUPPORTING AUTOMATIC DEPENDENT SURVEILLANCE - BROADCAST (ADS-B) AIRCRAFT SURVEILLANCE APPLICATIONS (ASA)

1 Applicability

This ETSO gives the requirements which Avionics Supporting Automatic Dependent Surveillance - Broadcast (ADS-B) Aircraft Surveillance Applications (ASA) that are designed or 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 Section 2 of EUROCAE ED-194A, dated June 2014/ Radio Technical Commission for Aeronautics (RTCA) DO-317B, dated June 17, 2014, Minimum Operational Performance Standards for Aircraft Surveillance Applications System as modified by [Appendix 1](#) of this ETSO.

Functional equipment classes for this ETSO are defined by the avionics equipment functionality they provide for one or more of the applications listed in Table 1. The four equipment functionalities are Cockpit Display of Traffic Information (CDTI) (Surface Only), CDTI, and Airborne Surveillance and Separation Assurance Processing (ASSAP) and ADS-B Traffic Advisory System (ATAS) Annunciator Panel. Applicable performance standards for these classes are identified per equipment class in Appendix L of ED-194A/DO-317B and are based on Section 2 of ED-194A/DO-317B. The functional equipment classes are shown in table 1.

Application	Criticality		Equipment Class			
	Loss of Function	Hazardous & Misleading Information	CDTI (Surface Only) (A)	CDTI (B)	ASSAP (C)	ATAS Annunciator Panel (D)
(1) Enhanced Visual Acquisition (EVAcq)	Minor	Major	Not Permitted	B1	C1	Not Applicable
(2) Basic Surface (Runways)	Minor	Major (> 80 Knots) Minor (< 80 Knots)	A2	B2	C2	Not Applicable
(3) Basic Surface (Runways + Taxiways)	Minor	Major (> 80 Knots) Minor (< 80 Knots)	A3	B3	C3	Not Applicable

Application	Criticality		Equipment Class			
	Loss of Function	Hazardous & Misleading Information	CDTI (Surface Only) (A)	CDTI (B)	ASSAP (C)	ATAS Annunciator Panel (D)
(4) Visual Separation on Approach (VSA)	Minor	Major	Not Permitted	B4	C4	Not Applicable
(5) Basic Airborne (AIRB)	Minor	Major	Not Permitted	B5	C5	Not Applicable
(6) In-Trail Procedures (ITP)	Minor	Major	Not Permitted	B6	C6	Not Applicable
(7) ADS-B Traffic Advisory System (ATAS)	Minor	Major	Not Permitted	B7	C7	D7
(8) CDTI Assisted Visual Separation (CAVS)	Minor	Major	Not Permitted	B8	C8	Not Applicable

Table 1 – ASA Functional Equipment Classes (per ED-194A/DO-317B)

The in-trail procedures (ITP) application (item 6 in Table 1) supports a new separation standard in procedural airspace. ITP application enables aircraft that desire flight level changes in procedural airspace to achieve these changes on a more frequent basis, thus improving flight efficiency and safety. The ITP achieves this objective by permitting a climb-through or descend-through maneuver between properly equipped aircraft, using a new distance-based longitudinal separation minimum during the maneuver.

ASSAP equipment authorised under this ETSO must contain or support an interface to an ADS-B receiver. If the receiver is embedded in the equipment, it must meet ETSO-C154c, *Universal Access Transceiver (UAT) Automatic Dependent Surveillance-Broadcast (ADS-B) Equipment Operating on Frequency of 978 MHz or ETSO-C166b, Extended Squitter Automatic Dependent Surveillance - Broadcast (ADS-B) and Traffic Information Service - Broadcast (TIS-B) Equipment Operating on the Radio Frequency of 1090 Megahertz (MHz)*. If the receiver is not embedded, the installation manual must have a requirement to interface to an ETSO-C154c or ETSO-C166b approved ADS-B receiver.

If intended for installation on aircraft with traffic advisory system (TAS) or traffic alert and collision avoidance system (TCAS) equipment, ASSAP equipment authorised under this ETSO must contain or support an interface to equipment complying with ETSO-C147(), *Traffic Advisory System (TAS) Airborne Equipment*, ETSO-C118(), *Traffic Alert and Collision Avoidance System (TCAS) Airborne Equipment, TCAS I, or ETSO-C119(), Airborne Collision Avoidance System II (ACAS II)*. If the ASSAP equipment does not support this functionality, the installation manual must prohibit installation on an aircraft equipped with TAS or TCAS.

Class A and B equipment authorised under this ETSO must comply with ETSO-C165a *Electronic Map Systems for Graphical Depiction of Aircraft Position* when implementing surface applications. This ETSO shall take precedence where it differs from ETSO-C165a. Databases used to support moving maps integrated with the SURF application must meet at least 5 meter accuracy and 1 meter resolution. Databases used to support moving maps integrated with the SURF application

must meet EUROCAE ED-76/RTCA DO-200A Data Process Assurance Level 2 for state-provided data with essential integrity as defined in RTCA DO-272B.

Equipment authorised under this TSO may include or interface with airborne multipurpose electronic display equipment complying with ETSO-C113a.

Equipment authorised under this ETSO must contain or support an interface to position sources that meet one of the following ETSOs: ETSO-C129(), ETSO-C145(), ETSO-C146(), ETSO-C196() or equivalent.

3.1.2 Environmental Standard

See CS-ETSO Subpart A paragraph 2.1. The system performance to be demonstrated during the environmental testing is defined in EUROCAE ED-194A/RTCA DO-317 section 2.4.

Explosion testing in accordance with EUROCAE ED-14()/RTCA DO-160() section 9 is considered optional.

Electrostatic discharge testing in accordance with EUROCAE ED-14()/RTCA DO-160() Section 25 is required for all equipment having control elements and are expected to be touched during operation.

3.1.3 Computer Software

See CS-ETSO Subpart A paragraph 2.2.

3.1.4 Electronic Hardware Qualification

See CS-ETSO Subpart A paragraph 2.3.

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO Subpart A paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a major failure condition for malfunctions causing the display of hazardous misleading information in airborne aircraft and aircraft on the ground greater than 80 knots. Failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a minor failure condition for malfunctions causing the display of hazardous misleading information in aircraft on the ground less than 80 knots groundspeed. Loss of function has been determined to be a minor failure condition.

4 Marking

4.1 General

Marking as 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.

[Amdt ETSO/7]

[Amdt ETSO/12]

APPENDIX 1 TO ETSO-C195B – AMENDMENT TO ED-194A/DO-371B

ED Decision 2016/029/R

A2.1 Introduction

This Appendix amends ED-194A/DO-371B to address specific issues raised since publication of the document.

A2.2 TCAS II Integration with TSAA

TCAS integration is addressed in ED-194A/DO-371B section 2.2.4.5.3.3, titled 'TSAA Traffic Caution alerts on Correlated TCAS Tracks'. Replace the current section 2.2.4.5.3.3 with the following text:

The TSAA application may be integrated with TCAS I, TCAS II, or TAS systems.

If an ADS-B/ADS-R/TIS-B track is correlated with a TCAS track, then the alerts shall (2223) only be presented from either the TSAA application or the TCAS system (i.e., not both).

If TSAA and TCAS II are installed on the same aircraft, TCAS II resolution advisories (RAs) shall (####) have priority over all other alerts.

If TSAA and TCAS II are installed on the same aircraft, TCAS II traffic advisories (TAs) shall (####) be generated for the TCAS tracks by the TCAS II TA function. TSAA may generate traffic alerts for ADS-B only traffic not correlated with a TCAS track.

TSAA alerts should take precedence over TCAS I or TAS traffic alerts (TAs) when the TCAS track is correlated with an ADS-B or ADS-R track; but, TCAS traffic alerts should take precedence over TSAA alerts when the TCAS track is correlated with a TIS-B track.

A2.3 TCAS Validation of ITP Traffic

TCAS validation of ITP traffic is addressed in ED-194A/DO-371B section 2.2.4.4.2.1, titled 'Validation of Traffic Position with TCAS Data'. Add the following text to the end of the second paragraph.

ASSAP is not required to support ADS-R or TIS-B traffic for use with the ITP application.

A.2.4 TCAS Validation of CAVS Traffic

TCAS validation of CAVS traffic is addressed in ED-194A/DO-371B section 2.2.4.6.2.1, titled 'Validation of Traffic Position with TCAS Data'. Remove all instances of the text '/ADS-R' from this section and add the following text to the end of the second paragraph.

ASSAP is not required to support ADS-R or TIS-B traffic for use with the CAVS application.

[Amdt ETSO/12]

ETSO-C196b

ED Decision 2020/011/R

**AIRBORNE SUPPLEMENTAL NAVIGATION SENSORS FOR GLOBAL POSITIONING
SYSTEM EQUIPMENT USING AIRCRAFT-BASED AUGMENTATION****1 Applicability**

This ETSO provides the requirements which airborne supplemental navigation sensors for Global Positioning System equipment using aircraft-based augmentation that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

Note: Revision b provides applicants with the option to use an ETSO-2C206 GNSS circuit card assembly (CCA) as part of their ETSO application. There is no technical change to the MOPS in comparison with ETSO-C196a.

2 Procedures**2.1 General**

The applicable procedures are detailed in CS-ETSO, [Subpart A](#).

2.2 Specific

This section applies only for ETSO articles that use an ETSO-2C206 GNSS CCA.

Applicants who use an ETSO-2C206 GNSS CCA will need to coordinate with their GNSS CCA supplier for at least the following aspects:

2.2.1 Access to the Information of the Selected ETSO-2C206 CCA

The applicant is responsible for establishing the necessary communication channels with the ETSO-2C206 holder company. Applicants who use an ETSO-2C206 SBAS CCA will need to coordinate with their SBAS CCA supplier to obtain the documentation that supports ETSO-2C206.

The applicant's organisation shall establish a means of communication to obtain timely notifications of design changes, open problem reports (at least the ones that impact the usage of the CCA), occurrence reports and airworthiness directives that affect or relate to the ETSO-2C206 article.

2.2.2 Assessment of Design Changes

The applicant shall perform an impact analysis of the design changes to the ETSO-2C206 article, and shall perform the necessary development life-cycle activities that are impacted by the ETSO-2C206 changes.

Note: If a major change (as assessed per point 21.A.611) is applied to the ETSO-2C206 article, which is installed in the ETSO-C196b article, it is also systematically considered to be major for the ETSO-C196b function.

2.2.3 Assessment and Reporting of Open Problem Reports (OPRs)

The applicant shall perform the assessment of the ETSO-2C206 CCA OPRs. The applicant shall report the resulting OPRs that affect the ETSO-C196b article.

3 Technical Conditions

3.1 Basic

3.1.1 Minimum Performance Standard

The applicable standards are those provided in the Radio Technical Commission for Aeronautics (RTCA) document DO-316, Minimum Operational Performance Standards (MOPS) for Global Positioning System/Aircraft Based Augmentation System Airborne Equipment, dated 14 April 2009, Section 2.

Use of an ETSO-2C206 GNSS CCA functional sensor

ETSO-196b applicants have the option to use an ETSO-2C206 GNSS CCA functional sensor. Applicants who choose to use an ETSO-2C206 GNSS CCA can take credit for certification compliance by virtue of the ETSO-2C206 ETSOA for:

- meeting the MPS Section 2.1 requirements;
- the development assurance of the hardware/software;
- the classification of the failure conditions;
- the MPS Section 2.3 performance testing (functional qualification), except that specified in Appendix 1 to this ETSO; and
- partial environmental testing performed on the ETSO-2C206 GNSS CCA.

After the integration of the ETSO-2C206 CCA in the ETSO-196b article, the applicant shall perform the testing described in Appendix 1. The applicant shall also complete the environmental qualification testing. The testing shall include the detailed functional test procedures delivered by the ETSO-2C206 GNSS CCA provider. This testing is required to address the paragraphs of this ETSO that are not covered by the items listed above.

Note: An end-use equipment manufacturer that uses an ETSO-2C206 SBAS CCA functional sensor assumes full responsibility for the design and the function under their ETSO-C196b authorisation.

3.1.2 Environmental Standard

See CS-ETSO, [Subpart A](#), paragraph 2.1.

Test to EUROCAE ED-14() Sections 9 and 26 are considered to be optional. Tests to Sections 10, 11, 12, 13, and 14 are required only when the component is installed on the outside of the aircraft, such as the antenna.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

Applicants who use ETSO-2C206 GNSS CCA functional sensors may use the ETSO 2C206 authorisation as substantiation for compliance with the software development assurance aspects of the CCA.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

Applicants who use ETSO-2C206 GNSS CCA functional sensors may use the ETSO 2C206 authorisation as substantiation for compliance with the hardware development assurance aspects of the CCA.

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

A failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a major failure condition for a malfunction of oceanic/remote, en route and terminal navigation and lateral navigation (LNAV) approaches.

A failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a minor failure condition for a loss of navigation of oceanic/remote, en route and terminal navigation and lateral navigation (LNAV) approaches.

Note: These failure condition classifications are considered to be the minimum classifications. Guidance for the installation of navigation systems at the aircraft level (e.g. Certification Specifications and Acceptable Means of Compliance for Airborne Communications, Navigation and Surveillance (CS ACNS)) could require a different failure condition classification.

3.2.2 Additional Specific

Barometric-aided Fault Detection and Exclusion (FDE). If the equipment uses barometric-aiding to enhance the availability of FDE, then the equipment must meet the requirements in RTCA document DO-316, Appendix G.

4 Marking

4.1 General

See CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

None.

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/7]

[Amdt ETSO/16]

APPENDIX 1 TO ETSO-C196B – END-USE EQUIPMENT MANUFACTURER TESTS FOR GNSS CCA FUNCTIONAL PVT SENSORS USED FOR NAVIGATION AND NON-NAVIGATION APPLICATIONS

ED Decision 2020/011/R

1. SCOPE

This Appendix describes the required supplementary equipment level testing, in addition to the environmental testing of RTCA document DO-316, Section 2.2, that the manufacturer of the end-use equipment is required to conduct in order to receive an ETSO-C196b authorisation if they use an ETSO-2C206 GNSS CCA functional sensor. These test procedures are intended to streamline and simplify the ETSO-C196b authorisation process for the manufacturer of the end-use equipment by allowing credit for the design and selected testing performed at the GNSS CCA functional sensor level. However, the manufacturer of the end-use equipment remains fully responsible for the design and control of the article per their ETSO-C196b authorisation.

2. GENERAL PRINCIPLES

- (a) The testing methods for GPS equipment have been standardised by RTCA document DO-316, and these serve as the basis for ETSO-C196b. RTCA document DO-316 was written to cover equipment that can be installed on aircraft. Section 2.2 specifically addresses the issues of the environment in which the equipment operates, and provides the approved test methods to validate its performance in this environment. Section 2.2 represents the RTCA consensus in identifying which RTCA document DO-316 requirements are sensitive to environmental effects. These requirements are listed in Table 2-2, referenced in Section 2.2.1.
- (b) The determination that a MOPS requirement is susceptible to the environment does not depend on whether or not the implementation is a GNSS CCA within an ETSO-C196b article. Only the sensitivity to the environment is affected. This is the same concept as an equipment enclosure that is designed to protect against a benign environment compared with one that is designed for a severe environment; the identification of the susceptible requirements is the same.
- (c) Therefore, this Appendix uses Table 2-2 of RTCA document DO-316, Section 2.2.1, to identify the MOPS requirements that are susceptible to environmental conditions for a GNSS CCA functional sensor in the end-use equipment. The focus is on the change in environment seen by the GNSS CCA functional sensor as a result of its installation in the end-use equipment. For example, other components inside the end-use equipment may radiate RF energy that could interfere with the GPS functions; therefore, the ambient testing performed at the CCA level is not equivalent to the tests performed in the end-use equipment. This is the basis for defining the Section 2.3 performance tests that need to be repeated by the manufacturer of the end-use equipment.
- (d) Table 2-2, referenced in RTCA document DO-316, Section 2.2.1, is the prime source to determine the MOPS performance requirements that are susceptible to environmental conditions. Based on that table, the susceptible requirements can be grouped into two categories: those that are susceptible to most types of environmental conditions (described in Section 3) and those that are susceptible to only a few (described in Section 4).

3. PERFORMANCE REQUIREMENTS THAT ARE SUSCEPTIBLE TO MOST ENVIRONMENTAL CONDITIONS

3.1. RTCA document DO-316: Accuracy, sensitivity and dynamic range

The RTCA document DO-316 requirements for accuracy (2.1.3.1) and for sensitivity and dynamic range (2.1.1.10) are sensitive to most environmental conditions. Section 3 identifies the testing that manufacturers of end-use equipment are required to repeat to demonstrate that the GNSS CCA functional sensor continues to meet the accuracy and dynamic range performance requirements after installation in the end-use equipment. All the tests shall be run under conditions in which the functions of the end-use equipment are fully enabled to create the worst-case environment.

3.2. RTCA document DO-316: Section 2.3.6 Accuracy Test

- (a) The accuracy test described in Section 2.3.6 is actually a joint test that covers accuracy, sensitivity and dynamic range. This joint testing also applies under the environment as stated in Section 2.2.1.1.5, with the environmental adaptations as described in Section 2.2.1.1.1.
- (b) The demonstration of accuracy is performed in accordance with Section 2.3.6 only for the test case with broadband external interference noise. This test must be repeated when the GNSS CCA functional sensor is installed in the end-use equipment, and it is sufficient to perform it using broadband interference.
 - (1) The environmental testing is limited to broadband interference, as it represents the worst-case signal-to-noise condition, which is the most sensitive to environmental effects. This applies equally to the environment for the GNSS CCA functional sensor that is created by the end-use equipment.
 - (2) Section 2.3.6 contains a measurement accuracy test in 2.3.6.1, with the simulator and interference conditions described in 2.3.6.2, and the detailed test procedure in 2.3.6.2.1. The Section 2.3.6 test must be run under the worst-case environment identified in Section 5 'Additional considerations for internal interference sources' below.
 - (3) Section 2.3.6.3 is a 24-hour actual satellite accuracy test. The Section 2.3.6.3 test exposes the equipment to a variety of signal conditions and data-processing conditions over varying satellite geometries that will increase the confidence that no unforeseen interactions between the components within the end-use equipment and the GNSS CCA functional sensor will go undetected.
- (c) The test threshold is relaxed from 110 % to 125 %, as specified in Table 2-6 of the Section 2.3.6.2.1 test procedure, to shorten the duration of the test. However, the Section 2.3.6 testing for the GNSS CCA functional sensor in the end-use equipment shall be under the ambient conditions per Section 2.3 with the 110-% test pass threshold for maximum test sensitivity.
- (d) Only the broadband external interference noise test case using the minimum satellite power will be executed in most cases to shorten the duration of the test. The testing of Sections 2.3.6.1 and 2.3.6.2 will be repeated for both the minimum and the maximum satellite power only for the worst-case environment.

4. PERFORMANCE REQUIREMENTS THAT ARE PARTIALLY SUSCEPTIBLE TO ENVIRONMENTAL CONDITIONS

- (a) Table 2-2 in RTCA document DO-316 indicates that the acquisition time (2.1.1.7) and the reacquisition time (2.1.1.9) requirements are sensitive to four environmental conditions: icing, lightning-induced transient susceptibility, lightning direct effects, and normal/abnormal operating conditions. The requirements for loss of navigation (2.1.1.11.2) and loss of integrity (2.1.1.11.1) are sensitive to low and high operating temperatures.

Note: RTCA document DO-316 Table 2-2 contains a typo that erroneously numbers the loss of navigation and loss of integrity requirements as 2.1.1.13.2 and 2.1.1.13.1.

- (b) The lightning-induced transient susceptibility, lightning direct effects, or icing environmental conditions are not pertinent to the environment that is created by the end-use equipment relative to the GNSS CCA functional sensor. However, the manufacturer of the end-use equipment remains responsible for meeting the overall environmental qualification at the end-use equipment level.
- (c) Loss of navigation and loss of integrity indications are limited to temperature testing and the information in RTCA document DO-316, Sections 2.2.1.1.2 and 2.2.1.1.3, is appropriate. The purpose is to ensure that the interface that is used to indicate the loss of navigation or integrity is functional under the environmental conditions that are present after the GNSS CCA functional sensor is installed in the end-use equipment. Sections 2.2.1.1.2 and 2.2.1.1.3 indicate that any source that generates the indication can be used, since it is the interface and not the detection mechanism that is verified. The temperature testing performed at the end-use equipment level is the worst-case scenario. It is not necessary to repeat the GNSS CCA level test at room temperature in the end-use equipment since the environmental qualification adequately addresses the testing for these requirements.
- (d) EUROCAE ED-14 Section 16 relates to aircraft power supplies (refer to ETSO Section 3.1.2 for the environmental qualification requirements). Sections 16.5.1.2 and 16.6.1.2 are for normal/abnormal operating conditions. Given the potential susceptibility of the GNSS CCA functional sensor to power supply noise, it is prudent to repeat the tests at the end-use equipment level on this basis. Table 2-2, referenced in RTCA document DO-316, Section 2.2.1, does not guarantee the execution of specific acquisition testing.
- (e) Sections 4.1 and 4.2 identify the testing that manufacturers of end-use equipment are required to repeat to demonstrate that the GNSS CCA functional sensor continues to meet the acquisition time and reacquisition time performance requirements relative to the normal/abnormal operating conditions after installation in the end-use equipment. All the tests shall be run under conditions in which the functions of the end-use equipment are fully enabled to create the worst-case environment.

4.1. RTCA DO-316: Section 2.3.3 Initial Acquisition Test Procedures

The information in RTCA document DO-316, Section 2.2.1.1.4, on the initial acquisition test in Section 2.3.3, applies. The manufacturer of the end-use equipment shall repeat the initial acquisition testing described in RTCA document DO-316, Section 2.3.3.

4.2. RTCA document DO-316: Section 2.3.4 Satellite Reacquisition Time Test

The manufacturer of the end-use equipment is required to repeat the satellite reacquisition time testing in RTCA document DO-316, Section 2.3.4.

5. ADDITIONAL CONSIDERATIONS FOR INTERNAL INTERFERENCE SOURCES

- (a) Installing a GNSS CCA functional sensor into end-use equipment that also includes other functions requires a careful evaluation of the potential internally radiated and conducted interference. The manufacturer of the end-use equipment must evaluate each operating mode to determine whether the mode changes the environment for the installed GNSS CCA functional sensor. If there is only one environment or there is clearly one worst-case environment, then the accuracy and message loss rate testing in Section 3 can be run in that operating mode only. For example, if the end-use equipment includes an RF transmitter that radiates at one frequency, one could reasonably argue that setting the transmitter at full power with maximum data throughput would generate a clear worst-case environment in which to run all the testing.
- (b) In the case of multiple environments, the accuracy and message loss rate tests can either be run under each environment, or the methodology in RTCA document DO-316, Section 2.2.1.2.3, can be used to run an aggregate with approximately equal time in each mode. The methodology in Section 2.2.1.2.3 must be used to identify the modes of greatest susceptibility under which the combined accuracy and message loss rate tests are repeated in addition to the aggregate test. For example, the 2.2.1.2.3 methodology is appropriate for end-use equipment that contains a high-power transmitter that operates on a large number of frequencies such that it is impractical to run a test at each frequency. This is analogous to the large number of frequencies that need to be tested during the EUROCAE ED-14 Section 19 testing on induced signal susceptibility and the Section 20 testing on radio frequency susceptibility, and this is the reason why the Section 2.2.1.2.3 methodology was developed.
- (c) It is sufficient to identify one worst-case environment when performing acquisition and 24-hour accuracy testing.

6. SUMMARY

- (a) The manufacturer of end-use equipment that incorporates a GNSS CCA functional sensor is required to repeat the following RTCA document DO-316 Section 2.3 testing under ambient conditions (see paragraph 5) after installing the GNSS CCA functional sensor in the end-use equipment:
 - The Section 2.3.6 accuracy test adapted per Section 2.2.1.1.1, except that the 110 % test pass threshold is used.
 - Note: Refer to Section 5 ‘Additional considerations for internal interference sources’ of this Appendix, which could affect the test methodology.
 - The Section 2.3.3 initial acquisition test.
 - The Section 2.3.4 satellite reacquisition time test.
- (b) The manufacturer of the end-use equipment remains responsible for completing a full environmental qualification evaluation (see ETSO Section 3.1.2) at the end-use equipment level. The manufacturer of the end-use equipment that incorporates a GNSS CCA functional sensor is required to repeat the Loss of Navigation and Loss of Integrity indication environmental testing according to RTCA document DO-316, Sections 2.2.1.1.2 and 2.2.1.1.3.

[Amdt ETSO/16]

ETSO-C198

ED Decision 2013/012/R

AUTOMATIC FLIGHT GUIDANCE AND CONTROL SYSTEM (AFGCS) EQUIPMENT**1 Applicability**

This ETSO gives the requirements which Automatic Flight Guidance and Control System (AFGCS) Equipment 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 RTCA DO-325, Automatic Flight Guidance and Control Systems and Equipment, dated 08/12/2010.

3.1.2 Environmental standard

See CS-ETSO, [Subpart A](#), paragraph 2.1.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne electronic hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific**3.2.1 Failure condition classification**

See CS-ETSO, [Subpart A](#), paragraph 2.4.

There is no standard minimum failure condition classification for this ETSO. The failure condition classification appropriate to the equipment will depend on the intended use of the equipment in a specific aircraft.

4 Marking**4.1 General**

Marking as 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.

[Amdt ETSO/8]

ETSO-C199 A1

ED Decision 2020/011/R

TRAFFIC AWARENESS BEACON SYSTEM (TABS)**1 Applicability**

This ETSO provides the requirements for the applicable equipment class defined by this ETSO which traffic awareness beacon systems (TABSs) that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

TABS devices are distinctly different from other transponders. TABS devices are intended for voluntary equipage on aircraft that are exempted from carrying a transponder or automatic dependent surveillance — broadcast (ADS-B) equipment, such as gliders, balloons and aircraft without electrical systems. TABS devices do not meet the transponder or ADS-B requirements defined in Commission Implementing Regulation (EU) No 1207/2011 of 22 November 2011 laying down requirements for the performance and the interoperability of surveillance for the single European sky. TABS equipment built to the minimum requirements of this ETSO will enable an aircraft to be visible to other aircraft equipped with:

- a Traffic Advisory System (TAS) as defined in ETSO-C147();
- a Traffic Alert and Collision Avoidance System I (TCAS I) as defined in ETSO-C118();
- a Traffic Alert and Collision Avoidance System II, (TCAS II), as defined in ETSO-C119d;
- ADS-B IN capability as defined in ETSO-C154c, ETSO-C166b (), and ETSO-C195b.

2 Procedures**2.1 General**

The 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**

TABS requirements are derived from existing transponder and ADS-B requirements. Equipment that only meets the minimum TABS requirements will provide the capability to be seen by other aircraft equipped with traffic advisory systems, but may not support its detection by ground surveillance systems that rely on full transponder functionality. A designer who builds equipment to meet this ETSO may decide to incorporate more capability than what is outlined in this ETSO, as long as it meets the applicable requirements in the referenced standards (e.g. EUROCAE ED-73E, MOPS for Secondary Surveillance Radar Mode S Transponders, as amended by [Appendix 1 to ETSO-C112e](#)).

TABS functionality is divided into four categories: the transponder function, the altitude source function, the ADS-B OUT function, and the position source function.

A Class A TABS:

- includes the transponder, altitude source, and ADS-B OUT functionality; refer to subparagraphs (a), (b), and (c) below;
- consists of a Class A device, or an ETSO-C112e and an ETSO-C166b-compliant device.

A Class B TABS:

- includes the Global Navigation Satellite System (GNSS) position source functionality; refer to subparagraph (d) below;
- consists of a Class B device, or an ETSO-C129a (cancelled), ETSO-C145c or later revision, ETSO-C146c or later revision, or an ETSO-C196b-compliant GPS.

A TABS may include an ADS-B IN function, but it is not required. If it is implemented, the ADS-B IN function shall meet the performance specified in ETSO-C195b as well as ETSO-C154c, or ETSO-C166b, or all three. A TABS is intended to make the aircraft a valid TIS-B and ADS-R client.

- (a) The transponder functionality must meet a subset of the requirements in document RTCA document DO-181E, MOPS for Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment, dated 17 March 2011, Section 2, for a Level 2, Class 2 transponder as amended by [Appendix 1](#).
- (b) The altitude source functionality must meet the requirements of ETSO-C88a or later revision, Automatic Pressure Altitude Reporting Code Generating Equipment, dated 5 August 2016.
- (c) The ADS-B OUT function must meet a subset of the requirements found in document EUROCAE ED-102A, Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance — Broadcast (ADS-B) and Traffic Information Services — Broadcast (TIS-B), dated December 2009, including Corrigendum-1, Section 2, dated January 2012, Class B0 as amended by Appendix 1. The system must be built such that it transmits Navigation Integrity Code (NIC), Navigation Accuracy Category for Position (NACp), Navigation Accuracy Category for Velocity (NACv), Geometric Vertical Accuracy (GVA), and Safety Integrity Level (SIL) values that are appropriate for the GNSS receiver used.
- (d) The position source function must use a GNSS receiver that meets the requirements defined in Appendix 1. The intent of this ETSO is to allow the use of commercially available GNSS position sources. The receiver must be capable of using SBAS-provided corrections and health messages, as defined in Appendix 1, in order to provide a means to prevent the TABS from transmitting false or misleading information. The receiver may continue to provide position when outside of SBAS coverage or when using unmonitored satellites. TABS Class B position sources may not be used for certified navigation equipment.

3.1.2 Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1.

For Class A equipment, demonstrate the required performance under the test conditions specified in RTCA document DO-181E Section 2.3 and EUROCAE ED-102A, including Corrigendum-1, Section 2.3, dated January 2012.

For Class B equipment, demonstrate the required performance under the test conditions specified in [Appendix 3](#).

3.1.3 Software

See CS-ETSO, Subpart A, paragraph 2.2.

This requirement applies to Class A equipment only. Class B equipment is exempt from the software qualification defined in this paragraph.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

This requirement applies to Class A equipment only. Class B equipment is exempt from the electronic hardware qualification defined in this paragraph.

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

A failure of the function defined in paragraph 3.1.1 of this ETSO that results in misleading information is a minor failure condition.

A failure of the function defined in paragraph 3.1.1 of this ETSO that results in a loss of function is a minor failure condition.

Class B equipment is intended to be met by commercially available GNSSs and is unlikely to be designed specifically to support a minor hazard classification. The suitability of Class B equipment suitability for supporting the function in paragraph 3.1.1 of this ETSO is established by performing the functional and environmental testing in [Appendix 2](#) and Appendix 3 to this ETSO with no further analysis required.

4 Marking

4.1 General

See CS-ETSO, Subpart A, paragraph 1.2.

4.2 Specific

None.

5 Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

EUROCONTROL Documents: EUROCONTROL, STA/R/460/0001/1, Study to Address the Detection and Recognition of Light Aircraft in the Current and Future ATM Environment, Issue 1.0, Final Report, dated 31 March 2005.

FCC Documents: Federal Communication Commission document OET Bulletin 65 Ed 97-01, Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields is available on the internet at:

http://transition.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet65/oet65.pdf

UK Public Health Documents Public Health England document HPA-RPD-031, Exposure to EMFs from Lightweight Aviation Transponders, dated September 2007, ISBN 978-0-85951-605-1, can be obtained on line by going to:

<http://www.hpa.org.uk/Publications/Radiation/HPARPDSeriesReports/HpaRpd031/>

Global Positioning System Signals, Measurements, and Performance, Ganga-Jamuna Press, by Pratap Misra and Per Enge. ISBN: 0-9709544-0-9

[Amdt ETSO/13]

[Amdt ETSO/16]

APPENDIX 1 TO ETSO-C199 A1 – TRAFFIC AWARENESS BEACON SYSTEM (TABS) REQUIREMENTS

ED Decision 2020/011/R

A1 Introduction

A1.1 TABS Intent

A1.1.1 The intent of a TABS is to increase safety by encouraging the voluntary equipage of a low-cost, compact, easy-to-install device that will allow other aircraft equipped with collision avoidance systems and traffic advisory systems to track and display the TABS aircraft. TABSs are intended to be used on aircraft that are exempted from carrying a transponder or Automatic Dependent Surveillance — Broadcast (ADS-B) equipment, such as gliders, balloons and aircraft without electrical systems. TABS devices do not meet the transponder requirements defined in Commission Implementing Regulation (EU) No 1207/2011 of 22 November 2011 laying down requirements for the performance and the interoperability of surveillance for the single European sky. A TABS will allow these exempted aircraft to be visible to other aircraft equipped with:

1. a Traffic Advisory System (TAS) as defined in ETSO-C147();
2. a Traffic Alert and Collision Avoidance System I (TCAS I) as defined in ETSO-C118();
3. a Traffic Alert and Collision Avoidance System II, (TCAS II), as defined in ETSO-C119d;
4. ADS-B IN capability as defined in ETSO-C166b, and ETSO-C195b; or
5. ADS-B IN capability as defined in ETSO-C154c in airspace where UAT is used.

A1.1.2 A TABS is designed to:

6. reply to ATCRBS Mode C, and Mode S UF=0, 4, 5, 20 and 21 interrogations;
7. not reply to ATCRBS Mode A interrogations;
8. not reply to Mode S UF=11, and 16 interrogations;
9. incorporate ETSO-C88b, Automatic Pressure Altitude Reporting Code-Generating Equipment;
10. transmit ADS-B Messages: Aircraft Identification and Category, Airborne Position, Airborne Velocity, Emergency Priority Status Message, and Aircraft Operational Status;
11. optionally provide Surface Position Messages;
12. optionally use a commercial GNSS source meeting the requirements of this ETSO.

A1.1.3 A TABS can potentially act as a low-cost platform for other aviation applications. Although additional capabilities are beyond the scope of this ETSO, TABSs may include additional functions such as data loggers, search and rescue transmitter, or provide flight information services.

A1.2 Requirements

A1.2.1 TABS requirements are derived from existing Mode S transponder and 1090 MHz Extended Squitter ADS-B requirements. A designer who builds equipment to meet this ETSO may decide to incorporate the full transponder and ADS-B capability by using a device that meets ETSO-C112e and ETSO-C166b. If they elect to implement the full functionality, they must demonstrate that functionality against the unmodified test procedures in EUROCAE ED-102A, including Corrigendum-1, dated January, 2012, that are required by ETSO-C112e and ETSO-C166b respectively. Designers who wish to take advantage of the reduced transponder requirements afforded to ETSO-C199 Class A devices must meet the modified requirements outlined in paragraphs A1.2.3 Transponder Function Requirements, A1.2.4 Altitude Source Function Requirements, and A1.2.5 ADS-B OUT Function Requirements in this

Appendix in their entirety. Designers wishing to take advantage of the Class B reduced GNSS requirements will need to meet the requirements outlined in paragraphs A1.2.6 GNSS Position Source Function Requirements.

A1.2.2 MOPS text is used here with the permission of the RTCA. Table 1 provides notes in italics and parenthesis explaining how to read the tables that modify the text in the source documents.

(Source document reference)	Modified text for this ETSO
(This is a copy of the original text from the source document. Material to be deleted from this original text is marked with ~~strikethrough formatting~~ .)	(This is the requirement for this ETSO. Modifications to the source text are marked in bold and underlined to assist in identifying changes).

Table 1 — (Source document reference) (type of change)

A1.2.3 Transponder Function Requirements Derived From DO-181E (For Class A Devices)

A1.2.3.1 The transponder function must meet the Minimum Performance Standards (MPS) qualification and documentation requirements in RTCA, Inc. document RTCA document DO-181E, Section 2, for a Level 2, Class 2, transponder as modified below.

A1.2.3.1.1 Flight Crew Control Function Changes

A1.2.3.1.2 A cost factor in any device is the control and display functions to interface with the human operator. TABS display and control requirements are a subset of those required for transponders. Some user controls are allowed via an external device prior to flight (e.g., a personal electronic device (PED)). If the system is powered by batteries, display of the available battery life is recommended. Table 2 provides an overview of the flight crew control functions.

Operation mode	Required Controls	Required Indicators
In flight (i.e., control head)	- Power, - Emergency (3/A code 7700), - IDENT (optional)	Power on, Transponder Fail, ADS-B Fail, Battery indicator (optional)
Non-flight (optional in flight) (i.e., Personal Electronic Device PED)	- Set 4096 code, - Set Flight ID	Display of 4096 code, Display of Flight ID
Maintenance actions (allowed in non-flight conditions only)	- Set ICAO 24-bit aircraft address, - Set implementation specific configuration	Display of ICAO 24-bit aircraft address, Display of implementation specific configuration. Display software version (optional)

Table 2 — Summary of Control and Indication Requirements by Operation Mode

A1.2.3.1.3 RTCA document DO-181E, Section 2.1.7.a, Flight Crew Control Functions, is amended as shown in Table 3.

DO-181E text	Modified text for this ETSO
The following functions Shall be provided a. A means of selecting each of the ATCRBS 4096 reply codes, ~~and of~~ indicating the code selected.	The following functions SHALL be provided <u>as indicated in items a-f.</u> a. A means of selecting <u>and displaying</u> the ATCRBS 4096 code <u>on the ground SHALL be provided. A means of selecting and displaying the ATCRBS 4096 code in flight is optional. A means of setting the Mode 3/A code to 7700 (emergency), either by entering in the value or an automated means such as a switch, SHALL be provided. A means of setting an alternate 4096 code other than the primary 4096 code, either by entering in the value or an automated means such as a switch, SHALL be provided.</u>

Table 3 — DO-181E Section 2.1.7.a amendment

A1.2.3.1.4 RTCA document DO-181E, Section 2.1.7.b, Flight Crew Control Functions, is amended as shown in Table 4.

DO-181E text	Modified text for this ETSO
The following functions Shall be provided b. A means of selecting the air/ground state: 1) An automatic means ~~shall be the only acceptable means~~ to determine the air/ground state. 2) If an automatic means is not available, the transponder Shall ensure that the air/ground state is Airborne	The following functions SHALL be provided <u>as indicated in items a-f.</u> b. A means of selecting the air/ground state: 1) An automatic means to determine the air/ground state <u>is recommended.</u> 2) If an automatic means is not <u>implemented</u>, the transponder SHALL ensure that the air/ground state is Airborne.

Table 4 — DO-181E Section 2.1.7.b amendment

A1.2.3.1.5 RTCA document DO-181E, Section 2.1.7.c, Flight Crew Control Functions, is amended as shown in Table 5.

DO-181E text	Modified text for this ETSO
The following functions Shall be provided c. A means of selecting the condition in which all transponder functions, other than transmission on the reply frequency and associated self-testing, are operational (i.e., the Standby condition). Return to normal operation from this condition Shall be possible within five seconds.	The following functions SHALL be provided <u>as indicated in items a-f.</u> c. A means of selecting the condition in which all transponder functions, other than transmission on the reply frequency and associated self-testing, are operational (i.e., the Standby condition) <u>is not required. However, if provided</u>, return to normal operation from Standby condition SHALL be possible within five seconds.

Table 5 — DO-181E Section 2.1.7.c amendment

A1.2.3.1.6 RTCA document DO-181E, Section 2.1.7.d, Flight Crew Control Functions, is amended as shown in Table 6.

DO-181E text	Modified text for this ETSO
The following functions Shall be provided d. A means of initiating the IDENT (SPI) feature.	The following functions SHALL be provided <u>as indicated in items a-f.</u> d. A means of initiating the IDENT (SPI) feature <u>is optional.</u>

Table 6 — DO-181E Section 2.1.7.d amendment

A1.2.3.2 Reply Rate Capability Changes

A1.2.3.2.1 This section reduces the minimum reply rate capability of the TABS consistently with the interrogation acceptance based on two assumptions. The following rationale describes how the modified reply rates were chosen.

A1.2.3.2.1.1 Assumption 1. The worst-case Mode C interrogation count in a 100-millisecond interval from 1 ATCRBS radar is approximately 14 interrogations. 4 ATCRBS radar overlapping beam dwells in 1 second is approximately 53 Mode C interrogations. The Mode C interrogation acceptance rate from 10 TCAS I units is approximately 15 interrogations per second. This represents a total demand on the TABS of 68 Mode C replies per second for this example.

A1.2.3.2.1.2 Assumption 2. The worst-case Mode S reply rate is primarily derived from the expected interrogation pattern of a set of 50 nearby TCAS II units all equipped with hybrid surveillance. The radar load from only roll-call interrogations would be small and would require networked sensors, otherwise the Mode S ground interrogation acceptance rate from radar systems would be 0 (zero).

A1.2.3.2.2 Based on assumptions 1 and 2, RTCA document DO-181E Section 2.2.3.4 Reply Rate Capability is changed as follows:

A1.2.3.2.2.1 RTCA document DO-181E, Section 2.2.3.4.1.a, ATCRBS Reply Rate Capability, is amended as shown in Table 7.

DO-181E text	Modified text for this ETSO
The transponder <u>Shall</u> be able to continuously generate at least ~~500~~ ATCRBS 15-pulse replies per second.	The transponder Shall be able to continuously generate at least <u>100</u> ATCRBS 15-pulse replies per second.

Table 7 — DO-181E Section 2.2.3.4.1.a amendment

A1.2.3.2.2.2 RTCA document DO-181E, Section 2.2.3.4.1.c, ATCRBS Reply Rate Capability, is amended as shown in Table 8.

DO-181E text	Modified text for this ETSO
For Class 2 equipment, the transponder Shall be capable of a peak reply rate of ~~1000~~ ATCRBS 15-pulse replies per second for a duration of 100 milliseconds.	For Class 2 equipment, the transponder SHALL be capable of a peak reply rate of <u>150</u> ATCRBS 15-pulse replies per second for a duration of 100 milliseconds.

Table 8 — DO-181E Section 2.2.3.4.1.c added

A1.2.3.2.2.3 RTCA document DO-181E, Section 2.2.3.4.2.a, Mode S Reply Rate Capability, is amended as shown in Table 9.

DO-181E text	Modified text for this ETSO
A transponder equipped for only short Mode S downlink formats (DF), Shall have the following minimum reply rate capabilities:	A transponder equipped for only short Mode S downlink formats (DF), SHALL have the following minimum reply rate capabilities:
~~50~~ Mode S replies in any 1-second interval.	<u>29</u> Mode S replies in any 1-second interval.
~~18~~ Mode S replies in a 100-millisecond interval.	<u>10</u> Mode S replies in a 100-millisecond interval.
~~8~~ Mode S replies in a 25-millisecond interval.	<u>5</u> Mode S replies in a 25-millisecond interval.
~~4~~ Mode S replies in a 1.6-millisecond interval.	<u>3</u> Mode S replies in a 1.6-millisecond interval.

Table 9 — DO-181E Section 2.2.3.4.a amendment

A1.2.3.2.2.4 RTCA document DO-181E, Section 2.2.3.4.2.b, Mode S Reply Rate Capability, is amended as shown in Table 10.

DO-181E text	Modified text for this ETSO
A transponder equipped for long Mode S reply formats Shall be able to transmit as long replies:	A transponder equipped for long Mode S reply formats SHALL be able to transmit as long replies:
At least ~~16~~ of the 50 Mode S replies in any 1-second interval.	At least <u>10</u> of the 29 Mode S replies in any 1-second interval.
At least ~~6~~ of the 18 Mode S replies in a 100 millisecond interval.	At least <u>4</u> of the 10 Mode S replies in a 100-millisecond interval.
At least <u>4</u> of the 8 Mode S replies in a 25 millisecond interval.	At least <u>3</u> of the 5 Mode S replies in a 25-millisecond interval.
At least 2 of the 4 Mode S replies in a 1.6 millisecond interval.	At least 2 of the 4 Mode S replies in a 1.6-millisecond interval.

Table 10 — DO-181E Section 2.2.3.4.2.b amendment

A1.2.3.3 Reply Rate Limiting Changes

A1.2.3.3.1 The modifications in this section address reply rate limiting for ATCRBS and Mode S reply rates consistently with the previous section.

A1.2.3.3.2 RTCA document DO-181E, Section 2.2.7.3.1, ATCRBS Reply Rate Limiting, is amended as shown in Table 11.

DO-181E text	Modified text for this ETSO
A sensitivity-reduction reply rate limit Shall be incorporated in the transponder for ATCRBS replies. The limit Shall be capable of being adjusted between ~~500~~ continuous ATCRBS Mode A and Mode C replies per second and the maximum continuous rate of which the transponder is capable, or ~~2000~~ replies per second, whichever is less, without regard to the number of pulses in each reply. Sensitivity reduction Shall apply only to the receipt of ATCRBS, ATCRBS/Mode S All Call, and ATCRBS Only All Call interrogations.	A sensitivity-reduction reply rate limit SHALL be incorporated in the transponder for ATCRBS replies. The limit SHALL be capable of being adjusted between <u>100</u> continuous ATCRBS Mode C replies per second and the maximum continuous rate of which the transponder is capable, or <u>200</u> replies per second, whichever is less, without regard to the number of pulses in each reply. Sensitivity reduction SHALL apply only to the receipt of ATCRBS interrogations.

Table 11 — DO-181E Section 2.2.7.3.1 amendment

A1.2.3.4 RTCA document DO-181E, Section 2.2.13.1.2.c, Variable Direct Data, is amended as shown in Table 12.

DO-181E text	Modified text for this ETSO
c. <u>On-the-Ground Condition</u> The transponder ~~shall~~ report the automatically determined on-the-ground state as determined by the aircraft in the Flight Status (FS), Vertical Status (VS), and Capability (CA) fields (see §2.2.14.4.15, §2.2.14.4.42, and §2.2.14.4.6), except when reporting airborne status when on-the-ground is reported to the transponder under the conditions specified in §2.2.18.2.7.	c. <u>On-the-Ground Condition</u> The transponder <u>may</u> report the automatically determined on-the-ground state as determined by the aircraft in the Flight Status (FS), Vertical Status (VS), and Capability (CA) fields (see paragraphs 2.2.14.4.15, 2.2.14.4.42, and 2.2.14.4.6), except when reporting airborne status when on-the-ground is reported to the transponder under the conditions specified in paragraph 2.2.18.2.7.

Table 12 — DO-181E Section 2.2.13.1.2.c amendment

A1.2.3.5 RTCA document DO-181E, Section 2.2.13.1.2.d, Variable Direct Data, is amended as shown in Table 13.

DO-181E text	Modified text for this ETSO
d. <u>Special Position Identification (SPI)</u> ~~In the ATCRBS mode, an SPI pulse shall be transmitted upon request, following a Mode A reply. In the FS field of Mode S replies, an equivalent of the ATCRBS SPI pulse shall be transmitted upon the same request. The code is transmitted for 18 ± 1.0 seconds after initiation and can be reinitiated at any time.~~	d. <u>Special Position Identification (SPI)</u> In the FS field of Mode S replies, an equivalent of the ATCRBS SPI pulse <u>shall</u> be transmitted upon <u>request if the optional IDENT flight crew control is implemented per A1.2.3.1.6 of this ETSO</u>. The code is transmitted for 18 ± 1.0 seconds after initiation and can be reinitiated at any time.

Table 13 — DO-181E Section 2.2.13.1.2.d amendment

A1.2.3.6 RTCA document DO-181E, Section 2.2.13.1.2.e, Variable Direct Data, is amended as shown in Table 14.

DO-181E text	Modified text for this ETSO
e. <u>Aircraft Identification Data</u> If the aircraft uses a flight number for aircraft identification, a means shall be provided for the variable aircraft identification to be inserted by the pilot while on the ground, ~~or during flight. The means for modifying and displaying aircraft identification shall be a simple crew action independent of the entry of other flight data.~~	e. <u>Aircraft Identification Data</u> If the aircraft uses a flight number for aircraft identification, a means SHALL be provided for the variable aircraft identification to be inserted by the pilot while on the ground. <u>A means may be provided for modifying aircraft identification in flight.</u>

Table 14 — DO-181E Section 2.2.13.1.2.e amendment

A1.2.3.7 Interrogation Acceptance Protocol Changes (All-Call reply capability)

A1.2.3.7.1 The transponder All-Call interrogation reply acceptance requirements are reduced to reply only to ATCRBS Mode C (P1-P3) interrogations. The purpose is to reduce the reply rate of TABS while maintaining TCAS and TAS interoperability. The requirements of this ETSO are identical to RTCA document DO-181E except for the changes shown below.

A1.2.3.7.2 RTCA document DO-181E, Section 2.2.18.2.2.b, Interrogation Acceptance Protocol (Figure 2-12), is amended as shown in Table 15.

DO-181E text	Modified text for this ETSO
All-Call Address – If the address extracted from the received interrogation consists of 24 ONEs and UF=11, the transmission is a Mode S-Only All-Call and the received interrogation Shall ~~be accepted according to “i” below unless the lockout protocol is in effect. Mode S-Only All-Call Shall not be accepted (no replies) when in the on-the-ground state (consistent with the CA, VS and FS fields)~~	All-Call Address – If the address extracted from the received interrogation consists of 24 ONEs and UF=11, the transmission is a Mode S-Only All-Call and the received interrogation SHALL not be accepted.

Table 15 — DO-181E Section 2.2.18.2.2.b amendment

A1.2.3.7.3 RTCA document DO-181E, Section 2.2.18.2.2.c, Interrogation Acceptance Protocol (Figure 2-12), is amended as shown in Table 16.

DO-181E text	Modified text for this ETSO
ATCRBS/Mode S All-Call – An ATCRBS/Mode S All-Call interrogation (1.6 microseconds P4) Shall be ~~accepted unless the TD timer is running or side lobe suppression is in effect or when in the “on-the-ground” state (consistent with the CA, VS and FS fields).~~	ATCRBS/Mode S All-Call – An ATCRBS/Mode S All-Call interrogation (1.6 microseconds P4) SHALL not be accepted.

Table 16 — DO-181E Section 2.2.18.2.2.c amendment

A1.2.3.8 RTCA document DO-181E, Section 2.2.18.2.2.g, Interrogation Acceptance Protocol, paragraph g, All-Call Lockout Conditions, is amended as shown in Table 17.

DO-181E text	Modified text for this ETSO
All-Call Lockout Conditions – On receipt of a Mode S-Only All-Call (UF=11) ~~containing an Interrogator Code (IC and CL fields) corresponding to the designator of a running TL timer, the interrogation Shall not be accepted. unless the contained PR code is 8 through 12 and the “on-the-ground” report (CA, VS or FS field) does not include the ground condition. Upon receipt of a Mode S-Only All-Call (UF=11) containing II=0, the interrogation Shall be accepted if the TD timer is not running or if the received PR code is 8 through 12 and the “on-the-ground” report (CA, VS or FS field) does not include the ground condition.~~	All-Call Lockout Conditions – On receipt of a Mode S-Only All-Call (UF=11) the interrogation SHALL not be accepted.

Table 17 — DO-181E Section 2.2.18.2.2.g amendment

A1.2.3.9 RTCA document DO-181E, Section 2.2.18.2.2.i, Interrogation Acceptance Protocol Stochastic All-Calls, should not be implemented in Class A TABS.

A1.2.3.10 Two new sections are added here to explicitly define interrogation acceptance criteria for TABS.

A1.2.3.10.1 RTCA document DO-181E, Section 2.2.18.2.2.L, Interrogation Acceptance Protocol (Figure 2-12), is added as shown in Table 18.

DO-181E text	Modified text for this ETSO
None	ATCRBS Mode A Rejection – ATCRBS Mode A interrogations (P1-P3 spacing 8 microseconds) SHALL not be accepted. Recovery from a Mode A interrogation shall adhere to the requirements of Section 2.2.7.2 defined for recovery from a desensitizing pulse.

Table 18 — DO-181E Section 2.2.18.2.2L addition

A1.2.3.10.2 RTCA document DO-181E, Section 2.2.18.2.2.m, Interrogation Acceptance Protocol (Figure 2-12), is added to as shown in Table 19. This change reduces the range at which addressed Mode S ground interrogations would be replied to. The intent is to reduce the reply rate of the TABS. Sensitivity to TCAS interrogations is not affected.

DO-181E text	Modified text for this ETSO
None	Ground-to-Air Mode S Acceptance – Mode S interrogations, excluding UF=0 SHALL be accepted at the Mode S MTL (paragraph 2.2.2.4 b) +3dB ± 1dB.

Table 19 — DO-181E Section 2.2.18.2.2.m addition

A1.2.3.11 RTCA document DO-181E, Section 2.2.18.2.3, Interrogation Reply Coordination, is amended as shown in Table 20.

DO-181E text		Modified text for this ETSO	
The transponder SHALL generate replies as follows, except when in the on-the-ground state:		The transponder SHALL generate replies as follows, except when in the on-the-ground state:	
Interrogations	Replies	Interrogations	Replies
ATCRBS Mode A	4096 Codes	ATCRBS Mode A	<u>SHALL not reply</u>
ATCRBS Mode C	Altitude Codes	ATCRBS Mode C	Altitude Codes
ATCRBS Mode A/Mode S All-Call	Reply is DF=11	ATCRBS Mode A/Mode S All-Call	<u>SHALL not</u> Reply
ATCRBS Mode C/Mode S All-Call	Reply is DF=11	ATCRBS Mode C/Mode S All-Call	<u>SHALL not</u> Reply
Mode S-only All-Call (UF=11)	Reply is DF=11	Mode S-only All-Call (UF=11)	<u>SHALL not</u> Reply

Table 20 — DO-181E Section 2.2.18.2.3 amendment

A1.2.3.12 RTCA document DO-181E, Section 2.2.18.2.4, Lockout Protocol, should not be implemented in Class A TABS.

A1.2.3.13 RTCA document DO-181E, Section 2.2.18.2.5, Multisite Lockout Protocol, should not be implemented in Class A TABS.

A1.2.3.14 RTCA document DO-181E, Section 2.2.18.2.7, Flight Status and Vertical Status Protocols, is amended as shown in Table 21.

DO-181E text	Modified text for this ETSO
Mode S-equipped aircraft Shall report details of their flight status. The source of and the rules for such reports are as follows: a. Alert – The transponder Shall transmit the 4096 identification code in ~~ATCRBS Mode A replies~~ and in the ID field of downlink format DF=5. ~~This code can be changed by the pilot, and~~ when a change is made an alert condition Shall be established. If the identification code is changed to 7500, 7600 or 7700, the alert condition Shall be permanent. If the identification code is changed to any other value, the alert condition Shall be temporary and self-cancelling after 18 ± 1 seconds (TC timer). The TC timer Shall be retriggered and continued for 18 ± 1 seconds after any change has been accepted by the transponder function. The alert condition Shall be reported in the FS field. The permanent alert condition Shall be terminated and replaced by a temporary alert condition when the identification code is set to a value other than 7500, 7600 or 7700.	Mode S-equipped aircraft SHALL report details of their flight status. The source of and the rules for such reports are as follows: a. Alert – The transponder SHALL transmit the 4096 identification code in the ID field of downlink format DF=5. When a change is made an alert condition SHALL be established. If the identification code is changed to 7500, 7600 or 7700, the alert condition SHALL be permanent. If the identification code is changed to any other value, the alert condition SHALL be temporary and self-cancelling after 18 ± 1 seconds (TC timer). The TC timer SHALL be retriggered and continued for 18 ± 1 seconds after any change has been accepted by the transponder function. The alert condition SHALL be reported in the FS field. The permanent alert condition SHALL be terminated and replaced by a temporary alert condition when the identification code is set to a value other than 7500, 7600 or 7700.

Table 21 — DO-181E Section 2.2.18.2.7 amendment

A1.2.3.15 RTCA document DO-181E, Section 2.2.18.2.9, All-Call Reply Protocol, should not be implemented in Class A TABS.

A1.2.3.16 RTCA document DO-181E, Section 2.2.19.1, Minimum Level 2 Transponder Requirements, is amended as shown in Table 22.

DO-181E text	Modified text for this ETSO
The operational functions described in §1.4.3.2 require that this transponder Shall, in addition to the functions of the Level 1 transponder: a. Process uplink and downlink formats DF=16, UF=DF=20 and 21 (Figure 2-14). The format UF=16 is ~~optional~~. ~~Note: UF=16 is supported by transponders connected to an on-board operational TCAS (see §2.2.22).~~ ~~b. Receive broadcast transmissions from sensors (§2.2.19.1.11).~~ c. Follow the protocols for: ~~Comm-A (see §2.2.19.1.10).~~ Comm-B (see §2.2.19.1.12). ~~Comm-U/V (air-air) (see §2.2.19.1.16).~~ ~~Multisite message operation (see §2.2.19.2).~~ Report Codes 4 through 7 in the CA field (see §2.2.14.4.6). TCAS crosslink capability (see §2.2.19.1.18).	The operational functions described in paragraph 1.4.3.2 require that this transponder SHALL, in addition to the functions of the Level 1 transponder: a. Process uplink and downlink formats DF=16, UF=DF=20 and 21 (Figure 2-14). The format UF=16 <u>SHALL not be accepted. TABS SHALL not be installed with an on-board TCAS system.</u> <u>b. Requirement Deleted.</u> c. Follow the protocols for: Comm-B (see paragraph 2.2.19.1.12.1 through 2.2.19.1.12.3). Report Codes 4 through 7 in the CA field (see paragraph 2.2.14.4.6). TCAS crosslink capability (see paragraph 2.2.19.1.18).

Table 22 — DO-181E Section 2.2.19.1 amendment

A1.2.3.17 RTCA document DO-181E, Section 2.2.19.1.3, Information Transfer, should not be implemented in Class A TABS.

A1.2.3.18 RTCA document DO-181E, Section 2.2.19.1.4, Interrogation-Reply Coordination, is amended per Table 23. Equipment using Minimum Level 2 Transponder Requirements, SHALL follow the text in DO-181E as written.

DO-181E text		Modified text for this ETSO	
The transponder SHALL generate replies to interrogations as follows:		The transponder SHALL generate replies to interrogations as follows:	
Interrogation	Reply	Interrogation	Reply
ATCRBS Mode A (see Note)	~~4096 code~~	ATCRBS Mode A (see Note)	<u>SHALL not reply</u>
ATCRBS Mode C (see Note)	Altitude Code	ATCRBS Mode C (see Note)	Altitude Code
ATCRBS/Mode S All-Calls (see Note)	~~DF=11~~	ATCRBS/Mode S All-Calls (see Note)	<u>SHALL not reply</u>
UF=4 and UF=5	as below	UF=4 and UF=5	as below
UF=11 (see Note)	~~DF=11~~	UF=11 (see Note)	<u>SHALL not reply</u>
UF=20 and UF=21	as below	UF=20 and UF=21	as below
Broadcast	None	Broadcast	None

Table 23 — DO-181E Section 2.2.19.1.4 amendment

A1.2.3.19 The Lockout Protocol described in RTCA document DO-181E, Section 2.2.19.1.5, should not be implemented in Class A TABS.

A1.2.3.20 The UM Protocol described in RTCA document DO-181E, Section 2.2.19.1.9, should not be implemented in Class A TABS.

A1.2.3.21 The Comm-A Protocol described in RTCA document DO-181E, Section 2.2.19.1.10, should not be implemented in Class A TABS.

A1.2.3.22 The Broadcast Protocol described in RTCA document DO-181E, Section 2.2.19.1.11, should not be implemented in Class A TABS.

A1.2.3.23 The Air-Initiated Comm-B Protocol described in RTCA document DO-181E, Section 2.2.19.1.12.4, should not be implemented in Class A TABS.

A1.2.3.24 The Comm-B Broadcast Protocol described in RTCA document DO-181E, Section 2.2.19.1.12.5, should not be implemented in Class A TABS.

A1.2.3.25 The Updating the Data Link Capability Report described in RTCA document DO-181E, Section 2.2.19.1.12.6.3, should not be implemented in Class A TABS.

A1.2.3.26 The Change of Aircraft Identification described in RTCA document DO-181E, Section 2.2.19.1.13.e, should not be implemented in Class A TABS.

A1.2.3.27 Linked Comm-A Coding described in RTCA document DO-181E, Section 2.2.19.1.14, should not be implemented in Class A TABS.

A1.2.3.28 The Comm-U/V Protocol described in RTCA document DO-181E, Section 2.2.19.1.16, should not be implemented in Class A TABS.

A1.2.3.29 The Data Handling Interfaces described in RTCA document DO-181E, Section 2.2.19.1.17, should not be implemented in Class A TABS.

A1.2.3.30 The Multisite Message Protocol described in RTCA document DO-181E, Section 2.2.19.2, should not be implemented in Class A TABS.

A1.2.3.31 Surveillance Identifier (SI) requirements contained in RTCA document DO-181E, Section 2.2.24.2, should not be implemented in Class A TABS.

A1.2.3.32 The Elementary Surveillance (ELS) Compliant Transponder requirements in RTCA document DO-181E, Section 2.2.24, do not apply to TABS equipment. TABS SHALL not claim ELS compliance. Changes made to ELS registers do not need to be indicated via a Comm-B broadcast. If one or more of the ELS registers are supported, then Section 2.2.24 requirements SHALL apply except Sections 2.2.24 b 4, 2.2.24 c, 2.2.24.2, 2.2.24.3.2.5, and 2.2.24.3.4, which do not apply.

A1.2.3.33 The Enhanced Surveillance (EHS) Compliant Transponders requirements in RTCA/DO-181E, Section 2.2.25, do not apply to TABS. TABS equipment SHALL not claim EHS compliance. Changes made to EHS registers do not need to be indicated via a Comm-B broadcast. If one or more of the EHS registers are supported, then Section 2.2.25 requirements SHALL apply except Sections 2.2.25.1.2.4 and 2.2.25.2.3, which do not apply. Also, Section 2.2.25, paragraph 6 'Transponder capable of supporting EHS...', must support ELS per A1.2.3.32 of this ETSO.

A1.2.4 Altitude Source Function Requirements (For Class A Devices)

A1.2.4.1 The altitude source function shall meet the performance requirements of ETSO-C88b, Automatic Pressure Altitude Reporting Code-Generating Equipment, dated 5 August 2016. It is recommended that the altitude source provide 25 ft or better resolution.

A1.2.5 ADS-B OUT Function Requirements Derived From EUROCAE ED-102A, including Corrigendum-1, (For Class A Devices)

A1.2.5.1 The ADS-B OUT function must be 1090 Extended Squitter (ES) OUT, to support TCAS surveillance. The 1090ES OUT function must meet the Minimum Performance Standards (MPS)

qualification and documentation requirements in EUROCAE ED-102A, MOPS for 1090 MHz Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B), dated December, 2009, including Corrigendum-1, Section 2, dated January, 2012, for a Class B0 ADS-B OUT transmitter with the following modifications.

A1.2.5.2 EUROCAE ED-102A, including Corrigendum-1, Section 2, dated January, 2012, Paragraph 2.2.2.1.c, Mode S Transponder Based Transmitters, is amended as shown in Table 24.

ED-102A text	Modified text for this ETSO
If the ADS-B transmitter is based on Mode S transponders, then for transponder functions it Shall comply with RTCA/DO-181D (EUROCAE ED-73C) for each class of transponder specified in the latest version of FAA TSO C112 (ETSO 2C112)	~~If the ADS-B transmitter is based on Mode S transponders, then for~~ The transponder functions SHALL comply with RTCA/DO-181E (EUROCAE ED-73E) for each class of transponder specified in the latest version of ETSO-C112 (FAA TSO C112), except where modified by Appendix 1 to this ETSO.

Table 24 — ED-102A Section 2.2.2.1.c amendment

A1.2.5.3 The output power SHALL be as specified in EUROCAE ED-102A, including Corrigendum-1, dated January, 2012, Section 2.2.2.2.10.1.a., for Class A0 and B0 equipment. The RF Peak Output power SHALL be at least 18.5 dBW (70 watts).

A1.2.5.4 Broadcast of the ADS-B Surface Position Messages defined in EUROCAE ED-102A including Corrigendum-1, Section 2.2.3.2.4, is optional.

A1.2.5.5 EUROCAE ED-102A including Corrigendum-1, Section 2.2.3.2.7.2, Aircraft Operational Status Messages, is amended as shown in Table 25.

ED-102A text	Modified text for this ETSO
The 'Aircraft Operational Status Message' is used to provide the current status of the aircraft. The format of the Aircraft Operational Status Message shall be as specified in Figure 2-11, while further definition of each of the subfields is provided in the subsequent paragraphs.	The 'Aircraft Operational Status Message' is used to provide the current status of the aircraft. The format of the Aircraft Operational Status Message shall be as specified in Figure 2-11, while further definition of each of the subfields is provided in the subsequent paragraphs. Broadcast of Aircraft Operational Status Message subtype=1, Surface Messages, is optional.

Table 25 — Aircraft Operational Status Message

A1.2.5.6 When TABS is installed with a position source meeting the Class B requirements of this ETSO and transmitting a valid position, the transmitted NIC SHALL be set to 6 (0.5 NM), reference EUROCAE ED-102A including Corrigendum-1, dated January 2012, Section 2.2.8.1.16. The transmitted SIL SHALL be set to 1 (1×1E-3/ h), reference EUROCAE ED-102A including Corrigendum-1, dated January 2012, Section 2.2.5.1.40. When TABS is installed with a position source compliant with ETSO-C145, ETSO-C146 or ETSO-C196, NIC and SIL SHALL be set in accordance with EUROCAE ED-102A including Corrigendum-1, dated January, 2012. When the position is not valid, NIC and SIL SHALL be set to 0 (zero).

A1.2.5.7 The System Design Assurance (SDA), SHALL be set to 1, reference EUROCAE ED-102A, including Corrigendum-1, dated January 2012, Section 2.2.5.1.50. The probability of an undetected fault causing transmission of false or misleading information SHALL be less than or equal to 1E-3.

A1.2.5.8 Navigation Accuracy Category for Position, (NACp) SHALL be derived from the Horizontal Figure of Merit (HFOM) in accordance with EUROCAE ED-102A, including Corrigendum-1, dated January 2012, Section A.1.4.9.9; however, TABS Class B position sources may not provide HFOM directly. When HFOM is not available directly, HFOM SHALL be derived from Horizontal Dilution of Precision (HDOP) according to the following formula: $HFOM = 2 * HDOP * \text{User Equivalent Range Error}$

(UERE), where the UERE is 6 metres. This UERE is based on typical single frequency (L1) receiver performance and an assumption of mid-latitude atmospheric propagation. Although the real-time UERE may fluctuate, this assumption is sufficient to support the TABS use case. (Ref. Global Positioning System Signals, Measurements and Performance, by Pratap Misra and Per Enge, copyright 2001).

A1.2.5.9 When a TABS is installed with a position source meeting the Class B requirements of this ETSO and transmitting a valid position, the transmitted Navigation Accuracy Category for Velocity, (NACv) SHALL be set to 1 (10 m/s), reference EUROCAE ED-102A including Corrigendum-1, dated January, 2012, Section 2.2.5.1.19. When position is not valid, NACv SHALL be set to 0 (zero).

A1.2.5.10 Geometric Vertical Accuracy (GVA) SHALL be derived from Vertical Figure of Merit, (VFOM) in accordance with EUROCAE ED-102A including Corrigendum-1, dated January, 2012, Section 2.2.3.2.7.2.8. Class B position sources may not provide VFOM directly. When VFOM is not available directly, VFOM SHALL be derived from Vertical Dilution of Precision (VDOP) according to the following formula: $VFOM = 2 * VDOP * UERE$, where the UERE is 6 metres.

A1.2.5.11 The Type Code 31, Operational Status Message, subfield 'Airborne Capability Class Code', SHALL be changed to indicate the device is a TABS.

A1.2.5.11.1 The Operational Status Message SHALL be modified to indicate that it meets the performance standards of this ETSO. ED-102A, including Corrigendum-1, dated January, 2012, paragraph 2.2.18.4.7 and Figure 2-40, is modified by this ETSO. Message bits 53-54, (ME Bits 21-22), SHALL describe the capabilities of the TABS per Table 26. Set bit 54 to 1 (one) to indicate that either TABS Class A, Class B, or both classes of equipment are installed.

Bit 53	Bit 54	Description
0	0	Not TABS equipped
0	1	TABS Equipped
1	0	TABS device (reserved for future use)
1	1	TABS device (reserved for future use)

Table 26 — ED-102A Airborne Capability Class Message format

A1.2.6 GNSS Position Source Function Requirements (For Class B Devices)

A1.2.6.1 Manufacturers may use commercial off-the-shelf (COTS) GNSS position sources to meet the performance of this ETSO as long as the sensor meets the requirements in this section. The position source shall be capable of using satellite-based augmentation system (SBAS) corrections and health messages to exclude satellites from the position solution or to correct satellite range errors. In areas where the SBAS is available, the TABS shall use the SBAS corrections and health messages to exclude satellites from the position solution or to correct satellite range errors. In areas where the SBAS is not available or out of service, the TABS may continue to operate. The regional airspace authority will determine what operational impacts this may have on air-to-ground usage of TABS equipment. According to the FAA the GPS constellation experiences a significant ramp error approximately once a year. During these events, a chipset which uses the SBAS will, depending on the received SBAS messages, either correct or exclude the faulty satellite. Refer to RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, when interpreting SBAS-related requirements.

A1.2.6.2 The GNSS position source SHALL provide a GPS-only solution for use by the TABS ADS-B function. The FAA and EASA have not evaluated the performance of other GNSS systems for use in support of aviation-intended functions. This ETSO will be updated once sufficient analysis has been performed to show that other GNSS are appropriate for use by TABS equipment. Note, the GPS-only solution refers to the use of the GPS satellite constellation, it does not exclude augmentation of the GPS solution, such as provided by SBAS or GBAS systems.

A1.2.6.3 The GNSS horizontal position error SHALL not exceed 30 metres, 95th percentile, when the Horizontal Dilution of Precision (HDOP) is 2.5 or less. The GNSS position source SHALL either transmit a Horizontal Figure of Merit (95 %) (HFOM) or an HDOP metric.

Note: The 30-metre horizontal position fixing error requirement assumes a UERE of 6 metres, consistent with Section A1.2.5.8.

A1.2.6.4 Removed.

A1.2.6.5 The GNSS position source SHALL be capable of transmitting horizontal velocity measurements more accurate than 10 m/s, 95th percentile.

A1.2.6.6 The GNSS position source SHALL not transmit false or misleading data in the presence of broadband interference. There is no minimum interference rejection requirement for TABS equipment and loss of position in the presence of interference is acceptable behaviour.

A1.2.6.7 The GNSS position source SHALL not use SBAS corrections when the SBAS satellite is broadcasting message type 0.

A1.2.6.8 The GNSS position source SHALL exclude satellites with UDREI=15 reported in the SBAS fast corrections.

A1.2.6.9 The GNSS position source SHALL apply SBAS fast and long-term corrections when available.

A1.2.6.10 The GNSS position source SHALL be capable of transmitting geometric altitude, Height Above the Ellipsoid (HAE) measurements more accurate than 45 metres, 95th percentile, when the Vertical Dilution of Precision (VDOP) is 3.7 or less. The GNSS position source SHALL either transmit a Vertical Figure of Merit (95 %) (VFOM) or a Vertical Dilution of Precision (VDOP) metric.

Note: The 45-metre vertical position fixing error requirement assumes a UERE of 6 metres, consistent with Section A1.2.5.10.

A1.2.7 Antenna Function Requirements

A1.2.7.1 The requirements for transponder antennas are specified in ETSO-C112e. The requirements for GNSS antennas are specified in ETSO-C190 and ETSO-C144a. The antennas should be designed to meet the performance specified in the applicable ETSO. However, the TABS may benefit significantly in installation costs from implementations where the antennas are integrated in the TABS equipment. Small degradations in antenna performance may be acceptable as a trade-off for installation cost.

A1.2.7.2 Antennas may be installed internally on aircraft that are transparent to radio frequencies. An internal antenna may not be appropriate on aircraft with a metal hull. If an antenna is installed internally, testing will need to be conducted to ensure the TABS is not negatively impacted and installation guidance must accompany the unit to ensure the system is properly fitted to the aircraft.

A1.2.7.3 Because TABS may be installed on a radio frequency (RF) transparent fuselage near a pilot or passenger, or in a cockpit in close proximity to a pilot or passenger, consideration must be given to antenna placement to ensure it does not pose a hazard to humans or combustible materials. Manufacturers must provide installation guidance describing the minimum safe distance the antenna can be to the nearest human body or if applicable, combustible material. Appendix 3 to this ETSO provides a more in-depth discussion of this subject based on FCC and European documents.

A1.2.8 Form factor and power

A1.2.8.1 An ideal implementation of the TABS would be a single integrated unit with minimal connections to the airframe, such as; mechanical mounting, power, and static air source. Where the equipment might be shared between multiple airframes, the mechanical mounting could incorporate an airframe-specific configuration module (containing such items as the ICAO 24-bit aircraft address), and be designed such that no tools are required to remove or install the TABS.

A1.2.8.2 Low-power consumption design is important. Designs specifically intended for long-term battery operation are ideal. If the TABS is battery powered, it should be designed to provide system integrity commensurate with the failure condition category / classification stated in paragraph 3.2.1.

[Amdt. ETSO/13]

[Amdt. ETSO/16]

APPENDIX 2 TO ETSO C-199 A1 – TEST REQUIREMENTS

ED Decision 2020/011/R

A2 Testing Introduction

A2.1 Testing Intent

A2.1.1 This Appendix provides an acceptable means to verify the major functions of the TABS.

A2.1.2 The TABS is not intended to accept and reply to any UF=11 All-Call interrogations. RTCA document DO-181E tests like 2.4.2.1 Step 6 that use the Mode S Only All-Call interrogation (UF=11) will need to use a different interrogation, such as a UF=0 interrogation.

A2.2 Testing Requirements

A2.2.1 The tests defined here are derived from tests in the reference documents or written here to ensure compliance with the intended capabilities of TABS equipment. These tests are one acceptable means to demonstrate that the equipment meets the functional requirements defined in Appendix 1 to this ETSO. Functionality not modified by Appendix 1 should be verified by the test outlined in the applicable standards, e.g. RTCA document DO-181E.

A2.2.2 Table 27 provides notes in italics and parenthesis explaining how to read the tables that modify the text in the source documents.

(Source document reference)	Modified text for this ETSO
(This is a copy of the original text from the source document. Material to be deleted from this original text is marked with ~~strikethrough formatting~~ .)	(This is the requirement for this ETSO. Modifications to the source text are marked in <u>bold and underlined</u> to assist in identifying changes).

Table 27 — (Source document reference) (type of change)

A2.2.3 Testing Transponder Function Requirements Derived From DO-181E (For Class A Devices)

A2.2.3.1 Testing of the transponder function of the TABS should follow the tests outlined in document RTCA document DO-181E, Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment, dated 17 March 2011, Section 2.3, 2.4, and 2.5, with the following exceptions:

A2.2.3.1.1 Testing of Flight Crew Control Functions

A2.2.3.1.2 Testing should verify that the requirements of RTCA document DO-181E, as modified by paragraph A1.2.3.1.2 of this ETSO, have been properly incorporated.

A2.2.3.1.3 Testing should verify that changes made to paragraph 2.1.7 a, in RTCA document DO-181E, per Section A1.2.3.1.3, have been properly incorporated.

A2.2.3.1.3.1 Testing should verify the requirements of A1.2.3.1.3, by performing the test outlined in RTCA document DO-181E Section 2.5.4.11. Test results should verify that the 4096 code can be set while on the ground. If the 4096 code can be set in flight, testing should verify that the 4096 code can be set while in the air (weight-off-wheels condition) per RTCA/DO-181E Section 2.5.4.11.

A2.2.3.1.3.2 Testing should verify the requirements of A1.2.3.1.3, by performing the test outlined in RTCA/DO-181E Section 2.5.4.11. Testing should verify that a means of selecting and transmitting Mode 3/A code 7700 (emergency) is provided and tested per RTCA document DO-181E Section 2.5.4.11.

A2.2.3.1.3.3 Testing should verify the requirements of A1.2.3.1.3, by performing the test outlined in RTCA document DO-181E Section 2.5.4.11. Testing should also verify that a means of selecting and transmitting an alternate Mode 3/A codes is provided and tested per RTCA document DO-181E Section 2.5.4.11.

A2.2.3.1.4 Testing should verify the requirements of A1.2.3.1.4, by performing the test outlined in RTCA document DO-181E Section 2.5.4.3.b. Test results should verify aircraft without a means of determining air/ground state, report in the air at all times. Aircraft with an automatic means to determine the air/ground state, must verify that the air/ground state is set properly. Perform the test outlined in RTCA document DO-181E Section 2.5.4.3.b. If capable of determining the air/ground state, test results should verify that the aircraft reports in the air when in the air, and on the ground when on the ground.

A2.2.3.1.5 Testing should verify that the requirements of A1.2.3.1.5, have been properly incorporated. If a means of selecting the standby condition is provided, testing should verify return to normal operation from standby condition is within 5 seconds.

A2.2.3.1.6 Testing should verify that the requirements of A1.2.3.1.6, have been properly incorporated. If a means of initiating the IDENT (SPI) feature is installed, testing shall verify it functions properly per RTCA document DO-181E Section 2.5.4.3. (see Also A1.2.3.5 and A2.2.3.5).

A2.2.3.2 Testing Reply Rate Capability Changes

A2.2.3.2.1 This section provides test criteria for the reply rate changes based on assumptions made in Section A1.2.3.2.1.

A2.2.3.2.2 Testing should verify that changes made to A1.2.3.2.2 have been correctly incorporated into TABS equipment.

A2.2.3.2.2.1 Testing should verify that the requirements of A1.2.3.2.2.1 of this ETSO have been satisfied. Testing outlined in RTCA document DO-181E, Section 2.3.2.2.3 step 1, should verify that the transponder be able to continuously generate at least 100 ATCRBS 15-pulse replies per second.

A2.2.3.2.2.2 Testing should that verify the requirements of A1.2.3.2.2.2 of this ETSO have been satisfied. Testing outlined in RTCA document DO-181E, Section 2.3.2.2.3 step 3, should verify that the transponder is capable of a peak reply rate of 150 ATCRBS 15-pulse replies per second for a duration of 100 milliseconds.

A2.2.3.2.2.3 Testing should verify that the changes made to RTCA document DO-181E Section 2.2.3.4.2.a have been correctly incorporated into TABS equipment per A1.2.3.2.2.3.

A2.2.3.2.2.3.1 Testing should verify that the requirements of RTCA document DO-181E, Section 2.2.3.4.2.a, as modified by paragraph A1.2.3.2.2.3 of this ETSO have been satisfied. Testing outlined in RTCA document DO-181E, Section 2.3.2.2.3 step 2, should verify that the transponder provides at least 29 short Mode S replies in any 1-second interval.

A2.2.3.2.2.3.2 Testing should verify that the requirements of RTCA document DO-181E, Section 2.2.3.4.2.a, as modified by paragraph A1.2.3.2.2.3 of this ETSO have been satisfied. Testing outlined in RTCA document DO-181E, Section 2.3.2.2.3 step 3, should verify that the transponder provides at least 10 short Mode S replies in a 100-millisecond interval.

A2.2.3.2.2.3.3 Testing should verify that the requirements of RTCA document DO-181E, Section 2.2.3.4.2.a, as modified by paragraph A1.2.3.2.2.3 of this ETSO have been satisfied. Testing outlined in RTCA document DO-181E, Section 2.3.2.2.3 step 4, should verify that the transponder provides at least 5 short Mode S replies in a 25-millisecond interval.

A2.2.3.2.2.3.4 Testing should verify that the requirements of RTCA document DO-181E, Section 2.2.3.4.2.a, as modified by paragraph A1.2.3.2.2.3 of this ETSO have been satisfied. Testing outlined in RTCA document DO-181E, Section 2.3.2.2.3 step 5, should verify that the transponder provides at least 3 short Mode S replies in a 1.6-millisecond interval.

A2.2.3.2.2.4 Testing should verify that the changes made to RTCA document DO-181E, Section 2.2.3.4.2.b, have been correctly incorporated into TABS equipment per A1.2.3.2.2.4.

A2.2.3.2.2.4.1 Testing should verify that the requirements of RTCA/DO-181E, Section 2.2.3.2.4.2.b, as modified by paragraph A1.2.3.2.2.4 of this ETSO have been satisfied. Testing outlined in RTCA document DO-181E, Section 2.3.2.2.3 step 2, should verify that the transponder provides at least 10 of the 29 Mode S replies as long-format replies in any 1-second interval.

A2.2.3.2.2.4.2 Testing should verify that the requirements of RTCA document DO-181E, Section 2.2.3.2.4.2.b, as modified by paragraph A1.2.3.2.2.4 of this ETSO have been satisfied. Testing outlined in RTCA document DO-181E, Section 2.3.2.2.3 step 3, should verify that the transponder provides at least 4 of the 10 Mode S replies as long-format replies in a 100-millisecond interval.

A2.2.3.2.2.4.3 Testing should verify that the requirements of RTCA document DO-181E, Section 2.2.3.2.4.2.b, as modified by paragraph A1.2.3.2.2.4 of this ETSO have been satisfied. Testing outlined in RTCA document DO-181E, Section 2.3.2.2.3 step 4, should verify that the transponder provides at least 3 of the 5 Mode S replies as long-format replies in a 25-millisecond interval.

A2.2.3.2.2.4.4 Testing should verify that the requirements of RTCA document DO-181E, Section 2.2.3.2.4.2.b, as modified by paragraph A1.2.3.2.2.4 of this ETSO have been satisfied. Testing outlined in RTCA document DO-181E, Section 2.3.2.2.3 step 5, should verify that the transponder provides at least 2 of the 4 Mode S replies as long-format replies in a 1.6-millisecond interval.

A2.2.3.3 Testing Reply Rate Limiting Changes

A2.2.3.3.1 Testing should verify that the requirements of RTCA document DO-181E, Section 2.2.7.3.1, as modified by paragraph A1.2.3.3.1 of this ETSO have been satisfied. Testing outlined in RTCA document DO-181E, Section 2.4.2.2.5 step 1, should be performed to verify that the unit does not reply to Mode A interrogations.

A2.2.3.3.2 Testing should verify that the requirements of RTCA document DO-181E, Section 2.2.7.3.1, as modified by paragraph A1.2.3.3.2 of this ETSO have been satisfied. Testing outlined in RTCA document DO-181E, Section 2.4.2.2.5 step 1, should be performed to verify the unit is capable of between 100 continuous ATCRBS Mode C replies per second and the maximum continuous rate of which the transponder is capable, or 200 replies per second, whichever is less, without regard to the number of pulses in each reply. Sensitivity reduction SHALL apply only to the receipt of ATCRBS interrogations.

A2.2.3.4 Testing should verify that the requirements of RTCA document DO-181E, Section 2.2.13.1.2.c, as modified by paragraph A1.2.3.4 of this ETSO have been satisfied. Testing should show that airborne status is set to in the air unless the aircraft is air/ground determination capable. If the aircraft can determine air/ground state, testing should show that this capability is determined on the ground when on the ground and in the air when in the air.

A2.2.3.5 Testing should verify that the requirements of RTCA document DO-181E, Section 2.2.13.1.2.d, as modified by paragraph A1.2.3.5 of this ETSO have been satisfied. If the aircraft is capable of providing SPI, follow the test outlined in A2.2.3.1.6 of this ETSO to verify that it functions properly per RTCA document DO-181E Section 2.5.4.3 (see also, Section A1.2.3.1.6 and A2.2.3.1.6).

A2.2.3.6 Testing should verify that the requirements of RTCA document DO-181E, Section 2.2.13.1.2.e, as modified by paragraph A1.2.3.6 of this ETSO have been satisfied. Testing should show the aircraft ID loaded while on the ground is broadcast. If aircraft ID can be changed in flight, testing should verify that aircraft ID can be changed in flight and the new aircraft ID is broadcast.

A2.2.3.7 Testing of Interrogation Acceptance Protocol Changes (All-Call reply capability)

A2.2.3.7.1 Except where noted here, testing of the Interrogation Acceptance Protocol capability should follow that called out in RTCA document DO-181E. Testing of the Interrogation Acceptance Protocol capability should be modified from those called out in RTCA document DO-181E to meet the changes made in A1.2.3.7.1.

A2.2.3.7.2 Testing should verify that the requirements of RTCA document DO-181E, Section 2.2.18.2.2.b, as modified by paragraph A1.2.3.7.2 of this ETSO have been satisfied. Various tests in RTCA document DO-181E Section 2.4 utilise the Mode S Only All-Call interrogation and the expected reply to execute the test procedure. A discrete interrogation should be used as a substitute for these test procedures. Testing outlined in RTCA document DO-181E, Section 2.5.4.2, should verify that UF=11 interrogations are not accepted.

A2.2.3.7.3 Testing should verify that the requirements of RTCA document DO-181E, Section 2.2.18.2.2.c, as modified by paragraph A1.2.3.7.3 of this ETSO have been satisfied. Testing outlined in RTCA document DO-181E, Section 2.5.4.2, should verify that an ATCRBS/Mode S All-Call interrogation (1.6-microseconds P4) is not accepted. The pulse decoder tests in Section 2.4.2.5 for ATCRBS/Mode S All-Call interrogation acceptance shall be modified to verify that no ATCRBS/Mode S All-Call interrogations that meet the criteria for acceptance in RTCA document DO-181E, Section 2.2.6.2, produce a reply.

A2.2.3.8 Testing of the requirements of RTCA document DO-181E, Interrogation Acceptance Protocol, per Sections 2.5.4.4 and 2.5.4.5, are not required per A1.2.3.8 of this ETSO.

A2.2.3.9 Testing of the requirements of RTCA document DO-181E, Stochastic All-Calls, per 2.5.4.13, is not required per A1.2.3.9 of this ETSO.

A2.2.3.10 Testing should verify the modified Mode S MTL requirements added to RTCA document DO-181E, per Section A1.2.3.10. Test to ensure that paragraphs 2.2.18.2.2.L and 2.2.18.2.2.m have been properly incorporated.

A2.2.3.10.1 Testing outlined in RTCA document DO-181E, Section 2.4.2, should verify that ATCRBS Mode A interrogations (P1-P3 spacing 8 microseconds) are not accepted per A1.2.3.10.1. Various tests in RTCA document DO-181E, Section 2.4, utilise Mode A interrogations to execute the test procedure. Mode C interrogations should be used as a substitute for these test procedures. The pulse decoder tests in RTCA document DO-181E, Section 2.4.2.5, for Mode A interrogation acceptance shall be modified to verify that no Mode A interrogations that meet the criteria for acceptance in RTCA document DO-181E, Section 2.2.6.2, produce a reply. The requirement for recovery from a Mode A interrogation per A1.2.3.10.1 shall be tested according to RTCA document DO-181E, Section 2.4.2.6 step 1, except using a Mode A interrogation from the master and a Mode C interrogation from the slave.

A2.2.3.10.2 Testing should verify the requirements added to RTCA document DO-181E, paragraph 2.2.18.2.2.m, have been properly incorporated per Section A1.2.3.10.2. Verify the requirement added by this ETSO, by performing the test procedure in RTCA document DO-181E, Section 2.4.2.1 step 6, using a UF=0 to verify the Mode S MTL in Section 2.2.2.4.b and UF=4, 5, 20 and 21 to verify the modified MTL per A1.2.3.10.2.

A2.2.3.11 Testing should verify that the requirements of RTCA document DO-181E, Interrogation Reply Coordination, Section 2.2.18.2.3, as modified by A1.2.3.11 of this ETSO are satisfied. Testing outlined in RTCA document DO-181E, Section 2.5.4.2, shall be modified to verify that the unit does not reply to ATCRBS Mode A interrogations. Test ATCRBS Mode A/Mode S All-Calls, ATCRBS Mode C/Mode S All-Calls or UF=11 interrogations per testing outlined in A2.2.3.7 and A2.2.3.10.

A2.2.3.12 Testing of RTCA document DO-181E, Lockout Protocol, Section 2.2.18.2.4, is not required since TABS devices do not reply to All-Call interrogations per A1.2.3.12 of this ETSO. Testing using interrogations in RTCA document DO-181E, Section 2.5.4.4, should be performed to verify the unit properly replies to interrogations containing lockout commands from ground interrogations.

A2.2.3.13 Testing of RTCA document DO-181E, Multisite Lockout Protocol, Section 2.2.18.2.5, is not required since TABS devices do not reply to All-Call interrogations per A1.2.3.13 of this ETSO. Testing using interrogations in RTCA document DO-181E, Section 2.5.4.5, should be performed to verify that the unit properly replies to interrogations containing multisite lockout commands from ground interrogations.

A2.2.3.14 Testing should verify that the requirements of RTCA document DO-181E, Flight Status and Vertical Status Protocols, Section 2.2.18.2.7, as modified by A1.2.3.14 of this ETSO are satisfied. Testing outlined in RTCA document DO-181E Section 2.5.4.7 should be performed to verify that the unit sets the flight status bits properly consistently with the capabilities provided for Mode 3/A code entry per A1.2.3.1.3.

A2.2.3.15 Testing the requirement of RTCA document DO-181E, All-Call Reply Protocol, Section 2.2.18.2.9, as modified by A1.2.3.15 is not required. Testing outlined in RTCA document DO-181E, Section 2.5.4.8, does not need to be performed since the TABS does not support the All-Call Protocol.

A2.2.3.16 Testing should verify the Level 2 Transponder Requirements of RTCA document DO-181E, Minimum Level 2 Transponder Requirements, Section 2.2.19.1, as modified by A1.2.3.16 of this ETSO are satisfied. Testing outlined in RTCA document DO-181E Section 2.5.3 should be performed to verify that the unit performs per design specifications. Also, testing outlined in RTCA document DO-181E, Section 2.5.4.17, should be performed to verify that the unit does not process DF=16 messages.

A2.2.3.17 No test is required to verify the requirements of RTCA document DO-181E, Information Transfer, Section 2.2.19.1.3, per A1.2.3.17.

A2.2.3.18 Testing should verify that the requirements of RTCA document DO-181E, Interrogation-Reply Coordination, Section 2.2.19.1.4, as modified by A1.2.3.18 are met. Use tests in A2.2.3.7 and A2.2.3.10 in this ETSO to verify the TABS does not reply to ATCRBS Mode A, ATCRBS/Mode S All Calls and UF=11 interrogations.

A2.2.3.19 Testing of the requirements of RTCA document DO-181E, Lockout Protocol, Section 2.2.19.1.5, per Section 2.5.4.4, are not required per A1.2.3.19 of this ETSO. Testing should verify the TABS does not perform the UM Protocol per RTCA document DO-181E, Section 2.5.4.18.

A2.2.3.20 Since TABS do not support the Comm-B protocol except for GICB extraction requests, the requirements of RTCA/DO-181E, UM Protocol, Section 2.2.19.1.9, do not apply, per A1.2.3.20. Using a subset of the interrogations identified in RTCA document DO-181E, Section 2.5.4.18, select 12 interrogations with UF 4, 5, 20 and 21 and containing DI=0, 1 and 7 and verify that the reply contains UM field of 0 (zero).

A2.2.3.21 Testing of the requirements of RTCA document DO-181E, Comm-A Protocol, Section 2.2.19.1.10, per Section 2.5.4.15, is not required per A1.2.3.21 of this ETSO. Testing should verify that the TABS does not perform the Com-A Protocol per RTCA document DO-181E, Section 2.5.4.15.

A2.2.3.22 Testing of the requirements of RTCA document DO-181E, Broadcast Protocol, Section 2.2.19.1.11, as modified by A1.2.3.22 is not required since TABSs do not support this protocol.

A2.2.3.23 Testing of the requirements of RTCA document DO-181E, Air-Initiated Comm-B Protocol, Section 2.2.19.1.12.4, per Section 2.5.4.18, is not required per A1.2.3.23. To verify GICB extraction requirements, perform the portion of the test procedure of RTCA/DO-181E, Section 2.5.4.18 using interrogation patterns 1 to 24, to test the transponder in state 1 of the test matrix to verify proper reply content.

A2.2.3.24 Testing the requirements of RTCA document DO-181E, Comm-B Broadcast Protocol, Section 2.2.19.1.12.5, per 2.5.4.21 is not required per A1.2.3.24.

A2.2.3.25 Testing should verify the requirements of RTCA document DO-181E, Updating the Data Link Capability Report, Section 2.2.19.1.12.6.3, as modified by A1.2.3.25. Testing should verify that the TABS does not perform the Updating the Data Link Capability Report per RTCA document DO-181E, Section 2.5.4.33.

A2.2.3.26 Testing should verify the requirements of RTCA document DO-181E, Change of Aircraft Identification, Section 2.2.19.1.13.e, as modified by A1.2.3.26. Testing should verify that the TABS does not perform the Change of Identification per RTCA document DO-181E, Section 2.5.4.19.

A2.2.3.27 Testing the requirements of RTCA document DO-181E, Linked Comm-A Coding, Section 2.2.19.1.14, per 2.5.4.15, is not required per A1.2.3.27.

A2.2.3.28 Testing the requirements of RTCA document DO-181E, Comm-U/V Protocol, Section 2.2.19.1.16, per 2.5.4.17, as modified by A1.2.3.28 is not required.

A2.2.3.29 Testing the requirements of RTCA/DO-181E, Data Handling Interfaces, Section 2.2.19.1.17, per 2.5.4.20, as modified by A1.2.3.29 is not required.

A2.2.3.30 Testing the requirements of RTCA document DO-181E, Multisite Message Protocol, Section 2.2.19.2, per Section 2.5.4.5, as modified by A1.2.3.30 is not required.

A2.2.3.31 Testing the requirements of RTCA document DO-181E, Surveillance Identifier (SI), Section 2.2.24.2, per 2.6.2, as modified by A1.2.3.31 is not required.

A2.2.3.32 Testing the requirements of RTCA/DO-181E, Elementary Surveillance Capability, Section 2.2.24 as modified by A1.2.3.32, is not required. If one or more ELS registers are supported, test per RTCA/DO-181E, Section 2.6.

A2.2.3.33 Testing the requirements of RTCA document DO-181E, Enhanced Surveillance Capability, Section 2.2.25.3.2, as modified by A1.2.3.33 is not required. If the unit is Enhanced Surveillance Capability capable test per RTCA document DO-181E, Section 2.7.

A2.2.4 Testing Altitude Source Function Requirements

A2.2.4.1 Testing of the Altitude Source Function should follow that called out in ETSO-C88b, Automatic Pressure Altitude Reporting Code Generating Equipment, dated August 5, 2016.

A2.2.5 Testing ADS-B OUT Function Requirements (For Class A Devices)

A2.2.5.1 Testing should verify the ADS-B system performs its intended function per EUROCAE ED-102A, MOPS for 1090 MHz Extended Squitter Automatic Dependent Surveillance — Broadcast (ADS-B) and Traffic Information Services — Broadcast (TIS-B), dated December 2009, including Corrigendum 1, dated January 2012, except as modified by Section A1.2.5. Testing should follow the tests outlined in EUROCAE ED-102A, including Corrigendum 1, dated January 2012, Sections 2.3 and 2.4 with the following exceptions:

A2.2.5.2 Per Section A1.2.5.2, testing of transponder functions should follow the requirements in Sections A1.2.3 and A2.2.3 of this ETSO.

A2.2.5.3 Testing should verify the System RF Peak Power Output has a peak output level of at least 18.5 dBW (70 watts) per A1.2.5.3, reference EUROCAE ED-102A, including Corrigendum-1, dated January, 2012, RF Peak Power, Section 2.2.2.2.10.1.a. Testing outlined in ED-102A, Section 2.3.2.2.6.1 step 5, should verify that the unit under test provides a peak output power level of at least 18.5 dBW (70 watts).

A2.2.5.4 If the optional ADS-B Surface Position Messages function is provided, per Section, A1.2.5.4, testing should verify the ADS-B Surface Position Message is correctly populated and broadcast per EUROCAE ED-102A, Section 2.4.3.2.1.2.2.

A2.2.5.5 If the optional Typecode 31 subtype 1 Aircraft Operational Status Messages is provided per Section A1.2.5.5, testing should verify that the Aircraft Operational Status Messages is correctly populated and broadcast per EUROCAE ED-102A Section 2.4.3.2.7.2

A2.2.5.6 Per Section A1.2.5.6, testing should verify that NIC=6, and SIL=1 when using position from a Class B position source using test procedures in EUROCAE ED-102A, including Corrigendum 1, dated January 2012, Sections 2.4.8.1.5 and 2.4.5.1.40.

A2.2.5.7 Testing should verify that the System Design Assurance (SDA) is set to 1 to verify the requirement in Section A1.2.5.7, reference EUROCAE ED-102A, including Corrigendum 1, dated January 2012, System Design Assurance (SDA), Section 2.2.5.1.50.

A2.2.5.8 Per Section A1.2.5.8, testing should verify that Navigation Accuracy Category for Position (NACp) is set according to EUROCAE ED-102A including Corrigendum-1, dated January, 2012, Section 2.4.3.2.7.1.3.8. Testing should verify that the NACp is set appropriately when the position source is providing HDOP and not HFOM.

A2.2.5.9 If a TABS Class B position source is installed, verify that Navigation Accuracy Category Velocity (NACv) is set to 1 (10 m/s) per A1.2.5.9.

A2.2.5.10 Verify that Geometric Vertical Accuracy (GVA) is set per A1.2.5.10. Testing outlined in EUROCAE ED-102A, including Corrigendum 1, dated January, 2012, Section 2.4.3.2.7.2.8, should verify that GVA is set appropriately when the position source is providing VDOP and not VFOM.

A2.2.5.11 Verify Type Code 31, Airborne Capability Class Message, indicates that the unit under test is a TABS per A1.2.5.11.

A2.2.6 Testing of GNSS Position Source Function Requirements (For Class B Devices)

A2.2.6.1 A TABS incorporating a position source that is compliant with ETSO-C129, ETSO-C145, ETSO-C146 or ETSO-C196 must also meet the additional ADS-B criteria defined in AMC1 ACNS.D.ADSB.070 of CS-ACNS, to include any required testing. GNSS position sources that are not compliant with an existing GNSS ETSO will need to meet the requirements in paragraph A1.2.6 of this ETSO and verify it meets the minimum requirements by performing the tests outlined in Section A2.2.6 of this ETSO. The following tests were derived from a reduced set of requirements and associated tests found in RTCA document DO-229E.

A2.2.6.2 GPS Only Solution.

A2.2.6.2.1 Per paragraph A1.2.6.2, verify that the position source provides a GPS-SBAS or GPS Only solution for use by Class A TABS.

A2.2.6.3 Position Accuracy Tests.

A2.2.6.3.1 Two tests are used to verify the horizontal position accuracy to ensure the requirement in paragraph A1.2.6.3 is met. The first test is a 24-hour static scenario using live satellite signals. The second test uses a GNSS simulator to generate a scenario incorporating both static and dynamic aircraft manoeuvres.

A2.2.6.3.2 24-Hour Accuracy Test.

A2.2.6.3.2.1 The equipment SHALL be tested over a 24-hour period using live GPS satellite signals at a surveyed location. The equipment SHALL use an antenna representative of what will be used in an actual airborne installation. The horizontal position error SHALL be computed for each position estimate output by the equipment.

A2.2.6.3.2.2 Monitor the sensor-provided HFOM and VFOM, or HFOM and VFOM derived from the sensor-provided HDOP and VDOP per paragraphs A1.2.5.8 and A1.2.5.10. In order to pass the test, the horizontal position error must be less than 30 metres for at least 95 % of the samples and the horizontal accuracy reported must be greater than the actual position error for at least 95 % of the samples. In order to pass the test, the vertical position error must be less than 45 metres for at least 95 % of the samples and the vertical accuracy reported must be greater than the actual position error for at least 95 % of the samples.

A2.2.6.3.2.3 The horizontal position error SHALL not exceed 0.5 NM at any time during the test.

A2.2.6.3.2.4 Only those position outputs that are reported as valid by the equipment need to be considered for the accuracy evaluation. In order to pass the test, 99.9 % of the position outputs must be reported as valid, excluding those position reports prior to the first position fix.

A2.2.6.3.3 GPS Simulator-based Accuracy Tests.

A2.2.6.3.3.1 The equipment SHALL be tested using a GPS simulator scenario that includes both static and dynamic aircraft manoeuvres. The horizontal and vertical position errors SHALL be computed for each position estimate output by the equipment.

A2.2.6.3.3.2 Monitor the sensor-provided HFOM and VFOM, or HFOM and VFOM derived from the sensor-provided HDOP and VDOP per paragraphs A1.2.5.8 and A1.2.5.10. In order to pass the test, the horizontal position error must be less than 30 metres for at least 95 % of the samples and the horizontal accuracy reported must be greater than the actual position error for at least 95 % of the samples. In order to pass the test, the vertical position error must be less than 45 metres for at least 95 % of the samples and the vertical accuracy reported must be greater than the actual position error for at least 95 % of the samples.

A2.2.6.3.3.3 The horizontal position error SHALL not exceed 0.5 NM at any time during the test.

A2.2.6.3.3.4 Simulator Scenario Details

A2.2.6.3.3.4.1 Only those position outputs that are reported as valid by the equipment need to be considered for the accuracy evaluation. In order to pass the test, 99.9 % of the position outputs must be reported as valid, excluding those position reports prior to the first position fix.

A2.2.6.3.3.4.2 The simulator scenario SHALL use the standard 24-satellite constellation in RTCA document DO-229E Appendix B. The initial position and time should be chosen to ensure the satellite geometry supports the test pass-fail criteria, and the HDOP is close to 2.5 and the VDOP is close to 3.7.

A2.2.6.3.3.4.3 The simulation SHALL include both stationary and dynamic portions, as follows:

A2.2.6.3.3.4.3.1 At least 10 minutes of stationary position.

A2.2.6.3.3.4.3.2 A sequence of different manoeuvres, including acceleration to a constant velocity, climbs, descents, and turns.

A2.2.6.3.3.4.3.2.1 A series of turns should be included to ensure a constantly changing velocity to expose any effects of filtering on the position output.

A2.2.6.3.3.4.3.3 At least 10 minutes of accelerated manoeuvres SHALL be simulated.

A2.2.6.3.3.4.3.4 Aircraft dynamics are as follows: ground speed = 200 kt, horizontal acceleration=0.58 g, vertical acceleration of 0.5 g.

A2.2.6.3.3.4.4 The simulated satellite signals SHALL be set to -134 dBm while position measurements are taken. Signal powers may be increased at the beginning of the scenario to allow for initial acquisition.

A2.2.6.3.3.4.5 Simulated signals SHALL include ranging errors for atmospheric effects (troposphere and ionosphere) that adhere to approved models. Refer to DO-229E, Appendix A, Section A.4.2.4 and IS-GPS-200G, dated 5 September 2012.

A2.2.6.3.3.4.6 No interference needs to be simulated.

A.2.2.6.4 Reserved.

A2.2.6.5 Velocity Accuracy Tests.

A2.2.6.5.1 The velocity accuracy tests specified in AC 20-138D Appendix 4, Sections 4-2, 4-3 and 4-4, SHALL be performed per the requirement in A1.2.6.5 and show the unit provides an accuracy of 10 m/s or less, at least 95 % of the time. It is assumed that the GPS position source does not provide a velocity accuracy output and the TABS will broadcast NACv = 1. Only the tests required to demonstrate a NACv = 1 need be run.

A2.2.6.6 Interference Tests.

A2.2.6.6.1 The equipment SHALL be tested using simulated GPS signals mixed with an interfering signal of gradually increasing power until the equipment loses position to verify the requirement outlined in paragraph A1.2.6.6. The horizontal position accuracy will be evaluated.

A2.2.6.6.2 Simulator Scenario Details.

A2.2.6.6.2.1 Use the same simulator scenario set-up found in A2.2.6.3.3.4 with the following exceptions:

A2.2.6.6.2.2 The interfering signal SHALL be broadband noise with bandwidth of 20 MHz centred on 1575.42 MHz. The initial power spectral density SHALL be -170.5 dBm/Hz (-97.5 dBm total power).

A2.2.6.6.2.3 The scenario may need to be extended to allow sufficient time for increasing interference power.

A2.2.6.6.3 Test Procedure

A2.2.6.6.3.1 Step 1: The interfering signal SHALL initially be turned off.

A2.2.6.6.3.2 Step 2: The simulator scenario SHALL be engaged and the satellites' RF SHALL be turned on.

A2.2.6.6.3.3 Step 3: The equipment SHALL be powered on and initialized. It is assumed that the receiver has obtained a valid almanac for the simulator scenario to be tested prior to conducting these tests.

A2.2.6.6.3.4 Step 4: The receiver SHALL be allowed to reach steady state. When the receiver has reached steady state, an interfering broadband noise signal of -170.5 dBm/Hz SHALL be applied.

A2.2.6.6.3.5 Step 5: The interference power SHALL be maintained until the accuracy has reached steady state. Position measurements and validity indications SHALL be recorded during this interval.

A2.2.6.6.3.6 Step 6: The power of the interfering signal SHALL be increased by 2 dB and maintained for 200 seconds.

A2.2.6.6.3.7 Step 7: Go to Step 5 and repeat until the receiver is unable to maintain a position fix.

A2.2.6.6.4 Pass-Fail Criteria

A2.2.6.6.4.1 The horizontal position errors SHALL be computed for each position estimate output by the equipment.

A2.2.6.6.4.2 The horizontal position error SHALL not exceed 0.5 NM at any time during the test.

A2.2.6.6.4.3 Only those position outputs that are reported as valid by the equipment need to be considered for the accuracy evaluation. There is no minimum interference rejection requirement for TABS equipment, and loss of position in the presence of interference is acceptable behaviour.

A2.2.6.7 Verification of SBAS Message Type 0

A2.2.6.7.1 Test to verify that the GNSS position source does not use SBAS corrections when the SBAS satellite is broadcasting message type 0 per A1.2.6.7.

A2.2.6.7.2 Simulator Scenario Details

A2.2.6.7.2.1 The simulator scenario SHALL use the standard 24-satellite constellation in RTCA document DO-229E Appendix B.

A2.2.6.7.2.2 A single SBAS satellite SHALL be simulated with a fast corrections (MT 2-5) update rate of 6 seconds.

A2.2.6.7.2.3 At 500 seconds into the scenario, the SBAS satellite SHALL start broadcasting message type 0 for 60 seconds. The message type 0 broadcast SHALL contain message type 2 data (if appropriate for the SBAS service being simulated).

A2.2.6.7.2.4 The scenario SHALL have a static user position.

A2.2.6.7.2.5 The simulated satellite signals SHALL be set to a nominal power level (-128 dBm).

A2.2.6.7.2.6 Simulated signals SHALL include ranging errors for atmospheric effects (troposphere and ionosphere) that adhere to approved models. Refer to DO-229E Appendix A Section A.4.2.4 and IS-GPS-200G, dated 5 September 2012.

A2.2.6.7.2.7 No interference needs to be simulated.

A2.2.6.7.3 Test Procedure

A2.2.6.7.3.1 Step 1: The simulator scenario SHALL be engaged and the satellites' RF SHALL be turned on.

A2.2.6.7.3.2 Step 2: The equipment SHALL be powered on and initialised. It is assumed that the receiver has obtained a valid almanac for the simulator scenario to be tested prior to conducting the tests.

A2.2.6.7.3.3 Step 3: Monitor the receiver output for the indication of SBAS use. Verify that the receiver indicates that SBAS is not in use before an SBAS satellite has been acquired.

A2.2.6.7.3.4 Step 4: Allow the receiver to reach steady-state navigation. Verify that the receiver indicates that SBAS is in use before proceeding to the next step.

A2.2.6.7.3.5 Step 5: 500 seconds into the scenario, the SBAS satellite SHALL start broadcasting message type 0.

A2.2.6.7.3.6 Step 6: Monitor the receiver output for the indication of SBAS use. Verify that the receiver indicates that SBAS is not used within 8 seconds.

A2.2.6.8 Exclusion of satellites identified by SBAS as unhealthy

A2.2.6.8.1 Test to verify that the GNSS position source excludes satellites with UDREI=15 reported in the SBAS fast corrections per A1.2.6.8. The ability of the position source to exclude unhealthy satellites based on the SBAS UDREI will be tested by injecting a ramp error on a satellite measurement and subsequently broadcasting an SBAS UDREI of 15 ('do not use') for that satellite.

A2.2.6.8.2 UDREI = 15 in fast corrections message (MT 2-5, 24)

A2.2.6.8.2.1 The equipment SHALL be tested to verify that the UDREI data contained in the SBAS fast corrections messages (MT 2-5, 24) is used to exclude unhealthy satellites.

Note: The test does not assume that the receiver outputs an indication that the unhealthy satellite has been removed from the position solution. Instead, it uses a pass criterion based on horizontal position error.

A2.2.6.8.2.2 Simulator Scenario Details

A2.2.6.8.2.2.1 The simulator scenario SHALL use the standard 24-satellite constellation in RTCA document DO-229E Appendix B.

A2.2.6.8.2.2.2 A single SBAS satellite SHALL be simulated with a fast corrections (MT 2-5, 24) update rate of 6 seconds. The integrity information message (MT 6) SHALL not be broadcast.

A2.2.6.8.2.2.3 The simulation start time and location SHALL be such that the resulting HDOP is close to 5.0.

A2.2.6.8.2.2.4 The simulation SHALL use nominal aircraft dynamics, defined to be ground speed = 200 knots and horizontal acceleration = 0.58 g. These dynamics can be simulated as a series of turns.

A2.2.6.8.2.2.5 The scenario SHALL allow the receiver time to achieve steady-state navigation before introducing any satellite errors.

A2.2.6.8.2.2.6 The scenario SHALL introduce a ramp error on each simulated GPS satellite individually, as follows:

A2.2.6.8.2.2.6.1 Step 1: A 5-m/s ramp error SHALL be introduced on the simulated GPS satellite.

A2.2.6.8.2.2.6.2 Step 2: 6 seconds after the introduction of the ramp error, the simulated SBAS satellite SHALL broadcast a UDREI of 15 for the GPS satellite in the fast correction message.

A2.2.6.8.2.2.6.3 Step 3: The ramp error SHALL be applied until one of the following conditions occur:

1. The horizontal position error of a valid position output exceeds 0.5 NM; or
2. The ramp error exceeds 2 000 m; or
3. The affected GPS satellite is excluded from the solution.

A2.2.6.8.2.2.6.4 Step 4: Allow the receiver time to return to steady state before repeating Steps 1 to 3 on the next satellite.

A2.2.6.8.2.2.7 The simulated satellite signals SHALL be set to -134 dBm while position measurements are taken. Signal powers may be increased at the beginning of the scenario to allow for initial acquisition.

A2.2.6.8.2.2.8 Simulated signals SHALL include ranging errors for atmospheric effects (troposphere and ionosphere) that adhere to approved models. Refer to DO-229E, Appendix A, Section A.4.2.4 and IS-GPS-200G dated 5 September 5 2012.

A2.2.6.8.2.2.9 No interference needs to be simulated.

A2.2.6.8.2.3 Pass-Fail Criteria

A2.2.6.8.2.3.1 The test SHALL be run on two different space-time scenarios. The two scenarios SHALL be sufficiently separated to ensure that different satellite geometry is presented to the receiver.

A2.2.6.8.2.3.2 The horizontal position errors SHALL be computed for each position estimate output by the equipment during the test.

A2.2.6.8.2.3.3 The horizontal position error SHALL not exceed 0.5 NM at any time during the test.

A2.2.6.8.2.3.4 Only those position outputs that are reported as valid by the equipment need to be considered for the accuracy evaluation.

A2.2.6.9 Testing GNSS Position Source SBAS Fast and Long-Term Corrections

A2.2.6.9.1 Application of Fast Corrections (MT 2-5, 24) and Long-Term Corrections (MT 24, 25). The equipment SHALL be tested to verify that fast corrections and long-term corrections are applied properly per A1.2.6.9.

A2.2.6.9.2 Simulator Scenario Details

A2.2.6.9.2.1 The simulator scenario SHALL use the standard 24-satellite constellation in RTCA document DO-229E Appendix B.

A2.2.6.9.2.2 A single SBAS satellite SHALL be simulated with a fast corrections (MT 2-5, 24) update rate of 6 seconds and standard long-term corrections (MT 24, 25) update rate of 120 seconds.

A2.2.6.9.2.3 The simulation start time and location SHALL be such that the resulting HDOP is close to 5.0.

A2.2.6.9.2.4 The simulation SHALL use nominal aircraft dynamics, defined to be ground speed = 200 kt and horizontal acceleration = 0.58 g. These dynamics can be simulated as a series of turns.

A2.2.6.9.2.5 The scenario SHALL introduce a bias and ramp error on a single satellite selected so that the range error will result in the maximum horizontal position error if not corrected by SBAS. The SBAS long-term corrections will be applied to correct the bias error. At each 6-second update, SBAS fast corrections will be provided to correct the ramp error for the affected satellite, as follows:

A2.2.6.9.2.5.1 Step 1: A 70-metre bias SHALL be introduced on the simulated GPS satellite. Provide SBAS long-term corrections to correct the bias term. The bias magnitude was chosen to approximate the maximum value that can be corrected by the $\delta a f_0$ term in a type 25 message (using velocity code 0).

A2.2.6.9.2.5.2 Step 2: Start the scenario broadcasting MT25 with the correction for the bias error introduced on the selected satellite.

A2.2.6.9.2.5.3 Step 3: Allow the receiver time to acquire the GPS and SBAS satellites and obtain a steady-state differential fix, including sufficient time to acquire a type 25 message for the selected GPS satellite.

A2.2.6.9.2.5.4 Step 4: Inject a 5-m/s ramp error on the selected satellite in the same direction as the bias error.

A2.2.6.9.2.5.5 Step 5: At each 6-second update, provide SBAS fast corrections equivalent to the size of the growing ramp error.

A2.2.6.9.2.5.6 Step 6: The ramp error SHALL be applied until the ramp error plus bias error reaches 325 metres. Maintain the error of 325 metres for 5 minutes.

A2.2.6.9.2.6 The simulated satellite signals SHALL be set to -134 dBm while position measurements are taken. Signal powers may be increased at the beginning of the scenario to allow for initial acquisition.

A2.2.6.9.2.7 Simulated signals SHALL include ranging errors for atmospheric effects (troposphere and ionosphere) that adhere to approved models. Refer to DO-229E Appendix A Section A.4.2.4 and IS-GPS-200G dated September 5, 2012.

A2.2.6.9.2.8 No interference needs to be simulated.

A2.2.6.9.3 Pass-Fail Criteria

A2.2.6.9.3.1 The horizontal and vertical position errors SHALL be computed for each position estimate output by the equipment during the test.

A2.2.6.9.3.2 Monitor the sensor-provided HFOM and VFOM, or HFOM and VFOM derived from the sensor-provided HDOP and VDOP per paragraphs A1.2.5.8 and A1.2.5.10. Compare the HFOM against the horizontal position error for each valid position estimate. Compare the VFOM against the vertical position error for each valid position estimate. In order to pass the test, the horizontal and vertical position accuracy output must be greater than the actual position error at least 95 % of the time. Analyse the position estimates to determine whether the fast corrections and long-term corrections are being applied correctly.

A2.2.6.9.3.3 Only those position outputs that are reported as valid by the equipment need to be considered for the accuracy evaluation.

A2.2.6.9.3.4 The test only needs to be run using a single space/time scenario.

A2.2.6.10 Test the GNSS position source requirements in Section 0 by running the test outlined in Section A2.2.6.3.3.

[Amdt ETSO/13]

[Amdt ETSO/16]

APPENDIX 3 TO ETSO-C199 A1 – ENVIRONMENTAL TESTING FOR CLASS B EQUIPMENT

ED Decision 2020/011/R

A3 Environmental Test Considerations

A3.1 The environmental tests and performance requirements described in this subsection provide a laboratory means of determining the overall performance characteristics of the equipment under conditions that are representative of those that may be encountered in actual aeronautical operations.

A3.2 The following test procedures must be run when performing environmental testing on Class B equipment. Class B equipment only needs to be tested under DO-160D change 3 or later Environmental Test, Section 4 Temperature and Altitude, and Section 5 Temperature Variation Testing.

A3.3 The test procedure provided below is considered satisfactory for use in determining the performance of the equipment under environmental conditions. Although specific test procedures are cited, it is recognised that other methods may be preferred. These alternative procedures may be used if the manufacturer can show that they provide at least equivalent information. In such cases, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternative procedures.

Note: The intent of this section is to minimise the testing of commercial off-the-shelf (COTS) devices.

A3.4 Class B Equipment System Test

A3.4.1 Equipment Required: A representative antenna of what will be installed in an actual airborne TABS.

A3.4.2 Figure 1 provides a representation of the test setup.

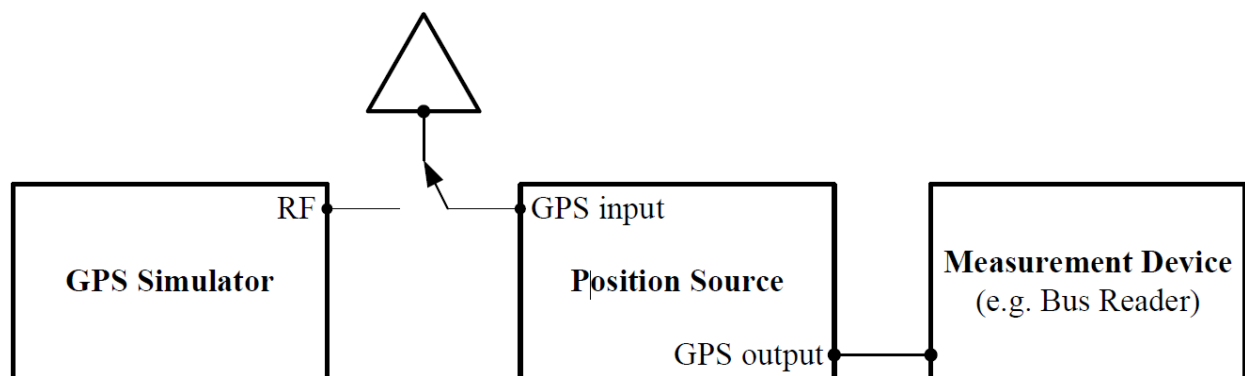


Figure 1 — Test Set-up

A3.4.3 Measurement Procedure:

A3.4.3.1 Set the test equipment to measure the output of the position source.

A3.4.3.1.1 Verify that the position information output by the GPS to the TABS is correct for:

A3.4.3.1.1.1 The latitude and longitude of the surveyed location when connecting the device to a live (e.g. rooftop) antenna, or;

A3.4.3.1.1.2 The output by the GPS simulator for the scenario outlined in Section A2.2.6.3.3

A3.4.3.1.2 Using the test set-up in A3.4.2, monitor the sensor-provided HFOM, or HFOM derived from the sensor-provided HDOP per paragraph A1.2.5.8. This output SHALL be compared against the horizontal position error for each valid position estimate. In order to pass the test, the horizontal position accuracy output must be greater than the actual position error for at least 95 % of the samples. The horizontal position error SHALL not exceed 0.5 NM at any time during the test.

[Amdt ETSO/13]

[Amdt ETSO/16]

ETSO-C200a

ED Decision 2016/029/R

LOW-FREQUENCY UNDERWATER LOCATING DEVICES (ACOUSTIC) (SELF-POWERED)

1 Applicability

This ETSO gives the requirements which Low-Frequency Underwater Locating Devices (Acoustic) (Self-Powered) that are designed and 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 document AS6254A Minimum Performance Standard for Low-Frequency Underwater Locating Devices (Acoustic) (Self-Powered), dated December 6, 2015.

3.1.2 Environmental standard

See CS-ETSO, [Subpart A](#), paragraph 2.1.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne electronic hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific

The battery used in the ULD authorised under this ETSO must meet the minimum performance standard found in the applicable battery ETSO such as ETSO-C142a, Non-Rechargeable Lithium Cells and Batteries for ULD powered by Lithium primary batteries. Lithium powered ULD must also meet the requirements in [Appendix 1](#) of this ETSO in addition to its battery meeting ETSO-C142a.

3.2.1 Failure condition classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

Failure or loss of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a minor failure condition.

4 Marking**4.1 General**

Marking as 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.

[Amdt ETSO/8]

[Amdt ETSO/12]

APPENDIX 1 TO ETSO-C200A LITHIUM BATTERY CONTAINMENT REQUIREMENTS

ED Decision 2016/029/R

The Airframe Low Frequency ULD must provide the containment of any hazardous products of the failure of its internal lithium battery without additional external containment devices other than the mounting bracket. Include the following note in the installation instructions and in the DDP.

Note: The ULD is intended to be mounted to the structure of the aircraft and provide a locating signal after a crash in water. **Placing the ULD inside a containment vessel will prevent it from performing its intended function of transmitting low frequency ultrasonic pulses to aid the location of the mishap aircraft.**

Sections 1.5, 1.6, 1.7 and 2 of RTCA/DO-347, Certification Test Guidance for Small and Medium Sized Rechargeable Lithium Batteries and Battery Systems, dated December 18, 2013, provide safety, design and qualification requirements and guidelines pertinent to designing safe batteries meeting CS-23, CS-25, CS-27 and CS-29 requirements and additional Special Conditions (SC) required for installation for the low frequency ULD on aircraft. Consider each of these requirements and guidelines when designing cells and batteries.

The requirements below include tests from RTCA/DO-347. Although written for rechargeable lithium batteries, EASA and the FAA consider these tests appropriate for demonstrating that non-rechargeable lithium batteries meet the SCs where indicated below. When conducting these tests and the test method states ‘charge the battery in accordance with the manufacturer’s instructions’, use a battery with a 100 % state of charge instead.

- 1) Lithium Primary Batteries used in Airframe Low Frequency ULD must independently:
 - a. Meet the requirements in ETSO-C142a, Non-rechargeable Lithium Cells and Batteries, including the tests in Appendix 1, Table 2, and
 - b. Pass the following tests in RTCA/DO-347, Certification Test Guidance for Small and Medium Sized Rechargeable Lithium Batteries and Battery Systems, dated December 18, 2013, as follows:
 - (1) Section 2.3.7 Short-circuit Test of a Cell
 - (2) Section 2.3.9 Short-circuit Test with Protection Disabled (required only for multi-cell batteries)
 - (3) Section 2.3.10 Insulation Resistance Test

Note: EASA published a [proposed special condition on ‘Non-rechargeable Lithium Battery Installations’](https://www.easa.europa.eu/documents/public-consultations/proposed-special-condition-%E2%80%99non-rechargeable-lithium-battery-installations)¹ requiring each individual cell within a battery be designed to maintain safe temperatures and pressures (SC1). The SC 2 addresses these same issues but at the battery level. SC 2 requires the battery to be designed to prevent propagation of a thermal event (i.e., self-sustained, uncontrolled increases in temperature or pressure) from one cell to adjacent cells.

¹ <https://www.easa.europa.eu/documents/public-consultations/proposed-special-condition-%E2%80%99non-rechargeable-lithium-battery>

- 2) The Airframe Low Frequency ULD with a primary lithium battery by itself or installed in its mounting bracket must pass the Section 2.3.15 Thermal Runaway Containment Test in RTCA/DO-347, Certification Test Guidance for Small and Medium Sized Rechargeable Lithium Batteries and Battery Systems, dated December 18, 2013. Do not compromise the integrity of the ULD to instrument or trigger the internal battery. Induce thermal runaway with either a. or b. below then complete c.
- a. Perform step e. of test method RTCA/DO-347 2.3.15.1 in lieu of RTCA/DO-347 2.3.15.1 steps c. and d. Step b is not required to complete step e. Apply the heating element to the exterior of the Airframe Low Frequency ULD or heat the ULD in a test chamber for this test to maintain the integrity of the item under test. Use of a test chamber heated to just above the triggering temperature will facilitate more accurate measurements of the ULD case temperature during the runaway.
 - b. Alternate method to induce a thermal runaway
In a cell closest to the center of the battery:
 - (1) Connect the terminals of a single electrically isolated cell to a power supply set to a constant voltage of at least 1.5 times the rated nominal cell voltage and charge with a current limit of I1 (or I_{max} if less than I1) of a single cell (+/- 50mA).
 - (2) Monitor the battery voltage during charge and terminate the charge when the peak voltage is reached.
 - (3) Subject the cell to a direct short circuit of less than 5 mOhm.
 - (4) Install the battery into the ULD (and bracket, as necessary) prior to the onset of Thermal Runaway.
 - (5) Monitor and record the battery voltage and current, the ULD case temperature, the ULD bracket temperature and continue with RTCA/DO-347 2.3.15.2 step g.
 - c. For RTCA/DO-347 2.3.15.1 steps g. and h., monitor and record the test chamber temperature and the external temperature of the ULD. Verify post-test that the battery did in fact experience thermal runaway by observing the ULD contained decomposition products akin to those obtained from conducting this test on a bare battery.
- 3) The ULD or the ULD in its mounting bracket must contain all non-gaseous products of 2 above. O-ring residue is acceptable. If any gasses are emitted, they must be emitted through a consistent, repeatable location such as around the closure threads or through a venting port.

Note 1: SC 3 of the [proposed special condition on 'Non-rechargeable Lithium Battery Installations'](https://www.easa.europa.eu/documents/public-consultations/proposed-special-condition-%E2%80%98non-rechargeable-lithium-battery-installations)¹ does allow explosive and toxic gases to be uncontained and not vented overboard if they do not accumulate in hazardous quantities.

Note 2: EASA and the FAA may impose additional special condition requirements for installation. Installers may use ETSO test data, including the battery containment test data as part of the certification package in showing compliance with an EASA or FAA installation special condition.

¹ <https://www.easa.europa.eu/documents/public-consultations/proposed-special-condition-%E2%80%98non-rechargeable-lithium-battery-installations>

- 4) The applicant shall document and make available to EASA and to the installer:
 - a. The test results to include the nature and volume of any gasses emitted, maximum case temperature during a thermal runaway, and whether or not the mounting bracket was required to attain containment.
 - b. If venting occurs, the venting location so that installers may design and fabricate appropriate venting systems that will not interfere with the intended function of the ULD as described in the Note at the beginning of this Appendix.
 - c. If the applicant chooses to incorporate a venting port in the ULD and/or ULD mounting bracket, the interface in the installation instructions or drawing.
- 5) Develop a means to prevent inadvertent opening of ULDs with failed batteries that may be under internal pressure. This may include voltage or external temperature checks prior to opening the device. The applicant shall include any appropriate cautions and warnings and document them in the installation and maintenance instructions.

[Amdt ETSO/12]

ETSO-C201

ED Decision 2016/013/R

ATTITUDE AND HEADING REFERENCE SYSTEMS (AHRS)**1 Applicability**

This ETSO provides the requirements which Attitude and Heading Reference Systems (AHRSs) that are designed and 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 RTCA Document No RTCA/DO-334 'Minimum Operational Performance Standards (MOPS) for Solid-State Strap-Down Attitude and Heading Reference Systems (AHRS)', dated 21.3.2012.

This ETSO applies to solid state strap-down AHRS intended to output pitch and roll attitude that does not use gimbaled sensors. It also addresses the optional functions of heading, turn, slip and the display of information provided by an AHRS.

When the article provides heading, turn and slip, degraded mode, uses aiding, includes a display, or provides information generated by the AHRS to a stand-alone display, it must, in particular, meet the requirements as listed in the table below.

Optional Functions/Mode/Source	Requirement
Heading	2.2.3
Turn and Slip	2.2.5
Degraded Mode	2.2.4
Aiding	2.2.6
Display	2.5

3.1.2 Environmental Standard

See CS-ETSO, [Subpart A](#), paragraph 2.1.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Electronic Hardware Qualification

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific

None.

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

4 Marking

4.1 General

Marking as 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.

[Amdt ETSO/11]

ETSO-C202

ED Decision 2016/013/R

CARGO STOPPER DEVICES**1 Applicability**

This ETSO provides the requirements which Cargo Stopper Devices that are designed and 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 Document No AS6554 'Cargo Stopper Devices', dated 6.7.2011 except as modified by [Appendix 1](#) of this ETSO

3.1.2 Environmental Standard

See Section 3.8 of AS6554.

3.1.2.1 Specific:

Consideration shall be given to available data regarding potential environmental degradation for the component straps and filling materials.

- (1) Environmental degradation due to aging, ultra-violet (UV)-exposure, weathering, etc., for any materials used in the construction of cargo stopper devices shall be considered.
- (2) Textile Performance: See SAE Aerospace Information Report (AIR) 1490B, Environmental Degradation of Textiles, dated December 2007, for available data for textile performance when exposed to environmental factors. These data shall be taken into account for consideration of the effects of environmental degradation on cargo stopper devices with the expected storage and service life.

Note: Environmental degradation data other than that documented in AIR 1490B may be used if substantiated by the applicant and approved by EASA.

3.1.3 Software

n/a

3.1.4 Electronic Hardware Qualification

n/a

3.2 Specific

None.

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

4 Marking**4.1 General**

Marking as detailed in CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

In addition the following marking shall be applied:

- The rated ultimate load in daN and lbf;
- The Expiration date in the format 'EXP YYYY-MM'

5 Availability of Referenced Document

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/11]

APPENDIX 1 TO ETSO-C202

ED Decision 2016/013/R

The applicable standard is SAE AS6554 ‘Cargo Stopper Devices’, dated 6.7.2011

It shall be modified as follows:

AS6554 section:	Action:
Section 1	To be disregarded.
Section 3.7	To be replaced: Fire Protection. The materials used in the cargo stoppers shall not have an average burn rate greater than 2.5 inches per minute when tested horizontally in accordance with the applicable portions of CS-25, Appendix F, part I, paragraph (b).
Section 4.3	To be disregarded.
Section 5	To be disregarded.
Section 6	To be disregarded.

[Amdt ETSO/11]

ETSO-C203 A1

ED Decision 2018/002/R

FIRE CONTAINMENT COVER (FCC)**1 Applicability**

This ETSO provides the requirements which fire containment covers (FCCs) that are designed and 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 International AS6453, Fire Containment Cover-Design, Performance, and Testing Requirements, August 2013, as amended by [Appendix 1](#) of this ETSO.

3.1.2 Environmental Standard

The required performance under the test conditions specified in SAE AS6453 Section 4.6 and Sections 6.1.2 through 6.1.5 as modified in the appendix of this TSO shall be demonstrated.

3.1.3 Software

None.

3.1.4 Airborne Electronic Hardware

None.

3.2 Specific**3.2.1 Failure Condition Classification**

See CS-ETSO Subpart A paragraph 2.4.

4 Marking**4.1 General**

Marking as detailed in CS-ETSO, Subpart A, paragraph 1.2.

4.2 Specific

Each fire containment cover conforming to this Standard shall bear at least the following markings near the bottom edges on the two opposite long sides:

- ‘FIRE CONTAINMENT COVER’, in bold characters at least 150 mm (6 in) high,
- Substantiated protection time (e.g. ‘Minimum protection duration 6 hours’),
- The IATA ULD ID (size) codes for the pallets and nets with which the FCC can be used.
- Expiration date in the format ‘EXP YYYY-MM’.

In addition, each fire containment cover conforming to this Standard shall bear the markings identified in SAE AS6453 Section 7.3 and Section 7.4 as amended in Appendix 1 of this ETSO

5 Availability of Referenced Document

See CS-ETSO, Subpart A, paragraph 3.

[Amdt ETSO/12]

[Amdt ETSO/13]

APPENDIX 1 TO ETSO-C203 A1 – MINIMUM PERFORMANCE STANDARD (MPS) FOR FIRE CONTAINMENT COVERS

ED Decision 2018/002/R

This Appendix prescribes the MPS for Fire Containment Covers. The applicable standard is SAE International AS6453, Fire Containment Cover – Design, Performance, and Testing Requirements dated August 2013 and modified as follows:

AS6453 Section	Action
1.1 – 1.2	Disregard
1.4	Disregard
1.7	Disregard
2	Disregard references to Japanese Airworthiness Standard Part 3 and Civil Aviation Agency of China Regulations CAAC CCAR-25 and CTSO C90
3.2	Disregard second sentence
4.1	Disregard
4.2.1	Disregard Note 4 and Note 6
4.3.1	Add to the end of the sentence 'which is sufficiently flexible to allow the FCC to collapse with the fire load'.
4.3.3 – 4.3.6	Disregard
4.4	Disregard
4.5.3	Disregard
4.5.4	Disregard
4.5.6 – 4.5.8	Disregard
4.6.5	Disregard the phrase 'as part of the required traceability code (see 7.2)'
4.6.7	Disregard
4.7	Disregard
5.1.1	Add 'seams and corners' after 'The fire container cover's material'.
5.1.1	Disregard references to CCAR-25 and JAS Part 3
5.1.2	Disregard
5.1.3	Disregard
5.2.2	Disregard references to CCAR-25 and JAS Part 3
5.2.4	Disregard
5.3	Disregard
6.1.1.1	Disregard references to CCAR-25 and JAS Part 3
6.1.1.2.b	Disregard references to CCAR-25 and JAS Part 3
6.1.1.5	Add the following sentence to the end of this section 'The FAA Aircraft Materials Fire Test Handbook includes an allowance for a brief ignition on the upper surface of the test specimen as long as the 400 degree F requirement is not exceeded.'
6.1.1.6 – 6.1.1.7	Disregard
6.1.6	Disregard
6.2.1	Replace the words in the end of the second sentence 'paragraph 4.3.2 of the US DOT/FAA/AR-TN05/20 document (see reference [16] in Bibliography).' with the following, 'the bulk load fire scenario section of report US DOT/FAA/TC-TN12/11.'
6.2.3	Disregard references to CCAR-25 and JAS Part 3
6.2.4	Disregard

6.2.6	Disregard ‘then with a repaired unit in order to substantiate the retained repair method. The test record files shall be used to substantiate the defined degree of damage as allowable operational serviceability limits, and repair method approval.’
6.2.7 – 6.2.9	Disregard
7.1 – 7.2	Disregard
7.3	Disregard last sentence
7.5	Disregard
8	Disregard
9	Disregard
Annex D	Disregard

[Amdt ETSO/12]

[Amdt ETSO/13]

ETSO-C207a

ED Decision 2020/011/R

AERONAUTICAL MOBILE AIRPORT COMMUNICATION SYSTEM (AeroMACS)**1 Applicability**

This ETSO provides the requirements which aeronautical mobile airport communication system (AeroMACSs) that are designed and 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**

The 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**

The applicable standards are those provided in EUROCAE ED-223, minimum operational performance standard (MOPS) for aeronautical mobile airport communication system (AeroMACS), dated October 2013.

Note: AeroMACS equipment may provide access in the airport environment to one or more of the following services: air traffic services (ATS), aeronautical operational communication (AOC) including aeronautical information services and meteorological (AIS/MET) information, airline administrative communication (AAC), and airport authority communication, as well as aircraft access to system-wide information management (SWIM) services. AeroMACS AMS equipment is intended for use while on the airport surface only. Passenger information and entertainment service and passenger-owned devices are not included in this ETSO. AeroMACS is considered to be supplemental to the communication equipment required by the operational rules. AeroMACS is based on the Institute of Electrical and Electronics Engineers 802.16-2009 standard: Air interface for broadband wireless access systems and can only operate on the airport surface.

3.1.2 Environmental Standard

See CS-ETSO, [Subpart A](#), paragraph 2.1.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne electronic hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific

None.

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

A failure of the function defined in paragraph 3.1.1 of this ETSO that results in misleading data link communication is a minor failure condition. A loss of this function is a minor failure condition. The minor failure condition classification is based on the network protocol and/or application system layers above the AeroMACS AMS equipment to detect and annunciate errors that would result in misleading or missing ATS messages.

4 Marking

4.1 General

See CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

None.

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/12]

[Amdt ETSO/16]

ETSO-C209

ED Decision 2018/002/R

ELECTRONIC FLIGHT INSTRUMENT SYSTEM (EFIS) DISPLAY**1 Applicability**

This ETSO provides the requirements which electronic flight instrument system (EFIS) displays that are designed and 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 SAE AS6296, Electronic Flight Instrument System (EFIS) Display, dated March 2016, and AS8034B, Minimum Performance Standard for Airborne Multipurpose Electronic Displays, dated 27th June 2011.

Note1: The hardware, physical, and optical (ocular) requirements of EFIS displays are addressed in SAE AS8034B. The EFIS display requirements, expressed for a broad set of aircraft functions, are addressed in SAE AS6296.

Note2: This ETSO standard covers basic display standards (SAE AS8034B) and specific displayed functions requirements (SAE AS6296). Specific displayed functions can include, but are not limited to, flight instrumentation, navigation, engine and system status, alerting, surveillance, communication, terrain awareness, weather, and/or other displays. This ETSO standard does not provide standards for head up displays. Two functions covered within SAE AS6296 are required as a minimum. This ETSO does not address sensor requirements. This ETSO standard does not address the display of single function equipment (e.g., airspeed). Sensor requirements and single function equipment requirements are located in their respective ETSO.

3.1.2 Environmental Standard

See CS-ETSO, [Subpart A](#), paragraph 2.1.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3

3.2 Specific

None.

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4

The failure condition classification appropriate for the equipment will depend on the intended use of the equipment in a specific aircraft. The loss of function and malfunction failure condition classification for which the equipment is designed should be documented.

4 Marking

4.1 General

Marking as detailed in CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

Per SAE AS6296 Section 3.14, a specific marking is required:

‘See Installation Manual (IM) for Declared EFIS Functions’, or equivalent, on the primary (most prominent) component of the EFIS.

5 Availability of Referenced Document

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/13]

ETSO-C210

ED Decision 2018/002/R

AIRBORNE HEAD-UP DISPLAY**1 Applicability**

This ETSO provides the requirements which airborne head up displays that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

This ETSO standard does not address enhanced vision systems (either infrared, millimeter wave or other imaging technologies), displays worn by the pilot (goggles, helmet-mounted displays) or specific symbology to be displayed.

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 SAE AS8055A, Minimum Performance Standards for Airborne Head Up Display, dated July 2015.

Some requirements of SAE AS8055A Section 4 are installation-dependent and cannot be fully verified at TSO article level. When the manufacturer is not able to test the TSO article in conditions representative of the overall range of the intended installation cases:

- the installation conditions for which the manufacturer has performed the test should be documented
- the installation procedures must define the functional qualification required to ensure the installed performance meets AS8055A.

3.1.2 Environmental Standard

See CS-ETSO, [Subpart A](#), paragraph 2.1.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific

None.

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

The failure condition classification appropriate for the equipment will depend on the intended use of the equipment in a specific aircraft. The loss of function and malfunction failure condition classification for which the equipment is designed should be documented, considering also obstructions to the pilot's field of view resulting from potential malfunction conditions.

4 Marking

4.1 General

Marking as 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.

[Amdt ETSO/13]

ETSO-C214 A1

ED Decision 2020/011/R

FUNCTIONAL ETSO EQUIPMENT USING AN ETSO-2C153A-AUTHORISED IMA PLATFORM OR MODULE

1 Applicability

This ETSO standard is applicable to any equipment presented for an ETSO authorisation to a functional¹ ETSO standard, where the equipment implements one (or several) [ETSO-C153a](#)-authorised IMA platforms/modules for which the applicant seeks compliance credit from these ETSO authorisations to demonstrate compliance with a functional ETSO.

Note: This ETSO standard is also applicable to any equipment for which an applicant is seeking an ETSO authorisation of a functional ETSO standard where the applicant performs additional development on an already authorised ETSO-C214 ‘open’ class article and intends to take compliance credit from this authorisation to demonstrate compliance with further functional ETSO standards.

This ETSO standard provides the requirements which functional ETSO equipment using an ETSO-C153a-authorised IMA platform or module or integrating further an ETSO-C214-authorised article that is designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

EUROCAE ED-124 and RTCA document DO-297 recognise incremental IMA system approval by introducing intermediate acceptance steps. ETSO-C153a authorisation is the first step in the ETSO IMA authorisation process. This ETSO-C214 standard is an intermediate step to authorise functional ETSO equipment (F-ETSO equipment)² implementing an ETSO-C153a-authorised IMA platform or IMA module, when the applicant is seeking compliance credit from these preceding authorisations to demonstrate compliance with a functional ETSO standard. This ETSO standard defines the requirements and delta activities that shall be performed for the authorisation of the integrated F-ETSO equipment.

Note: This ETSO standard does not define the minimum operational performance specifications of the defined function; these are defined by the individual ‘functional’¹ ETSO standard, with which the applicant may elect to comply (refer to CS-ETSO [Subpart A](#), Section 2.5).

2 Procedures

2.1 General

The applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 Specific

2.2.1 Access to the information of the selected ETSO-C153a platforms/modules

The applicant is responsible for establishing the necessary communication channels with the ETSO-C153a holder company.

The applicant shall have access to all necessary design data as a ‘user’ of the ETSO-C153a platform (for instance, the declaration of design performance, user

¹ Functional ETSO standard: any ETSO standard of CS-ETSO describing an aircraft function, i.e. typically the majority of all ETSO standards except ETSO-C153a and this ETSO-C214.

² ‘F-ETSO equipment’ is the integrated equipment for which the applicant is seeking an ETSO standard approval, using ETSO-C153a platform(s)/module(s).

guide/manual per [ETSO-C153a Appendix 3](#), installation manual, environmental qualification plans/reports, etc.).

The applicant's organisation shall establish a communication means to obtain timely notifications of design changes, open problem reports (at least the ones impacting the usage of the platform), occurrence reports and airworthiness directives (ADs) that affect or relate to the ETSO-C153a platforms/modules.

2.2.2 Assessment of design changes

The applicant shall perform a change impact analysis on ETSO-C153a platform design evolutions on the functional ETSO equipment, and shall perform the necessary development life cycle activities that are impacted by the ETSO-C153a changes.

Note: The functional ETSO holder is responsible for assessing the classification of the changes to the F-ETSO equipment as minor or major as per Part 21.A.611 and for providing the necessary associated justification.

Change management processes shall be compliant with AMC 20-170 Section 5.4.

2.2.3 Assessment and reporting of open problem reports (OPRs)

The management, analysis and classification of OPRs shall be performed by the applicant following the objectives of CS-ETSO Subpart A, Section 2.7 and AMC 20-170 Section 5.5, for which objective a) of that section is adapted to the F-ETSO context as follows:

- a) *The reporting of open problem reports (OPRs) between the different ETSO-C153a platforms/modules and the F-ETSO equipment shall be established and assessed by the F-ETSO applicant.*

3 Technical conditions

3.1 Basic

3.1.1 Minimum performance standard

This section provides the minimum performance standard requirements for the process of further development of equipment using an ETSO-C153a authorised platform(s)/module(s) for which a functional ETSO authorisation (defined as the F-ETSO equipment) is sought.

The process requirements will cover the environmental qualification, the hardware development assurance, software development assurance and finally the integration of these developed items into the F-ETSO equipment to demonstrate compliance for the intended function, using the credit of the authorised ETSO-C153a platform(s)/module(s).

Definition of classes

This ETSO is an incremental step between ETSO-C153a and complete IMA systems certified during an aircraft type certification. Depending on the future evolution of the F-ETSO equipment, two classes have been defined:

- 'open' class, and
- 'closed' class.

‘Open’ class refers to an ETSO article that has been integrated taking into account the provisions for future evolution (*) of the ETSO article but restricted to an IMA context. That means that there are still shared resources available after the integration of all the functions of the F-ETSO article, and that the performance and usage constraints of the remaining resources have been characterised.

‘Closed’ class refers to ETSO articles that have been integrated and where no evolution (*) has been anticipated, with all IMA-related activities considered closed. The performance of the remaining resources is not characterised. An F-ETSO ‘closed’ class article no longer offers the capability for IMA development. Design changes may still be performed in accordance with the Part 21 provisions, as for other ETSO articles.

() The term ‘evolution’ in these sentences refers to further development of functions using the remaining resources of the IMA, and without affecting the performance of the already authorised F-ETSO function.*

Class	Minimum performance standard
‘Open’	Section 3 of this document and Appendix 1
‘Closed’	Section 3 of this document

3.1.1.1 Use of ‘ETSO-C153a’-authorised platforms/modules

Identification of the ETSO-C153a platforms/modules used

- (a) The applicant shall clearly define the ETSO-C153a platforms/modules used in the design and the associated ETSO-C153a authorisation credit that is intended to be used for the F-ETSO equipment compliance demonstration.
- (b) The ETSO approval and the part number of the ETSO-C153a platforms/modules used shall be clearly referenced in the ETSO certification programme. The ETSO approval and the part number, including the issue/minor revisions of the ETSO-C153a platforms/modules used, shall be clearly referenced in the declaration of design and performance (DDP).
- (c) Any resources/functions included in the ETSO-C153a platforms/modules but unused in the current F-ETSO equipment shall be clearly identified in the ETSO certification programme or any related software/hardware plans.
- (d) The applicant shall identify and quantify the usage (used and unused features) of the ETSO-C153a platform resources, including the usage of its health monitoring and fault management resources.

Proper use of the ETSO-C153a platform(s)/module(s)

- (e) The applicant shall demonstrate the proper use of the ETSO-C153a platform(s)/module(s), including compliance with the ETSO-C153a platform integration requirements/user requirements and with the requirements for the correct use of platform safety features. In particular, the applicant shall demonstrate that the use, the partitioning, the configuration of

the resources and the installation of the items are performed on the ETSO-C153a platform/modules in compliance with the ETSO-C153a user manual, installation manual or equivalent data (as documented per ETSO-C153a Appendix 3). This also includes the deactivation or disabling of unused ETSO-C153a functions/modules, when available, or the means to ensure that the intended function is performed without any interference from unused ETSO-C153a functions/modules.

3.1.1.2 Equipment/hardware/software development

The ETSO certification programme shall describe the F-ETSO equipment and its structural breakdown. This shall include the use and integration of the ETSO-C153a authorised platform(s)/module(s) within the F-ETSO equipment. The F-ETSO equipment certification programme shall introduce the planning, the organisation, the division of tasks and the development, validation, integration, and verification activities conducted on the F-ETSO article, including the tool environment used for those activities.

Considerations regarding the content of this ETSO certification programme and guidance can be found in ED-124 Chapter 4.4.3, referring to 'IMA system certification plans'.

In particular, the ETSO certification programme shall indicate the structure of the life cycle data that will support the compliance demonstration with the ETSO requirements.

Non-ETSO functions

Any non-ETSO function embedded in the equipment shall be developed and integrated in conformance to the requirements of this section, in order to be able to demonstrate that it does not interfere with the ETSO functions.

Any non-ETSO functions embedded in the equipment shall be clearly identified as non-ETSO functions in the ETSO certification programme.

3.1.1.2.1 Hardware development

The applicant shall clearly define the additional hardware part that will be developed and integrated with the ETSO-C153a platforms/modules that are used.

The development of the hardware shall be compliant with CS-ETSO, Subpart A, Section 2.3.

3.1.1.2.2 Software/application development

(a) The applicant shall clearly define the software applications that will be developed and integrated with the ETSO-C153a platforms/modules that are used and with any possible additional hardware.

(b) The development of hosted applications shall be compliant with CS-ETSO, Subpart A, Section 2.2.

- (c) The development of the hosted applications executing on an ETSO-2C153 platform shall comply with the Task 2 objectives defined in ED-124/DO-297 Table A-2 and Chapter 4.3.1, except Objective 4.3.1.d, and with the following adaptation for Objective 4.3.1.a, where the ED-124/DO-297 text is replaced by:

Objective 4.3.1.a:

‘Demonstrate that each application performs its intended function and satisfies the related ETSO standard and ETSO-C153a Section 2.2 requirements and the F-ETSO article requirements while properly utilising the appropriate platform resources and interfacing with other modules and/or applications.’

Particularly it shall be demonstrated that the hosted application on the ETSO-C153a platform/module complies with the user requirements provided by the ETSO-C153a provider (see the CS-ETSO/ETSO-C153a Appendix 3).

- (d) Any non-ETSO application embedded in the ETSO article shall be developed in conformance to the above requirements (b) and (c) in order to be able to demonstrate that it does not interfere with the ETSO functions.

The associated life cycle data to demonstrate the above requirements shall be produced and organised to support the functional ETSO system integration objectives, and to show that the applications are executing correctly within the platform and module requirements and limitations.

Even though the objectives for the development of hosted applications remain applicable, when relevant, some activities/life cycle data might be combined with F-ETSO equipment activities/data (next section).

3.1.1.2.3 Equipment integration process

There are several levels of integration that are possible for functional ETSO equipment using ETSO-C153a authorised platforms/modules, of which some examples are listed below:

- the integration of software applications on an ETSO-C153a platform;
- the integration of several ETSO-C153a modules to build an integrated equipment and its software applications; and
- the integration of additional hardware simultaneously with software applications, together with an ETSO-C153a platform/module or additional hardware, into an ETSO-C153a rack platform (class RH).

General objective

- (a) The applicant shall perform the integration of the ETSO-C153a platform(s) and modules used with any additional hardware and the hosted software applications. These integration activities have to be compliant with the ED-124/DO-297 Task 3 objectives defined in ED-124/DO-297 Table A-3 and Chapter 4.4.1, except Objective 4.4.1.a, and with the following adaptation for Objective 4.4.1.d where the ED-124/DO-297 text is replaced by:

Objective 4.4.1.d:

‘Demonstrate compliance with the applicable functional ETSO standards and related MOPS.’

Note: Even though the integration activities have their own objectives, when relevant, some activities/data might be combined with some activities/life cycle data of the development of the hosted applications (see Section 3.1.1.2.2).

Health monitoring and fault management

- (b) The applicant shall describe how the ETSO-C153a health monitoring and fault management resources are used and integrated with the other platform/modules/application features, resulting in the health monitoring and fault management of the functional ETSO equipment.

In particular:

Principles and mechanisms shall be defined in order to allow the consistent sharing of fault management data between ETSO-C153a module/platform resources and the functions of the ETSO article. Recovery mechanisms shall be defined to ensure the continuity of the functions of the ETSO article when needed.

Guidance on health monitoring and fault management can be found in ED-124 Chapters 3.6.1 to 3.6.7.

Guidance about health monitoring and fault management at the platform and application levels respectively can also be found in ED-124 Chapters 3.1.1.b.5 and 3.1.2.d.

Configuration data/parameter data items

- (c) AMC 20-170 Section 5.2 shall be followed.

Use of tools and tool qualification

- (d) AMC 20-170 Section 5.3 shall be followed.

3.1.1.2.4 Safety assessment

The safety assessment of the F-ETSO equipment shall consider the possible failures in the ETSO-C153a platform/modules used in the equipment that are described by the platform provider in their failure modes and effect analysis and the safety assessment of the F-ETSO equipment. If any assumptions have been made at the ETSO-C153a platform/modules level, they shall be validated by the F-ETSO safety assessment process.

Note: If additional hardware is added to an ETSO-C153a platform/module, it shall also be considered in the safety assessment.

3.1.2 Environmental standard

The applicant shall demonstrate the compliance of the integrated F-ETSO equipment with the environmental requirements identified in CS-ETSO Subpart A, paragraph 2.1.

If the applicant intends to reuse evidence from an earlier demonstration of compliance achieved by the ETSO-C153a platform/module, an assessment of the achieved performance shall be performed so as to identify any gaps between the earlier qualification of the ETSO-C153a platform/module and the intended F-ETSO environment, in compliance with the requirements of Subpart A, Section 2.1. The qualification test plan of the F-ETSO shall clearly identify any additional qualification activities and any tests that need to be (re)performed considering the impact of the integration of several hardware platforms/modules, as well as the possible differences between the intended environment of the F-ETSO equipment and the environment for which the ETSO-C153a platform/modules were qualified.

3.1.3 Software

See Section 3.1.1.2.2 of this ETSO standard.

3.1.4 Airborne electronic hardware

See Section 3.1.1.2.1 of this ETSO standard.

3.2 Specific

The installation manual shall include all the data necessary for the proper installation and use of the F-ETSO equipment.

The installation manual shall document a means to ensure the compatibility between the authorised ETSO-C153a platform/module and the authorised F-ETSO article. In particular, the installation manual shall provide compatibility and mixability information between the IMA ETSO-C153a platform/module and the F-ETSO hosted application(s).

3.2.1 Failure condition classification

See CS-ETSO, Subpart A, paragraph 2.4.

The failure condition classification that is appropriate for the ETSO article will not be driven by this ETSO standard but driven by the intended aircraft function and the minimum classification indicated in the functional ETSO standard with which the ETSO article is intended to comply.

4 Marking

4.1 General

See CS-ETSO, Subpart A, paragraph 1.2.

4.2 Specific

The applicant shall mark the ETSO article with ETSO-C214 and the selected class of the equipment:

- ETSO-C214 'Open', or
- ETSO-C214 'Closed'.

The applicant shall maintain the original ETSO marking of the ETSO-C153a platform and modules used in the F-ETSO equipment. When the technique of electronic marking was used, this electronic marking shall remain available, even after having developed additional software.

5 Availability of Referenced documents

See CS-ETSO, Subpart A, paragraph 3.

[Amdt ETSO/14]

[Amdt ETSO/16]

APPENDIX 1 TO ETSO-C214 A1 – ‘OPEN’ CLASS IMA EQUIPMENT

ED Decision 2020/011/R

This Appendix is applicable to ‘open’ class IMA equipment.

1 IMA resources of ‘open’ class equipment

When the C214-ETSO article is of the ‘open’ class, the F-ETSO applicant needs to properly characterise and document the resulting platform resources and partitioning features for the next user.

Three main cases of ‘open’ equipment are distinguished in order to adapt the requirements to the development specificities of the F-ETSO article as follows:

- a) When the applicant uses only one [ETSO-C153a](#) platform and does not augment its resources, as illustrated below:

Shared resources of the F-ETSO equipment

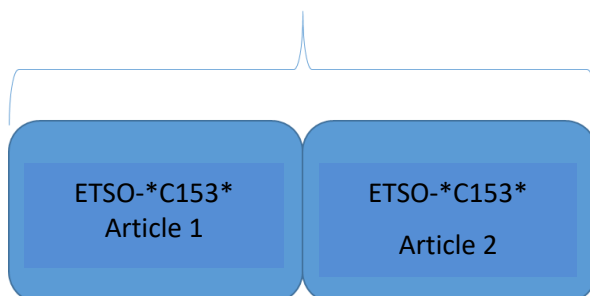


Note: ETSO-*C153* is intended to identify any existing amendment of this ETSO including its first release as ETSO-2C153

...then the applicant shall describe the use of the original ETSO-C153a platform with regard to the [ETSO-C153a Appendix 3](#) data (such as the user guide) and describe the remaining resources with respect to that Appendix 3 data so that it is clear which shared resources remain available for future incremental development by an independent user or aircraft manufacturer. In particular, the resources that are used and allocated shall be described and quantified.

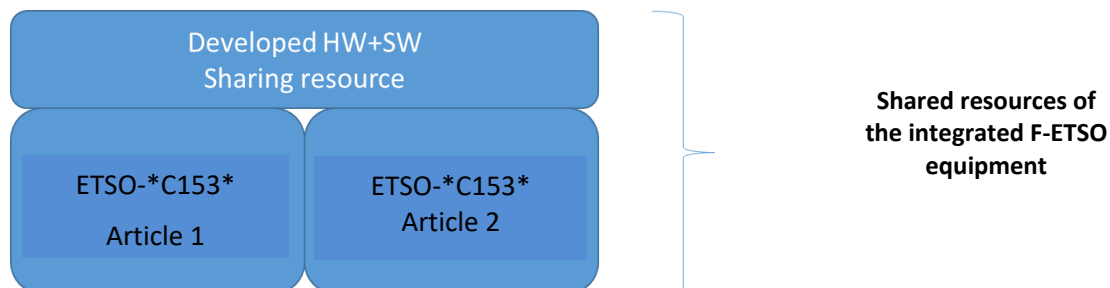
- b) When the F-ETSO equipment integrates multiple ETSO-C153a-authorized resources without augmenting the IMA sharing capability, as illustrated below:

Shared resources of the F-ETSO equipment



...the F-ETSO applicant shall characterise the resulting platform using the individual characterisation of the ETSO-C153a platform and document the resulting [ETSO-C214](#) ‘open’ platform in compliance with ETSO-C153a Appendix 3.

- c) When the F-ETSO equipment augments the IMA sharing resources with additional development (hardware and/or software), as illustrated below:



...the F-ETSO equipment development shall comply with [ETSO-C153a Appendix 2](#) and the related classes and document the augmented 'open' platform C214 in compliance with ETSO-C153a Appendix 3.

The applicant can use the ETSO-C153a Appendix 3 data of the ETSO-C153a platform/modules that are used and augment or amend them to elaborate the ETSO-C214 'open' platform user data, in compliance with ETSO-C153a Appendix 3.

Within the characterisation effort of resources, the applicant should in particular document the instructions for configuration of the ETSO-C214 article so that the next user can ensure the integrity and continuity of the system configuration, and ensure that the resource allocation, partitioning, and health monitoring would not be impaired when integrating the ETSOA article.

2 Continuous health monitoring capability

As a user of an ETSO-C153a platform/modules, the F-ETSO applicant should pay particular attention to ensuring that there is a continuous health monitoring capability. Health monitoring features provided in an 'open' class platform shall be continuously maintained and characterised throughout the integration process, and the health monitoring capability shall be made available for any potential further incremental development.

[Amdt ETSO/14]

[Amdt ETSO/16]

INDEX 2 EUROPEAN TECHNICAL STANDARD ORDERS

ETSO-2C11e

ED Decision 2003/10/RM

**POWERPLANT FIRE DETECTION INSTRUMENTS
(THERMAL AND FLAME CONTACT TYPES)****1 Applicability**

This ETSO gives the requirements which powerplant 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) 8028 „Powerplant Fire Detection Instruments Thermal and Flame Contact Types“, dated April, 1980.

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.

ETSO-2C19c A1

ED Decision 2020/011/R

PORTABLE WATER-SOLUTION TYPE HAND FIRE EXTINGUISHERS**1 Applicability**

This ETSO provides the requirements which portable water-solution type hand fire extinguishers that are designed and 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**

The 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**

The applicable standards are those provided in SAE International's Aerospace Standard AS245B, Water Solution Type Hand Fire Extinguisher, dated 1 November 1948, revised in April 2000, as amended by [Appendix 1](#) to this ETSO

3.1.2 Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1

3.1.3 Software

None.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 Specific**3.2.1 Failure Condition Classification**

See CS-ETSO, Subpart A, paragraph 2.4.

4 Marking**4.1 General**

See CS-ETSO, Subpart A, paragraph 1.2.

Instead of the optional serial number, the date of manufacture has to be marked.

4.2 Specific

In addition to the requirements of paragraph 4.1, the marking requirements of SAE International's Aerospace Standard AS245B, paragraph 3.2 are applicable.

5 Availability of Referenced Document

See CS-ETSO, Subpart A, paragraph 3

[Amdt ETSO/12]

[Amdt ETSO/16]

APPENDIX 1 TO ETSO-2C19c A1 – MPS PORTABLE WATER SOLUTION TYPE HAND FIRE EXTINGUISHERS

ED Decision 2020/011/R

The applicable standard is SAE AS245B, Water Solution Type Hand Fire Extinguisher, dated (revised) April 2004, shall be modified as follows:

AS245B section	Action									
Paragraph 4.1.2: Burst pressure	to be revised as follows: The burst pressure must be greater than or equal to ‘b’ times the design pressure (see Table 1 below). The design pressure is compatible with the maximum pressure encountered in use of the extinguisher and ensures a long service life for equipment when charged.									
Paragraph 5. Individual Performance Requirements:	to be revised as follows: All extinguishers, or extinguisher components shall be subjected at a minimum to the following tests: Requirement to be added: the proof pressure must be greater than or equal to ‘p’ times the design pressure (see table 1 below). Table 1: the ‘b’ and ‘p’ factors indicated depend on the type of extinguisher <table><tr><th></th><th>b</th><th>p</th></tr><tr><td>Type I</td><td>2,7</td><td>1,5</td></tr><tr><td>Type II</td><td>2,4</td><td>1,2</td></tr></table>		b	p	Type I	2,7	1,5	Type II	2,4	1,2
	b	p								
Type I	2,7	1,5								
Type II	2,4	1,2								

[Amdt ETSO/12]

[Amdt ETSO/16]

ETSO-2C34f

ED Decision 2003/10/RM

ILS GLIDE SLOPE RECEIVING EQUIPMENT OPERATING WITHIN THE RADIO FREQUENCY RANGE OF 328.6-335.4 MEGAHERTZ (MHZ)

1 Applicability

This ETSO gives the requirements which airborne ILS glide slope receiving equipment operating within the radio frequency range of 328.6-335.4 MHz 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 documents ED-47B dated September 1995 with amendment 1 dated 15 July 1997.

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.

ETSO-2C35d

ED Decision 2003/10/RM

RADAR MARKER RECEIVING EQUIPMENT**1 Applicability**

This ETSO gives the requirements which radio marker receiving equipment must meet in order to be identified with 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 EUROCAE document 1/WG7.

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.

ETSO-2C36f

ED Decision 2003/10/RM

**AIRBORNE ILS LOCALIZER RECEIVING EQUIPMENT OPERATING WITHIN THE
RADIO FREQUENCY RANGE 108-112 MEGAHERTZ****1 Applicability**

This ETSO gives the requirements which airborne ILS localizer receiving equipment operating within 108-112 MHz that are manufactured on or after the date of this ETSO must meet in order to be identified with 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 documents ED-46B dated September 1995 with amendment 1 dated 2 July 1997.

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-TSO [Subpart A](#) paragraph 3.

ETSO-2C40c

ED Decision 2003/10/RM

VOR RECEIVING EQUIPMENT OPERATING WITHIN THE RADIO FREQUENCY RANGE 108-117.95 MEGAHERTZ

1 Applicability

This ETSO gives the requirements which VOR receiving equipment operating within 108-117.95 MHz 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 ED-22B (1988) or RTCA DO-196 plus additions shown paragraph 3.2 below.

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

Radio Technical Commission for Aeronautics (RTCA) Document DO-196, used in US TSO-C40c differs from EUROCAE document ED-22B as follows:

- ED-22B demands greater minimum bearing accuracy ($\pm 2.7^\circ$ Vs $\pm 3.0^\circ$).
- ED-22B contain requirements and tests for operation with ASB Doppler VOR ground stations (ASB Doppler VORs are used in Europe and other parts of Europe but not in CONUS)

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.

ETSO-2C41d

ED Decision 2003/10/RM

AIRBORNE AUTOMATIC DIRECTION FINDING (ADF) EQUIPMENT**1 Applicability**

This ETSO gives the requirements which airborne automatic direction finding 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 ED-51 (1983 rev. 1987) or RTCA DO-179 plus additions shown paragraph 3.2 below.

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

Radio Technical Commission for Aeronautics (RTCA) Document DO-179 (1982), used in US TSO-C41d differs from EUROCAE document ED-51 as follows:

- ED-51 demands tuning increments of 0.5 kHz or less to match the European NDB frequency scheme (500 Hz channels), DO-179 demands increments of 1 kHz.

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.

ETSO-2C48a

ED Decision 2010/010/R

CARBON MONOXIDE DETECTOR INSTRUMENTS**1 Applicability****1.1 General**

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

1.2 Specific

This ETSO refers to two basic types of detector instruments:

- TYPE A instruments are completely self-contained and carry their own power source and warning system.
- TYPE B instruments are powered by the aircraft power supplies including the alarm system.

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**

See [Appendix 1](#)

3.1.2 Environmental Standard

See CS-ETSO [Subpart A](#) paragraph 2.1 and [Appendix 2](#)

3.1.3 Computer Software

See CS-ETSO [Subpart A](#) paragraph 2.2

3.1.4 Electronic Hardware Qualification

See CS-ETSO [Subpart A](#) paragraph 2.3

3.2 Specific**3.2.1 Failure Condition Classification**

See CS-ETSO [Subpart A](#) paragraph 2.4

Failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a minor failure condition.

4. Marking

4.1 General

Marking is detailed in CS-ETSO [Subpart A](#) paragraph 1.2

4.2 Specific

The component must be permanently and legibly marked with the equipment class as defined in paragraph 1.2 of this ETSO.

5 Availability of Referenced Document

See CS-ETSO [Subpart A](#) paragraph 3

[Amdt ETSO/6]

APPENDIX 1 TO ETSO-2C48A – MINIMUM PERFORMANCE STANDARD

ED Decision 2010/010/R

The following requirements apply to both TYPE A & B unless otherwise stated.

1 Performance Standard

- The Instrument shall trigger visual and aural alarm when CO is detected.
- The concentration against time characteristic of the alarm activation shall meet the requirements of Table 1 below:
- The instrument may provide a readout of actual detected CO concentration level in parts per million (ppm) by volume.
- The probability of false alarms should be shown by the manufacturer to be sufficiently remote so as not to encourage the flight crew to distrust the instrument.
- The warm-up time of the instrument should not exceed 5 minutes.

CONCENTRATION (ppm by volume)	NO ALARM BEFORE (minutes)	ALARM BEFORE (minutes)
Less than or equal to 30	DO NOT ALARM	DO NOT ALARM
More than 30	120	180
More than 50	60	90
More than 100	10	40
More than 300	No delay	3

Table 1: Alarm Activation Concentration

2 Alarm Operation

- There shall be a flashing AMBER indication, visible within the angle shown in Figure 1 below, whenever any of the criteria, described in Table 1, are met.

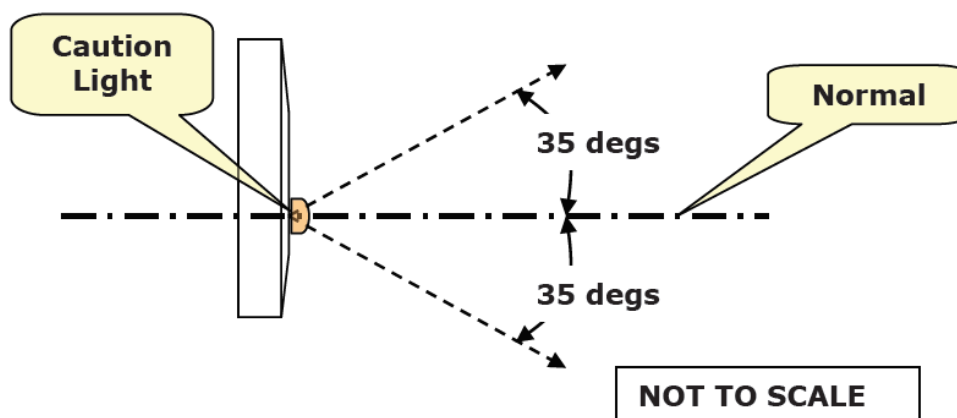


Figure 1 Plan View of Instrument showing Minimum Viewing Angle

- The flashing visual caution light shall be accompanied by an intermittent aural alarm of a distinctive characteristic that cannot be confused with other aural alarms or indications that are typically found in the aircraft.
- The aural alarm shall be of such a characteristic that the attenuation by an Automatic Noise Reduction Headset will be kept to a minimum.

- d. In order to mitigate any distraction at critical stages of the flight, the aural alarm should initially alarm at a low intensity. At each cycle of the alarm the intensity should be increased until it is at least 85dBA at a range of 3 metres.
- e. It shall be possible for the pilot to cancel the alarms. Once cancelled the instrument should re-set within 2 minutes. At this point, the instrument should continue to monitor the air and re-warn if the criteria of paragraph 1b are met.

3 Function/Power Indications

- a. Self test:
Both types of unit should have a function indicator which illuminates showing that a self test of the instrument has been successfully completed. The test should confirm as many of the functions as possible.
- b. Battery Power test. TYPE A only
The TYPE A unit shall provide the pilot with a steady visual indication that there is 5 hours or less of useful battery power remaining. If there is less than 2 hours left, the visual indication should be made to flash.

4 Standard Performance Test

The following is a detailed test requirement to be carried out when specified. During all tests the detector should be mounted in its normal operating orientation.

- a. Test gases for Alarm Operation: the following concentrations should be used to check the alarm operation.

REF	CO TEST GAS (ppm by volume)	NO ALARM BEFORE (minutes)	ALARM BEFORE (minutes)
A	20-25	240	-
B	31-37	120	180
C	51-61	60	90
D	101-121	10	40
E	301-361	-	3
F	5000-5500	-	3

- b. The test conditions for the standard test are:
 - Temperature: 15 to 25°C
 - Humidity: Between 30% and 70% Relative humidity.
 - Pressure: 980 to 1050 hPa
- c. Standard Test procedure: the following is required:
 - Switch on instrument and allow to warm up for 5 minutes
 - Purge with clean air for 15 minutes
 - Test Gas B and check alarm between 120 to 180 minutes
 - Purge with clean air for 15 minutes
 - Test Gas C and check alarm between 60 to 90 minutes
 - Purge with clean air for 15 minutes

- Test Gas D and check alarm between 10 to 40 minutes
 - Purge with clean air for 15 minutes
 - Test Gas E and check alarm before 3 minutes
- d. Digital Display
- If a digital display is featured on the equipment then it should be checked that it reads in the band $\pm 10\%$ of the actual value for each of the conditions above.

5 Low CO concentration test.

To ensure that nuisance warnings do not occur at low concentrations, carry out the following test exposing the instrument to the following gases:

- Clean air for 15 min
- Test gas A for 240 min or more
- Check that the alarm is not triggered
- Test gas B and ensure that alarm is triggered between 120 and 180 min

6 High CO concentration test.

To ensure that the instrument is capable of reacting to extremely high concentrations, carry out the following test exposing the instrument to the following gases:

- Pass clean air for 15 min
- Pass test gas F.
- Check that the alarm is triggered within 3 min.
- Pass clean air for 10 min
- Pass test gas B.
- Check that the alarm triggers between 120 and 180 min.

7 Documentation

The supplier shall provide written guidance in the following areas:

7.1 Operation

General description including the principle of operation including;

- Details of and interpretation of warnings.
- Details of and interpretation of test indications.
- Limitations.
- Battery changing procedure if applicable.

Action in the event of receiving a warning

Suggest generic actions helping the installer defining appropriate AFM procedures.

7.2 Installation

The installation instruction must make it clear which categories of aircraft the instrument is suitable for and any restrictions in its use must also be clearly stated.

A general description of

- the optimum position for the instrument in different aircraft types and
- the positions to be avoided to ensure reliable air sampling and to avoid compass interference.

7.3 Continued Airworthiness

Cleaning and other instructions as required.

[Amdt ETSO/6]

APPENDIX 2 TO ETSO-2C48A – ADDITIONAL TESTS

ED Decision 2010/010/R

The following additional tests are required.

- a Effect of Fuel contaminated air.
 - i Air contaminated with 1,000 ppm by volume of 100LL fuel is to be passed through the instrument for 2 hours
 - ii Verify that there are no false alarms during that period
 - iii Pass test sample D through the instrument and ensure that the alarm is triggered between 10 and 40 minutes
 - iv Repeat 2.2-a, 2.2-b and 2.2-c using JET A1 fuel.
 - v Repeat 2.2-a, 2.2-b and 2.2-c using MOGAS Leaded fuel to BS:4040:1988.
 - vi Repeat 2.2-a, 2.2-b and 2.2-c using MOGAS Unleaded fuel to BS:7070 or EN228:1995.
 - vii Repeat 2.2-a, 2.2-b and 2.2-c using diesel fuel

[Amdt ETSO/6]

ETSO-2C66b

ED Decision 2003/010/RM

**DISTANCE MEASURING EQUIPMENT (DME) OPERATING WITHIN THE RADIO
FREQUENCY RANGE OF 960-1215 MEGAHERTZ****1 Applicability**

This ETSO gives the requirements which distance 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 ED-54 (1987).

In addition to Chapter 5 of EUROCAE document ED-54, 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

Addition: equipment manufactured in accordance with this ETSO shall be compatible with 50 kHz VOR equipment.

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.

ETSO-2C75

ED Decision 2003/10/RM

HYDRAULIC HOSES ASSEMBLY**1 Applicability**

This ETSO gives the requirements which static hydraulic hoses assembly 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-TSO [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](#), Hydraulic Hoses Assemblies“dated December 15, 1962, except as mentioned in paragraph 3.2 below.

3.1.2 Environmental Standard

As stated in the Federal Aviation Administration Standard.

3.1.3 Computer Software

None

3.2 Specific

Proof of pressure: 2Pw as specified in CS-25 Appendix J.

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 hoses must be marked:

- if suitable for use with synthetic base fluids: letter „S“ immediately following the type designation.
- if suitable for use with petroleum base fluids: letter „P“ immediately following the type designation.
- if suitable for use with both synthetic base and petroleum base fluids: letters „S/P“ immediately following the type designation.
- if complying with the fire resistant requirements: letter „F“ immediately following the type and fluid designation.

4.2 Specific

None.

5 Availability of Referenced Document

See CS-ETSO [Subpart A](#) paragraph 3

APPENDIX 1 TO ETSO-2C75 – FEDERAL AVIATION ADMINISTRATION STANDARD FOR HYDRAULIC HOSE ASSEMBLIES

ED Decision 2003/10/RM

- 1.0 Purpose. To specify minimum airworthiness requirements for hydraulic hose assemblies intended for use on civil transport category aircraft.
- 2.0 Scope. This specification covers minimum airworthiness requirements for the following types of hydraulic hose assemblies:

Type	Pressure	Temperature
IA	Medium ¹	11160° F.
IB	High ²	22160° F.
IIA	Medium	275° F.
IIB	High	275° F.
IIIA	Medium	400° F.
IIIB	High	400° F.

3.0 General Requirements.

- 3.1 Materials. Materials shall be uniform in quality and suitable for the purpose intended. The suitability of the materials shall be determined on the basis of satisfactory service experience or substantiating qualification test.
- 3.2 Workmanship. Workmanship shall be of the quality necessary to produce hose assemblies free from all defects which may adversely affect proper functioning in service.
- 3.3 Qualification Tests, General.
- 3.3.1 Performance. There shall be no evidence of leakage, wicking, imperfections or damage of the hose or end fittings when the assembly is subjected to the tests specified herein.
- 3.3.2 Test Assemblies. A sufficient number of each type and size hose assembly to be qualified shall be selected at random and satisfactorily tested to the applicable provisions specified herein.
- 3.3.3 Fluid Aging. In all the tests involving fluid aged assemblies, the assemblies shall be filled with a suitable test fluid³ and soaked for 7 days in an air oven at the applicable temperature specified in paragraph 2.0.
- 3.3.4 Air Aging. In all the tests involving air aged assemblies, the assembly shall be aged for 7 days in air at the applicable temperature specified in paragraph 2.0.
- 3.3.5 Test Pressures. Unless otherwise noted, all pressures specified herein are hydraulic pressures and shall not be less than the applicable pressure shown in paragraph 7.1.
- 3.3.6 Test Temperatures. Unless otherwise specified, the fluid and ambient temperatures shall be room temperatures.

¹ The term „medium“ is used herein to mean anominal operating pressure of 1,500 p.s.i. or less.

² The term „high“ pressure means a nominal operating pressure greater than 1,500 p.s.i. and up to and including 3,000 p.s.i.

³ A suitable test fluid is one which is representative of that to be used with the applicable hose assembly in civil transport category aircraft operation.

3.3.7 End Fitting Design. If an end fitting incorporates a minor variation from the design of a similar fitting in a previously qualified hose assembly of the same type, then the hose assembly need not be retested. It is the responsibility of the manufacturer to determine that such a variation will not adversely affect the airworthiness of the hose assembly.

3.3.8 Corrosion. The design and manufacture of the hose assemblies shall be such that corrosive tendencies in any component part shall be effectively minimized.

4.0 Test Requirements, Type IA, IIA, IB, and IIB Hose Assemblies.

- 4.1 Proof Pressure. Hose assemblies shall be subjected, for at least 30 seconds, to a proof pressure test of at least 1.5 times the applicable pressure shown in paragraph 7.1.
- 4.2 Bending and Vacuum. A hose assembly shall be fluid aged in accordance with paragraph 3.3.3. It shall then be proof pressure tested in accordance with paragraph 4.1. The unfilled assembly shall then be bent over a form so that the radius and length shall conform to Table I except that, for -16 and larger size hoses, the length shall be 30 inches. The hose shall not flatten or deform at any section to an amount greater than 10 percent of the outside diameter of the hose. While still bent in this radius, a vacuum of 28 inches of mercury shall be applied and held for 5 minutes during which time the hose shall be checked for additional flattening. Application of the 28-inch Hg vacuum shall not result in more than a 20 percent reduction in OD at any section for all sizes up to and including -24 and a 35 percent reduction for size -32. After the vacuum is released, and the hose is dissected longitudinally, there shall be no evidence of ply separation, blistering, collapse, or other damage.
- 4.3 Hydraulic Leakage. An unaged hose assembly, not less than 12 inches in length, shall be subjected to 70 percent of the hydraulic burst pressure specified in paragraph 4.4 for 5 minutes. The pressure shall then be reduced to zero, after which it shall be raised to 70 percent of the specified burst pressure for another 5-minute period. The outer surface of the hose assembly shall be carefully checked after this period for conformance with paragraph 3.3.1. After completion of the hydraulic leakage test, the hose assembly shall be subjected to the Room Temperature Burst Pressure test specified in paragraph 4.4.
- 4.4 Room Temperature Burst Pressure. An unaged hose assembly of the applicable length specified in Table I shall be subjected to a burst pressure of 4.0 times the applicable pressure shown in paragraph 7.1. The rate of pressure rise shall be 20,000±5,000 p.s.i. per minute until the burst pressure is obtained.
- 4.5 Hydraulic Impulses. A fluid aged, air aged, and unaged hose assembly of lengths not less than those applicable lengths specified in Table I shall be proof pressure tested in accordance with paragraph 4.1 and then be connected to a manifold installed in an impulse test machine. The temperature of the test fluid shall be measured at the test manifold and shall be maintained at 120°±10° F. Hose assemblies of the -3 through -12 sizes shall be installed with the applicable bend radius shown in Table I and both ends shall be connected to a rigid support. Size -16 through -32 hose assemblies shall be installed straight with one end left free. Electronic measuring devices shall be used to measure the impulse pressures in the inlet manifold. Impulse cycling in accordance with Figure I shall be as follows:

Type	Size	No of Cycles
IA and IIA	-3 through -16	100,000
IA and IIA	-20 through -32	50,000
IB and IIB	-4 through -6	100,000
IB and IIB	-8	75,000
IB and IIB	-10	50,000
IB and IIB	-12	35,000
IB and IIB	-16	45,000
IIIA	all sizes	100,000
IIIB	all sizes through -8	250,000
IIIB	sizes -10 and -12	100,000
IIIB	-16	45,000

The following assemblies need not be subjected to any peak pressure greater than the applicable operating pressure:

Type	Size
IA and IIA	-20 through -32
IB, IIB and IIIB	-16
IIIA	-20 and -24

- 4.6 Cold Temperature Flexing. A fluid aged and an air aged hose assembly (reference paragraphs 3.3.3 and 3.3.4 respectively) shall be filled with a suitable test fluid and placed, for a 72-hour period in a cold chamber which is controlled to -65° to -70° F. While at this temperature, the assemblies shall be bent through 180°, in opposite directions, to the applicable radius specified in Table I, within a 4- second period. After removal from the cold chamber, the assemblies shall be subjected to the applicable proof pressure test. Dash 16 and larger size assemblies may be tested at -40° F. in lieu of the above specified temperature.

5.0 Test Requirements, Type III A Hose Assemblies.

- 5.1 Room Temperature Burst Pressure. Same as paragraph 4.4.

5.2 Bending and Vacuum.

- a. An unaged assembly shall be filled with test fluid and cold soaked at -65° to -70°F. for 24 hours and then bent to the applicable bend radius, through 180°, in opposite directions. Five complete cycles shall be conducted at the rate of approximately one cycle in 4 seconds. The assembly shall then be subjected to the applicable proof pressure test while still at -65° to -70°F.

- b. The assembly shall be emptied and heat soaked at 400°±10° F. for 4 hours while bent to the applicable bend radius and while being subjected to the following negative pressure:

28 inches of mercury for the -4 through -12 size.

18 inches of mercury for the -16 and -20 size.

14 inches of mercury for the -24 size.

The assembly shall then be cooled to room temperature while the negative pressure is maintained.

- c. After this test and after the hose is dissected longitudinally and inspected, there shall be no evidence of damage or breakdown.
- 5.3 Hydraulic Leakage. A hose assembly of the applicable length specified in Table I shall be subjected to the hydraulic leakage test specified in paragraph 4.3 after it has been pressurized, while at room temperature, to 25 p.s.i. for at least 5 minutes.
- 5.4 High Temperature Burst Pressure. An assembly, of the applicable length specified in Table I shall be filled with test fluid at 50 p.s.i. and heat soaked for 1-hour wherein ambient and fluid temperatures are $400^{\circ}\pm 10^{\circ}\text{F}$. The pressure shall then be increased to the rated operating pressure and held for 5 minutes. The pressure shall then be raised to three times the applicable pressure shown in paragraph 7.1 at a rate of $20,000\pm 5,000$ p.s.i.. During this test, one end of the assembly shall be free.
- 5.5 Hydraulic Impulses. Same as paragraph 4.5 except that the fluid and ambient temperatures shall be at $400^{\circ}\pm 10^{\circ}\text{F}$.
- 6.0 Test Requirements, Type IIIB Hose Assemblies.
 - 6.1 Hydraulic Leakage. Same as paragraph 5.3.
 - 6.2 Hydraulic Impulse. Same as paragraph 4.5 except that, in addition, the assembly shall be temperature cycled from room temperature to the specified ambient and fluid temperature, and back to room temperature, for at least 2 cycles. This test shall be programmed so that at least 80 percent of the impulses shall be at 400°F ambient and fluid temperatures.
 - 6.3 Thermal Shocks.
 - a. The test assembly shall be air aged in accordance with paragraph 3.3.4 and after aging shall be subjected to the applicable proof pressure for a minimum of 5 minutes.
 - b. The test assemblies shall then be mounted, empty, in a controlled temperature test set-up (typical set-up shown in Figure II) and the ambient temperature reduced to $-67^{\circ}\pm 2^{\circ}\text{F}$ for a minimum of 2 hours. At the end of this period, while still at this temperature, high temperature test fluid at a temperature of 400°F shall be suddenly introduced at a minimum pressure of 50 p.s.i. Immediately after the hot fluid has filled the assembly, the pressure shall be raised to the applicable proof pressure for a minimum of 5 minutes. Not more than 15 seconds shall elapse between the introduction of the high temperature fluid at 50 p.s.i. and the raising of the pressure to proof pressure.
 - c. The assembly shall then be subjected to the High Temperature Burst Pressure test specified in paragraph 5.4.
 - 6.4 Flexing. The assembly shall be mounted in the flex set-up as illustrated in Figure III, shall be filled with test fluid and subjected to the following test sequence. The temperatures indicated are both fluid and ambient. Flexing shall occur at a rate of 70 ± 10 cycles per minute during portions c. d. and e.
 - a. The test assemblies shall be soaked, with no pressure or flexing at a temperature of $-67^{\circ}\pm 2^{\circ}\text{F}$ for a minimum of one hour.
 - b. With no flexing, the test assemblies shall be pressurized to the proof pressure with the temperature still at -67°F for a minimum of 5 minutes (first cycle only).

- c. Flexing shall begin while the test assemblies are pressurized to the operating pressure with the temperature still at -67° F. for a minimum of 4,000 cycles.
- d. With the pressure reduced to zero p.s.i., flexing shall continue for 1,000 cycles at -67° F.
- e. Increase the temperature to 400°F. and flex for 1,000 cycles with the pressure at zero p.s.i. The pressure shall then be increased to the operating pressure with the temperature held at 400°F. Flexing shall continue until an accumulated total of 80,000 cycles is reached.
- f. Steps a. c. d. and e. shall be repeated for a total of 5 test sequences, i.e., 400,000 flexing cycles.
- g. After completion of step f. and with no flexing, the test assemblies shall be pressurized to the proof pressure with the temperature still at 400° F. for a minimum of 5 minutes (last cycle only).

7.0 Fire-Resistant Hose Assemblies. Fireresistant hose assemblies which are intended to be used in locations within fire zones shall comply with the applicable requirements specified herein and in addition shall also comply with the fire test described in FAA report entitled, „Standard Fire Test Apparatus and Procedure“ revised March 1961. The use of a protective sleeve over the hose and/or end fittings is permitted to facilitate compliance with the fire test requirements. Sleeve or protective covers shall be secured to the hose assembly so that fire-resistant properties will be maintained.

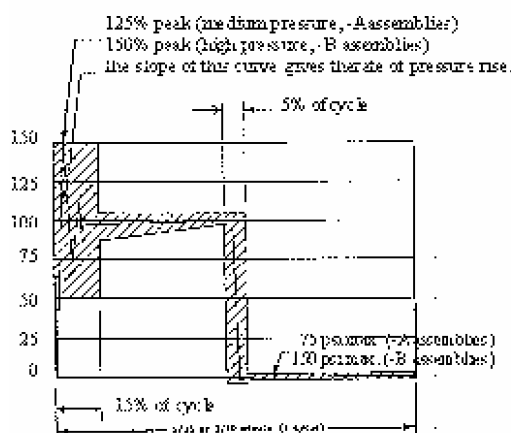
7.1 Fire Test Parameters.

Type Hose Assembly	Hose Size	Maximum Operating Pressure	Flow Rate GPM
IA and IIA	-3	1,500	7 x (ID) ²
	-4	1,500	"
	-5	1,500	"
	-6	1,500	"
	-8	1,500	"
	-10	1,500	"
	-12	1,000	"
	-16	800	"
	-20	600	3 x (ID) ²
IB and IIB	-24	500	1 x (ID) ²
	All	3,000	1 x (ID) ²
	IIIA	-3 to -10	1,500
		-12	1,000
		-16	1,250
		-20	1,000
		-24	750
	IIIB	All	3,000
			"

7.2 Criteria for Acceptability. The hose assembly shall be considered acceptable if it successfully withstands the applicable fire test for a period of 5 minutes without evidence of leakage.

TEST LENGTH AND MINIMUM BEND RADIUS

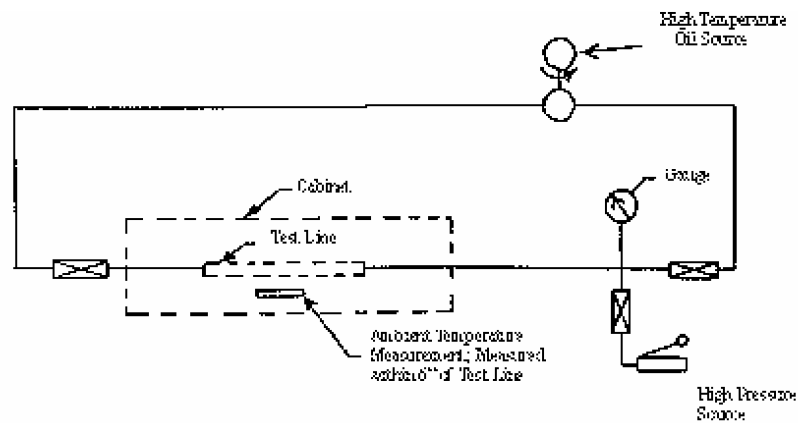
SIZE NUMBER	LENGTH OF TEST ASSEMBLY INCHES				MINIMUM BEND RADIUS AT INSIDE OF BEND INCHES			
	Type Hose Assemblies				Type Hose Assemblies			
	IA and IIA	IB and IIB	IIIA	IIIB	IA and IIA	IB and IIB	IIIA	IIIB
-3	14	—	—	—	3	—	—	—
-4	14	16	14	16	3	3	2	3
-5	16	18	16	—	3?	3?	2	—
-6	18	21	18	21	4	5	4	5
-8	21	24	21	24	4?	5%	4?	5%
-10	23½	30	23½	30	5½	6½	5½	6½
-12	27½	33	27½	33	6½	7%	6½	7%
-16	18	24	18	24	7?	9?	7?	9?
-20	18	—	18	—	9	—	11	—
-24	18	—	18	—	11	—	14	—
-32	18	—	—	—	13½	—	—	—

TABLE I
IMPULSE PRESSURE CURVE


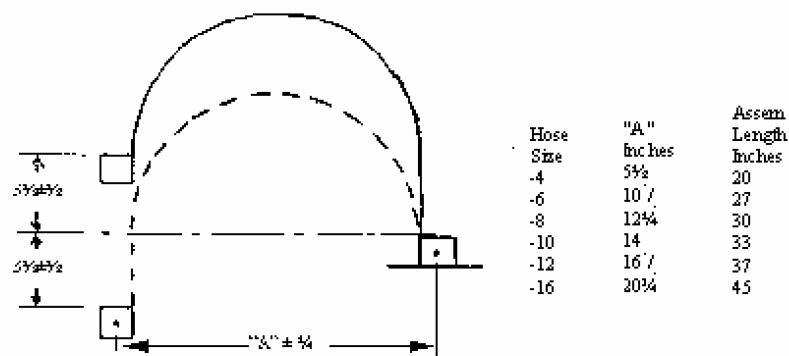
The curve shown above is the approximate pressure-time cycle determined to be of proper severity for impulse testing of hose assemblies. The pressure-time curve shall be confined to the shaded area indicated.

NOTE: Cycling tolerance = 35±5 or 70±10 cycles per minute.

FIGURE I



Typical Setup for High Temperature Pressure Testing
Figure II



Assembly Flex Test Setup
Figure III

ETSO-2C93b

ED Decision 2003/10/RM

**AIRBORNE INTERIM STANDARD MICROWAVE LANDING SYSTEM CONVERTER
EQUIPMENT****1 Applicability**

This ETSO gives the requirements which airborne interim standard microwave landing system converter 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 the EUROCAE document ED 36A, „MOPS for Microwave Landing System (MLS) Airborne Receiving Equipment“, dated February 1995.

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.

ETSO-2C104a

ED Decision 2003/10/RM

MICROWAVE LANDING SYSTEM (MLS) AIRBORNE RECEIVING EQUIPMENT**1 Applicability**

This ETSO gives the requirements which microwave landing system (MLS) airborne receiving 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 General****3.1.1 Minimum Performance Standard**

Standards set forth in EUROCAE document ED-36A dated February 1995 including amendment 1 of July 1997 and amendment 2 of September 1997).

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

Radio Technical Commission for Aeronautics (RTCA) Document DO-177 (1981), used in US TSO-C104 differs from EUROCAE document ED-36A in signal acquisition warning generation and test procedures.

4 Marking**4.1 General**

Marking is detailed in CS-TSO [Subpart A](#) paragraph 1.2.

4.2 Specific

None.

5 Availability of Referenced Document

See CS-ETSO [Subpart A](#) paragraph 3.

ETSO-2C122

ED Decision 2003/10/RM

**DEVICES THAT PREVENT BLOCKED CHANNELS USED IN TWO-WAY RADIO
COMMUNICATIONS DUE TO SIMULTANEOUS TRANSMISSIONS****1 Applicability**

This ETSO gives the requirements which devices that prevent blocked channels used in two-way radio communications due to simultaneous transmissions, 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 EUROCAE document ED-68, „MOPS for Devices that prevent Simultaneous Transmissions“, dated April 1992.

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

ETSO-2C123c

ED Decision 2020/011/R

COCKPIT VOICE RECORDER SYSTEMS**1 Applicability**

This ETSO provides the requirements that cockpit voice recorder (CVR) systems that are designed and 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**

The applicable procedures are detailed in CS-ETSO, [Subpart A](#).

2.2 Specific

All the information specified in EUROCAE ED-112A, Section 2-1, 2-1.3.4, excluding item 6, shall be documented in a manual and be made available to the accident investigation authorities on request. In addition, if special tools or recovery techniques are used to retrieve recorded information from any memory device that is used within the crash-protected memory module removed from a crash-damaged recorder, these tools/recovery techniques shall be also made available to the accident investigation authorities on request.

Note: Requests from accident investigation authorities can be independent of any ongoing investigation.

3 Technical Conditions**3.1 Basic****3.1.1 Minimum Performance Standard**

The applicable standards are those provided in EUROCAE ED-112A, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, that pertain to the CVR type, except Chapters I-1 and I-6, and Sections 2-1.1, 2-1.5, 2-1.6, 2-1.11, 2-1.12, 2-3.1, 2-5, 3, Annex I-A, Annex I-C, *and other ED-112A requirements related to installation, flight testing, aircraft maintenance* as amended by Appendix 1 to this ETSO.

Table 1 lists CVR types and the ED-112A Section and Part containing the MPS for each type:

Table 1 — CVR MPS Requirements

CVR Type	ED-112A Reference
Single-function CVR in a non-deployable recorder	Section 2 and Part I.
CVR function in a <u>deployable</u> recorder	Section 2 (except for tests covered by ETSO-2C517) and Part I. The recorder shall also comply with ETSO-2C517.
CVR function in a <u>combined non-deployable</u> recorder	Section 2, Section 4, and Part I.

CVR function in a combined deployable recorder

Section 2 (except for tests covered by ETSO 2C517), Section 4 and Part I. The recorder shall also comply with ETSO-2C517.

Note: A CVR article may cover multiple types. A CVR may be a combined CVR and may also be deployable, in which case the applicable MOPS are Sections 2, 4, Part I and the MOPS of ETSO 2C517, following the table above.

3.1.2 Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

A failure of the function defined in paragraph 3.1.1 of this ETSO is a minor failure condition.

A loss of the function defined in paragraph 3.1.1 of this ETSO is a minor failure condition.

The applicant must develop the system to be at least the development assurance level that is commensurate with these failure conditions.

Note: The failure classification requirement is driven by the use of CVRs in accident investigations.

4 Marking

4.1 General

See CS-ETSO, Subpart A, paragraph 1.2.

4.2 Specific

4.2.1 Lettering Identification

The equipment shall comply with the identification requirement in EUROCAE ED-112A, Section 2-1, paragraph 2-1.16.3, if it is fixed, and those of ETSO-2C517, if it is deployable.

5 Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

[Amdt ETSO/6]

[Amdt ETSO/13]

[Amdt ETSO/16]

APPENDIX 1 TO ETSO-2C123c – MPS FOR CRASH-PROTECTED AIRBORNE RECORDER SYSTEMS

ED Decision 2020/011/R

The standard EUROCAE ED-112a, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, shall be modified as per Table 1 below.

Table 1 — Modification of EUROCAE ED-112A

Location	Initial ED-112A text	Amending text
2-1.16.2 a. iii.	Impact shock, shear and tensile test, penetration resistance, static crush, deep sea pressure and sea water immersion.	Impact shock, shear and tensile test, penetration resistance, static crush, deep sea pressure and sea water immersion. Deep sea pressure and sea water immersion may be performed on two different units provided that both units undergo the rest of the sequence and that the period of the deep sea pressure test is 90 days.
2-4.2.7 a.	Unless it can be shown that the recording medium can withstand the conditions associated with deep sea immersion and that it is unlikely to be damaged as a consequence of collapse of any protective armour, immerse the recorder in sea water at a pressure of 60 MPa (equivalent to a depth of 6 000 m (20 000 ft) for a period of 30 days. This period may be reduced to 24 hours provided that the methods and materials used to protect the recording medium have been shown to be unaffected by sea water. To avoid damage to the test equipment, this test may be performed using any suitable liquid in the pressure chamber itself together with a means to separate this liquid from the sea water in which the recorder is immersed.	Unless it can be shown that the recording medium can withstand the conditions associated with deep-sea immersion and that it is unlikely to be damaged as a consequence of the collapse of any protective armour or except if the recorder is deployed during or following impact with water, immerse the recorder in seawater at a pressure of 60 MPa (equivalent to a depth of 6 000 m, i.e. 20 000 ft) for a period of 90 days. This period may be reduced to 24 hours provided that the test is performed once more after the sea water immersion test in 2-4.2.7 b. To avoid damage to the test equipment, this test may be performed using any suitable liquid in the pressure chamber itself together with a means to separate this liquid from the seawater in which the recorder is immersed.
2-4.2.7 b.	Unless it can be shown that the recording medium and the identification required by paragraph 2-1.16.3 are resistant to the corrosive effects of sea water, immerse the recorder in sea water at a depth of 3 m and nominal temperature of + 25°C for a period of 30 days.	Unless it can be shown that the recording medium and the identification required by paragraph 2-1.16.3 are resistant to the corrosive effects of seawater, immerse the recorder in seawater at a depth of 3 m and a temperature of at least + 25.0 °C for a period of 90 days.

[Amdt ETSO/16]

ETSO-2C124c

ED Decision 2020/011/R

FLIGHT DATA RECORDER SYSTEMS

1 Applicability

This ETSO provides the requirements that flight data recorder (FDR) systems that are designed and 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

The applicable procedures are detailed in CS-ETSO, [Subpart A](#).

2.2 Specific

All the information specified in EUROCAE ED-112A, Section 2-1, 2-1.3.4 excluding item 6, shall be documented in a manual and be made available to the accident investigation authorities on request. In addition, if special tools or recovery techniques are used to retrieve recorded information from any memory device used within the crash-protected memory module removed from a crash-damaged recorder, these tools/recovery techniques shall be also made available to the accident investigation authorities on request.

Note: Requests from accident investigation authorities can be independent of any ongoing investigation.

3 Technical Conditions

3.1 Basic

3.1.1 Minimum Performance Standard

The applicable standards are those provided in the applicable sections of EUROCAE ED-112A, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, that pertain to the FDR type, except Chapters II-1 and II-6, and Sections 2-1.1, 2-1.5, 2-1.6, 2-1.11, 2-1.12, 2-3.1, 2-5, 3, Annex II-A, Annex II-B, and other ED-112A requirements related to for aircraft-level equipment installation, flight testing, and aircraft maintenance as amended by Appendix 1 to this ETSO.

Table 1 lists FDR types and the ED-112A Section and Part containing the MPS for each type:

Table 1. Recorder MPS Requirements

Recorder Type	ED-112A Reference
Single-function FDR in a non-deployable recorder	Section 2 and Part II.
FDR function in a deployable recorder	Section 2 (except for tests covered by ETSO 2C517) and Part II. The recorder shall also comply with ETSO 2C517.
FDR function in a combined non-deployable recorder	Section 2, Section 4, and Part II.
FDR function in a combined deployable recorder	Section 2 (except for tests covered by ETSO 2C517), Section 4 and Part I.

The recorder shall also comply with ETSO 2C517.

Note: An FDR article may cover multiple types. An FDR may be a combined FDR and may also be deployable, in which case the applicable MOPS are Sections 2, 4, Part I and the MOPS of ETSO 2C517, following the table above.

3.1.2 Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.3.

A failure of the function defined in paragraph 3.1.1 of this ETSO is a minor failure condition.

A loss of the function defined in paragraph 3.1.1 of this ETSO is a minor failure condition.

The applicant must develop the system to be at least the development assurance level that is commensurate with this failure condition.

Note: The failure classification requirement is driven by the use of FDRs in accident investigations.

4 Marking

4.1 General

See CS-ETSO, Subpart A, paragraph 1.2.

4.2 Specific

4.2.1 Lettering Identification

The equipment shall comply with the identification requirement in EUROCAE ED-112A, Section 2-1, paragraph 2-1.16.3, if it is fixed, and those of ETSO-2C517, if it is deployable.

5 Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

[Amdt ETSO/6]

[Amdt ETSO/13]

[Amdt ETSO/16]

APPENDIX 1 TO ETSO-2C124c – MPS FOR CRASH-PROTECTED AIRBORNE RECORDER SYSTEMS

ED Decision 2020/011/R

The standard EUROCAE ED-112a, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, shall be modified as per Table 1 below.

Table 1 — Modification of EUROCAE ED-112A

Location	Initial ED-112A text	Amending text
2-1.16.2 a. iii.	Impact shock, shear and tensile test, penetration resistance, static crush, deep sea pressure and sea water immersion.	Impact shock, shear and tensile test, penetration resistance, static crush, deep sea pressure and sea water immersion. Deep sea pressure and sea water immersion may be performed on two different units provided that both units undergo the rest of the sequence and that the period of the deep sea pressure test is 90 days.
2-4.2.7 a.	Unless it can be shown that the recording medium can withstand the conditions associated with deep sea immersion and that it is unlikely to be damaged as a consequence of collapse of any protective armour, immerse the recorder in sea water at a pressure of 60 MPa (equivalent to a depth of 6 000 m (20 000 ft) for a period of 30 days. This period may be reduced to 24 hours provided that the methods and materials used to protect the recording medium have been shown to be unaffected by sea water. To avoid damage to the test equipment, this test may be performed using any suitable liquid in the pressure chamber itself together with a means to separate this liquid from the sea water in which the recorder is immersed.	Unless it can be shown that the recording medium can withstand the conditions associated with deep-sea immersion and that it is unlikely to be damaged as a consequence of the collapse of any protective armour or except if the recorder is deployed during or following impact with water, immerse the recorder in seawater at a pressure of 60 MPa (equivalent to a depth of 6 000 m, i.e. 20 000 ft) for a period of 90 days. This period may be reduced to 24 hours provided that the test is performed once more after the sea water immersion test in 2-4.2.7 b. To avoid damage to the test equipment, this test may be performed using any suitable liquid in the pressure chamber itself together with a means to separate this liquid from the seawater in which the recorder is immersed.
2-4.2.7 b.	Unless it can be shown that the recording medium and the identification required by paragraph 2-1.16.3 are resistant to the corrosive effects of sea water, immerse the recorder in sea water at a depth of 3 m and nominal temperature of + 25°C for a period of 30 days.	Unless it can be shown that the recording medium and the identification required by paragraph 2-1.16.3 are resistant to the corrosive effects of seawater, immerse the recorder in seawater at a depth of 3 m and a temperature of at least + 25.0 °C for a period of 90 days.

[Amdt ETSO/16]

ETSO-2C128

ED Decision 2003/10/RM

**DEVICES THAT PREVENT BLOCKED CHANNELS USED IN TWO-WAY RADIO
COMMUNICATIONS DUE TO UNINTENTIONAL TRANSMISSIONS****1 Applicability**

This ETSO gives the requirements which devices that prevent blocked channels used in two-way radio communications due to unintentional transmissions, 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 EUROCAE document ED-67, „MOPS for Devices that prevent Unintentional or Continuous Transmissions“, dated April 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 .

4.2 Specific

None.

5 Availability of Referenced Document

See CS-ETSO [Subpart A](#) paragraph 3.

ETSO-2C169a

ED Decision 2010/010/R

VHF RADIO COMMUNICATIONS TRANSCEIVER EQUIPMENT OPERATING WITHIN THE RADIO FREQUENCY RANGE 117.975 TO 137.000 MEGAHERTZ

1 Applicability

This ETSO gives the requirements which new models of VHF Radio Communications Transceiver Equipment Operating within the Radio Frequency Range 117.975 to 137.000 Megahertz that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

This ETSO cancels ETSO-2C37e “VHF Radio Communication Transmitting Equipment Operating within the Radio Frequency Range 117.975-137.000 Megahertz” and ETSO-2C38e “VHF Radio communication Receiving Equipment Operating within the Radio Frequency Range 117.975-137.000 Megahertz”.

2 Procedures

2.1 General

Applicable procedures are detailed in CS-ETSO Subpart A.

2.2 Specific

This ETSO applies to equipment intended for aircraft VHF amplitude modulated (AM) communications operating within 117.975 to 137.000 MHz. This includes 25 and 8.33 kHz channel spacing capabilities. VHF communication equipment covered by this ETSO is primarily intended for aeronautical operational control (AOC) and air traffic services (ATS) safety communications.

3 Technical Conditions

3.1 Basic

3.1.1 Minimum Performance Standard

Standards set forth in EUROCAE document ED-23C “Minimum Operational Performance Standards for Airborne VHF Receiver-Transmitter Operating within the Radio Frequency Range 117.975-137.000 MHz”, dated June 2009 for the equipment classes defined in the following table.

Table of Equipment Classes for VHF Communication Equipment

Equipment Class	Description
C	Receiver used in a 25 kHz channel separation environment having off-set carrier operation
D	Receiver used in a 25 kHz channel separation environment not having off-set carrier operation
E	Receiver used in an 8.33 kHz channel separation environment not having off-set carrier operation
H1 and H2	Receivers which are to be used in a 8,33 kHz channel separation environment and intended for off-set carrier operation with only two carriers.
3	Transmitter used in a 25 kHz channel separation environment and intended to operate with a range of 200 nautical miles.

Equipment Class	Description
4	Transmitter used in a 25 kHz channel separation environment and intended to operate with a range of 100 nautical miles.
5	Transmitter used in an 8.33 kHz channel separation environment and intended to operate with a range of 200 nautical miles.
6	Transmitter used in an 8.33 kHz channel separation environment and intended to operate with a range of 100 nautical miles.

It is recommended that, when applying for ETSO-2C169a authorisation, the applicant also applies for [ETSO-2C128](#) “Devices that Prevent Blocked Channels Used in Two-Way Radio Communications due to Unintentional Transmission” authorisation.

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

3.1.4 Electronic Hardware Qualification.

See CS-ETSO [Subpart A](#) paragraph 2.3

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO [Subpart A](#) paragraph 2.4

Failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a major failure condition.

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

[Amdt ETSO/6]

ETSO-2C176a

ED Decision 2020/011/R

AIRCRAFT COCKPIT IMAGE RECORDER SYSTEMS**1 Applicability**

This ETSO provides the requirements that aircraft cockpit image recorder (CIR) systems that are designed and 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**

The applicable procedures are detailed in CS-ETSO, [Subpart A](#).

2.2 Specific

All the information specified in EUROCAE ED-112A, Section 2-1, 2-1.3.4, excluding item 6, shall be documented in a manual and be made available to the accident investigation authorities on request. In addition, if special tools or recovery techniques are used to retrieve recorded information from any memory device used within the crash-protected memory module removed from a crash-damaged recorder, these tools/recovery techniques shall be also made available to the accident investigation authorities on request.

Note: Requests from accident investigation authorities can be independent of any ongoing investigation.

3 Technical Conditions**3.1 Basic****3.1.1 Minimum Performance Standard**

The applicable standards are those provided in the applicable sections of EUROCAE ED-112A, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013 that pertain to the Cockpit Image Recorder (CIR) type, except chapters III-1 and III-6, and Sections 2-1.1, 2-1.5, 2-1.6, 2-1.11, 2-1.12, 2-3.1, 2-5, 3, Annex III-A, Annex III-B, and other ED-112A requirements related to aircraft-level equipment installation, flight testing, and aircraft maintenance as amended by Appendix 1 to this ETSO.

The table below lists the types of recorder and the ED-112A section or part that contains the MPS for each of them:

Table 1 — CIR MPS Requirements

CIR Type	ED-112 Reference
Single CIR in a non-deployable recorder	Section 2 and Part III.
CIR function in a deployable recorder	Section 2 (except for tests covered by ETSO-2C517) and Part III. The recorder shall also comply with ETSO-2C517.
CIR function in a combined non deployable recorder	Section 2, Section 4 and Part III.

CIR Type	ED-112 Reference
CIR function in a combined deployable recorder	Section 2 (except for the tests covered by ETSO-2C517), Section 4 and Part I. The recorder shall also comply with ETSO-2C517.

Note: A CIR article may cover multiple types. A CIR may be a combined CIR and may also be deployable, in which case the applicable MOPS are in Sections 2, 4, Part I and the MOPS of ETSO-2C517, following the table above.

3.1.2 Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1

3.1.3 Software

See CS-ETSO, Subpart A, paragraph 2.2

3.1.4 Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

A failure of the function defined in paragraph 3.1.1 of this ETSO is a minor failure condition.

A loss of the function defined in paragraph 3.1.1 of this ETSO is a minor failure condition.

Note: The failure classification requirement is driven by the use of recorders in accident investigations.

4 Marking

4.1 General

See CS-ETSO, Subpart A, paragraph 1.2

4.2 Specific

4.2.1 Lettering Identification

The equipment shall comply with the identification requirement in EUROCAE ED-112A, Section 2-1, paragraph 2-1.16.3, if it is fixed, and those of ETSO-2C517, if it is deployable.

5 Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3

[Amdt ETSO/6]

[Amdt ETSO/13]

[Amdt ETSO/16]

APPENDIX 1 TO ETSO-C2176A – MPS FOR CRASH-PROTECTED AIRBORNE RECORDER SYSTEMS

ED Decision 2020/011/R

The standard EUROCAE ED-112A, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, shall be modified as per Table 1 below.

Table 1 — Modification of EUROCAE ED-112A

Location	Initial ED-112A text	Amending text
2-1.16.2 a. iii.	Impact shock, shear and tensile test, penetration resistance, static crush, deep sea pressure and sea water immersion.	Impact shock, shear and tensile test, penetration resistance, static crush, deep sea pressure and sea water immersion. Deep sea pressure and sea water immersion may be performed on two different units provided that both units undergo the rest of the sequence and that the period of the deep sea pressure test is 90 days.
2-4.2.7 a.	Unless it can be shown that the recording medium can withstand the conditions associated with deep sea immersion and that it is unlikely to be damaged as a consequence of collapse of any protective armour, immerse the recorder in sea water at a pressure of 60 MPa (equivalent to a depth of 6 000 m (20 000 feet) for a period of 30 days. This period may be reduced to 24 hours provided that the methods and materials used to protect the recording medium have been shown to be unaffected by sea water. To avoid damage to the test equipment, this test may be performed using any suitable liquid in the pressure chamber itself together with a means to separate this liquid from the sea water in which the recorder is immersed.	Unless it can be shown that the recording medium can withstand the conditions associated with deep-sea immersion and that it is unlikely to be damaged as a consequence of collapse of any protective armour or except if the recorder is deployed during or following impact with water, immerse the recorder in seawater at a pressure of 60 MPa (equivalent to a depth of 6 000 m, i.e. 20 000 feet) for a period of 90 days. This period may be reduced to 24 hours provided that the test is performed once after the sea water immersion test in 2-4.2.7 b. To avoid damage to the test equipment, this test may be performed using any suitable liquid in the pressure chamber itself, together with a means to separate this liquid from the seawater in which the recorder is immersed.
2-4.2.7 b.	Unless it can be shown that the recording medium and the identification required by paragraph 2-1.16.3 are resistant to the corrosive effects of sea water, immerse the recorder in sea water at a depth of 3 m and nominal temperature of +25°C for a period of 30 days.	Unless it can be shown that the recording medium and the identification required by paragraph 2-1.16.3 are resistant to the corrosive effects of seawater, immerse the recorder in seawater at a depth of 3 m and a temperature of at least + 25.0 °C for a period of 90 days.

[Amdt ETSO/16]

ETSO-2C177a

ED Decision 2020/011/R

DATA LINK RECORDER EQUIPMENT**1 Applicability**

This ETSO provides the requirements that new models of data link recorder systems that are designed and 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**

The applicable procedures are detailed in CS-ETSO, [Subpart A](#).

2.2 Specific

All the information specified in EUROCAE ED-112A, Section 2-1, 2-1.3.4, excluding item 6, shall be documented in a manual and be made available to the accident investigation authorities on request. In addition, if special tools or recovery techniques are used to retrieve recorded information from any memory device used within the crash-protected memory module removed from a crash-damaged recorder, these tools/recovery techniques shall be also made available to the accident investigation authorities on request.

Note: Requests from accident investigation authorities can be independent of any ongoing investigation.

3 Technical Conditions**3.1 Basic****3.1.1 Minimum Performance Standard**

The applicable standards are those provided in the applicable sections of EUROCAE document ED-112A 'Minimum Operational Performance Specification for Crash Protected Airborne Recorder Systems' dated September 2013 that pertain to the types of data link recorder as defined in Table 1 below, except for the following exclusions: Chapters IV-1 and IV-6, and Sections 2-1.1, 2-1.5, 2-1.6, 2-1.11, 2-1.12, 2-3.1, 2-5, 3 and Annex IV-B and other ED-112A requirements related to aircraft-level equipment installation, flight testing and aircraft maintenance and as amended by Appendix 1 to this ETSO.

Recorder Type	ED-112A Reference
Single DLR in a non-deployable recorder	Section 2 and Part IV.
DLR function in a deployable recorder	Section 2 (except for the tests covered by ETSO-2C517) and Part IV. The recorder shall also comply with ETSO-2C517.
DLR function in a combined non-deployable recorder	Section 2, Section 4 and Part IV.
CVR function in a combined deployable recorder	Section 2 (except for the tests covered by ETSO-2C517), Section 4 and Part I. The recorder shall also comply with ETSO-2C517.

Table 1 — MPS Requirements per recorder type

3.1.2 Environmental Standard

See CS-ETSO, [Subpart A](#), paragraph 2.1

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

A loss or erroneous behaviour of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a minor failure condition.

Note: The failure classification is driven by the use of recorders in accident investigations.

4 Marking

4.1 General

See CS-ETSO, [Subpart A](#), paragraph 1.2

4.2 Specific

The equipment shall comply with the identification requirement in EUROCAE ED-112A Section 2-1, paragraph 2-1.16.3, if it is fixed, and those of ETSO-2C517, if it is deployable.

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3

[Amdt ETSO/6]

[Amdt ETSO/12]

[Amdt ETSO/16]

APPENDIX 1 TO ETSO-2C177A – MPS FOR CRASH-PROTECTED AIRBORNE RECORDER SYSTEMS

ED Decision 2020/011/R

The standard EUROCAE ED-112A, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, shall be modified as per Table 1 below.

Table 1 — Modification of EUROCAE ED-112A

	Initial ED-112A text	Amending text
2-1.16.2 a. iii.	Impact shock, shear and tensile test, penetration resistance, static crush, deep sea pressure and sea water immersion.	Impact shock, shear and tensile test, penetration resistance, static crush, deep sea pressure and sea water immersion. Deep sea pressure and sea water immersion may be performed on two different units provided that both units undergo the rest of the sequence and that the period of the deep sea pressure test is 90 days.
2-4.2.7 a.	Unless it can be shown that the recording medium can withstand the conditions associated with deep sea immersion and that it is unlikely to be damaged as a consequence of collapse of any protective armour, immerse the recorder in sea water at a pressure of 60 MPa (equivalent to a depth of 6 000 m (20 000 feet) for a period of 30 days. This period may be reduced to 24 hours provided that the methods and materials used to protect the recording medium have been shown to be unaffected by sea water. To avoid damage to the test equipment, this test may be performed using any suitable liquid in the pressure chamber itself together with a means to separate this liquid from the sea water in which the recorder is immersed.	Unless it can be shown that the recording medium can withstand the conditions associated with deep-sea immersion and that it is unlikely to be damaged as a consequence of collapse of any protective armour or except if the recorder is deployed during or following impact with water, immerse the recorder in seawater at a pressure of 60 MPa (equivalent to a depth of 6 000 m, i.e. 20 000 ft) for a period of 90 days. This period may be reduced to 24 hours provided that the test is performed once more after the sea water immersion test in 2-4.2.7 b. To avoid damage to the test equipment, this test may be performed using any suitable liquid in the pressure chamber itself together with a means to separate this liquid from the seawater in which the recorder is immersed.
2-4.2.7 b.	Unless it can be shown that the recording medium and the identification required by paragraph 2-1.16.3 are resistant to the corrosive effects of sea water, immerse the recorder in sea water at a depth of 3 m and nominal temperature of +25°C for a period of 30 days.	Unless it can be shown that the recording medium and the identification required by paragraph 2-1.16.3 are resistant to the corrosive effects of seawater, immerse the recorder in seawater at a depth of 3 m and a temperature of at least + 25.0 °C for a period of 90 days.

[Amdt ETSO/16]

ETSO-2C197 A1

ED Decision 2020/011/R

INFORMATION COLLECTION AND MONITORING SYSTEMS

1 Applicability

This ETSO provides the requirements which information collection and monitoring systems (ICMSs) that record cockpit audio, aircraft data, airborne images, or data link communications and that are designed and 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

The applicable procedures are detailed in CS-ETSO, [Subpart A](#).

2.2 Specific

All the documents specified in EUROCAE ED-155, Section 2-1, 2-1.3.4, must be provided. In addition, a statement must be provided that tools are readily available for the retrieval of recorded information from any memory device used within the robust memory module removed from a crash damaged recorder.

Note: The documents and tools/special recovery techniques required above are meant to be offered to any safety investigation authority, whether or not the request from that authority is made in the frame of an ongoing investigation.

3 Technical Conditions

3.1 Basic

3.1.1 Minimum Performance Standard

The applicable standards are those provided in EUROCAE ED-155, Minimum Operational Performance Specification for Lightweight Flight Recording Systems, dated July 2009.

All ICMSs must meet the requirements in ED-155 Chapters 2-1, 2-2, 2-3 and 2-4 of Section 2. All deployable ICMS must also meet the requirements in ED-155 Chapters 3-1, 3-2, 3-3 and 3-4 of Section 3. Additionally, each Type of ICMS must meet the requirements of ED-155 listed in the table below.

ICMS Type	Your design must also meet the following requirements in ED-155	Your design does not need to meet the following requirements in ED-155
I	Part I, Cockpit Audio Recording System	I-2.1.7 and I-6
II	Part II, Aircraft Data Recording System	II-2.1.7, II-2.1.9, II-2.1.12, and II-6
III	Part III, Airborne Image Recording System	III-2.2 and III-6
IV	Part IV, Data-link Recording System	IV-2.1.6, IV-2.1.11, and IV-6

3.1.2 Environmental Standard

See CS-ETSO, [Subpart A](#), paragraph 2.1.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific

3.2.1 Minimum Dimensions for the Memory Module

The height (a), width (b), and depth (c) of the crash enclosure must each be 4 cm (1.5 inches) or greater.

3.2.2 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4

A failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a minor failure condition. A loss of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a minor failure condition.

Note: The failure classification is driven by the use of the recorders in accident investigations.

4 Marking

4.1 General

See CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

None.

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/7]

[Amdt ETSO/16]

ETSO-2C204a

ED Decision 2020/011/R

CIRCUIT CARD ASSEMBLY (CCA) FUNCTIONAL SENSORS USING SATELLITE-BASED AUGMENTATION SYSTEMS (SBASs) FOR NAVIGATION AND NON-NAVIGATION POSITION/VELOCITY/TIME (PVT) OUTPUT**1 Applicability**

This ETSO provides the requirements that circuit card assembly (CCA) functional sensors that use satellite-based augmentation systems (SBASs) for navigation and non-navigation position/velocity/time (PVT) output, which are designed and manufactured on or after the date of this ETSO, must meet in order to be identified with the applicable ETSO marking.

ETSO-2C204a is intended as a means for manufacturers of end-use equipment to rationalise their [ETSO-C145e](#) applications for Class Beta PVT sensors by using ETSO-authorised SBAS CCAs for partial certification credit.

An ETSO-2C204a article has a limitation that requires the manufacturer of end-use equipment to repeat selected detailed functional tests in the end-use equipment and complete the environmental qualification tests in RTCA document DO-229E (see paragraphs 3.1.2.2 and 3.2.2 below).

2 Procedures**2.1 General**

The 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**

The applicable standards are those provided for Class Beta functional equipment in RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, dated 15 December 2016, Section 2, as amended by Appendices 1 and 3 to this ETSO.

Class Beta equipment is defined in RTCA document DO-229E, Section 1.4.

The standards in this ETSO apply to CCAs that are intended to provide PVT information for navigation management unit applications that output deviation commands keyed to a desired flight path, or non-navigation applications such as automatic dependent surveillance — broadcast (ADS-B) or terrain awareness and warning systems (TAWS). In navigation applications, pilots or autopilots will use the deviations output by the navigation management unit to guide the aircraft. In non-navigation applications, the PVT outputs will provide the necessary inputs for the end-use equipment.

3.1.2 Environmental Testing and Test Procedures

3.1.2.1 Environmental Testing

For the applicable environmental standards, see CS-ETSO, [Subpart A](#), paragraph 2.1.

Nevertheless, not all types of environmental test are required for this ETSO standard, as the ETSO article for this ETSO standard is a CCA that will be later integrated into an item of ETSO equipment. Therefore, a minimal set of the environmental test conditions of EUROCAE ED-14/RTCA document DO-160 has been defined (refer to Table 1) in order to verify the performance of the ETSOA article under this minimal set of conditions. The required performance under a particular environmental test is defined in the related test section in RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, dated 15 December 2016, Section 2.4.

This minimal set is defined in Table 1 below. The chosen test category, associated with the selectable parameters in the test conditions per EUROCAE ED-14/RTCA document DO-160, should be documented in the installation manual as limitations for the installation.

The test sections that are identified as optional are not required for an ETSO-2C204a application. Nevertheless, the ETSO CCA article can be subjected to these test conditions by the applicant on a voluntary basis. If optional sections are not tested, they shall be marked with ‘X’ in the environmental testing summary.

Table 1 — Environmental Qualification Testing minimum set for ETSO-2C204a

Environmental Test	EUROCAE ED-14/RTCA DO-160 Section	Requirement for ETSO-2C204a
Temperature	4.5	Mandatory If the performance of the module under environmental conditions is dependent on the end-user equipment, it is the responsibility of the applicant to adapt the EUROCAE ED-14/RTCA DO-160 high and low operating temperature values and temperature variation cycles to the intended installation context. For example, in the case of temperature testing (Section 4.0 of EUROCAE ED-14/RTCA DO-160), the temperature of the environment of the CCA (inside an item of equipment) may be much higher or lower than the equipment level condition expressed in the aforementioned Section 4.0. Therefore, the applicant may qualify their CCA functional sensor based on a chosen intended environment, and, finally, indicate in the installation manual the temperature range for which the correct operation of the CCA is guaranteed.

		The dissipation constraints required for the CCA and documented in the installation manual should be considered when establishing the temperature test set-up.
Altitude	4.6	Mandatory
Temperature Variation	5.0	Mandatory As for Section 4.5, if the performance of the CCA under environmental conditions is dependent on the end-user equipment, it is the responsibility of the applicant to adapt the EUROCAE ED-14/RTCA DO-160 high and low temperature values and temperature variation cycles to the intended CCA installation context. As for Section 4.5, for example, in the case of temperature testing (Section 4.0 of EUROCAE ED-14/RTCA DO-160), in which the temperature of the environment of the CCA (inside an item of equipment) may be much higher or lower than the equipment level condition as expressed in Section 4.0 of EUROCAE ED-14/RTCA DO-160, the applicant can qualify their CCA based on a chosen intended environment, and, finally, indicate in the installation manual the temperature range for which the correct operation of the CCA functional sensor is guaranteed.
Humidity	6.0	Mandatory
Shock (operational)	7.2	Optional
Shock (Crash Safety)	7.3	Optional
Vibration	8.0	Optional Note: The CCA <u>technology</u> should be assessed for further vibration qualification (EUROCAE ED-14/RTCA DO-160). This preliminary assessment could consider the technology diversity of the components of the CCA, as well as the integration density and number of layers of the circuit card. The assessment could be confirmed by tests conducted on a circuit card that is representative of the CCA <u>technology</u> used in the article under certification. This preliminary assessment of the CCA technology under vibration conditions does not constitute credit for the qualification testing of the CCA when it is integrated into the end-user equipment.
Explosion Atmosphere	9.0	Optional
Waterproof	10.0	Optional
Fluids Susceptibility	11.0	Optional
Sand and Dust	12.0	Optional
Fungus Resistance	13.0	Optional
Salt Fog	14.0	Optional
Magnetic Effect	15.0	Optional
Power Input	16.0	Mandatory for CCA interfaces that are directly connected to the aircraft power distribution system.

Voltage Spike	17.0	Mandatory for CCA interfaces that are directly connected to the aircraft power distribution system. Note: CCA interfaces that are not directly connected to the aircraft power distribution system will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Audio Frequency Conducted Susceptibility — Power Input	18.0	Mandatory for CCA interfaces that are directly connected to the aircraft power distribution system. Note: CCA interfaces that are not directly connected to the aircraft power distribution system will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Induced-Signal Susceptibility	19.0	Mandatory for CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Radio Frequency Susceptibility (radiated and conducted)	20.0	Mandatory for the conducted susceptibility of CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Emission of Radio Frequency Energy	21.0	Mandatory for the conducted emission of CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Lightning-Induced Transient Susceptibility	22.0	Mandatory for CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Lightning Direct Effects	23.0	Optional
Icing	24.0	Optional
Electrostatic Discharge (ESD)	25.0	Optional
Fire, Flammability	26.0	Mandatory for flammability (ED-14/DO-160 Section 26, Category C)

3.1.2.2 Environmental Test Procedures for End User

The end user of this ETSO article will be required to complete the environmental qualification testing after integration of the ETSO-2C204a CCA. In order to allow the end user to properly test the functionality of the SBAS CCA functional sensor in environmental conditions, the applicant for the 'SBAS CCA functional sensor' shall provide the detailed functional test procedures to evaluate the required performance of the SBAS CCA functional sensor in compliance with RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, dated 15 December 2016, Section 2.4.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

A failure of the function defined in paragraph 3.1.1 of this ETSO is a:

- major failure condition for a loss of function and malfunction of en route, terminal, approach lateral navigation (LNAV), and approach LNAV/vertical navigation (VNAV) position data;
- major failure condition for a loss of function of approach localiser performance without vertical guidance (LP), and approach localiser performance with vertical guidance (LPV) position data; and
- hazardous failure condition for a malfunction of approach (LP and LPV) position data that results in misleading information.

3.2.2 Additional Specific

If the SBAS CCA functional sensor can only satisfy the requirements of RTCA document DO-229E when used with a particular antenna, the use of that antenna (by part number) shall be a requirement on the installation.

This requirement shall be included in the installation manual as a limitation.

The applicant shall have all the data necessary to evaluate the geostationary (GEO) satellite bias as defined in RTCA document DO-229E, Section 2.1.4.1.5, available for review by EASA.

If the SBAS CCA functional sensor uses barometric-aiding to enhance the availability of FDE, then the equipment shall meet the requirements in RTCA document DO-229E, Appendix G.

The applicant shall provide to the end user the detailed functional test procedures of the SBAS CCA functional sensor for the end user to complete the environmental testing.

The intended installation environment and the associated installation constraints should be documented in the installation manual.

Limitations

The following specific limitations shall be documented in the installation manual and in the declaration of design and performance (DDP) of the SBAS CCA functional sensor:

- ‘The manufacturer of the end-use equipment, who installs the <insert equipment model> SBAS CCA functional sensor, is required to perform the testing described in [ETSO C145<latest revision> Appendix 1](#) with the SBAS CCA functional sensor installed in the end-use equipment.’
- ‘The manufacturer of end-use equipment is required to complete full environmental qualification at the end-use equipment level.’

4 Marking

4.1 General

See CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

The SBAS CCA functional sensor must be permanently and legibly marked with the operational equipment class (e.g. Class 2), as defined in Section 1.4.2 of RTCA document DO-229E. The functional equipment class (e.g. Beta) defined in Section 1.4.1 of RTCA document DO-229E is not required to be marked.

It is sufficient to declare the proper functional equipment class in the DDP.

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/16]

APPENDIX 1 TO ETSO-2C204A – ADDITION TO RTCA DOCUMENT DO-229E

ED Decision 2020/011/R

This Appendix describes the modifications and additions to RTCA DO-229E that are required for compliance with this ETSO.

This Appendix adds a new Section 1.8.3, on cybersecurity and GNSS spoofing mitigation, to RTCA document DO-229E, and corrects a long-standing mistake in the Section 2.4 environmental requirements tables. The new section provides information for cybersecurity and GNSS spoofing mitigation to make RTCA document DO-229E consistent with the new RTCA MOPS template and RTCA document DO-253D, Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment, dated July 2017.

1.8.3 Cybersecurity and GNSS Spoofing Mitigation.

This section contains information to address intentional interference with the GNSS. Spoofing is caused by RF waveforms that mimic true signals in some ways, but deny, degrade, disrupt, or deceive the operation of a receiver when they are processed. Spoofing may be unintentional, such as effects from the signals of a GNSS repeater, or may be intentional and even malicious. There are two classes of spoofing:

Measurement spoofing introduces RF waveforms that cause the target receiver to produce incorrect measurements of the time of arrival or the frequency of arrival, or their rates of change;

Data spoofing introduces incorrect digital data to the target receiver for its use in the processing of signals and the calculation of positioning, navigation and timing (PNT).

Either class of spoofing can cause a range of effects: from incorrect outputs of PNT to receiver malfunctions. The onset of effects can be instantaneous or delayed, and the effects can continue even after the spoofing has ended. Improperly used or improperly installed GNSS re-radiators act like spoofers. Re-radiators, replay and GNSS emulator devices can present misleading information to GNSS equipment and/or could cause lasting effects.

Equipment manufacturers should implement measures to mitigate the processing of erroneous data. Cross-checks of GNSS sensor data against independent position sources and/or other detection monitors using GNSS signal metrics or data checks can be implemented in the antenna, receiver, and/or through integration with other systems at the aircraft level. Data validity checks to recognise and reject measurement and data spoofing should be implemented in the receiver. Additional guidance and best practices related to GPS equipment can be found in the U.S. Department of Homeland Security document 'Improving the Operation and Development of Global Positioning System (GPS) Equipment Used by Critical Infrastructure'¹ and GLOBAL POSITIONING SYSTEMS DIRECTORATE SYSTEMS ENGINEERING & INTEGRATION: INTERFACE SPECIFICATION, IS-GPS-200, Navstar GPS Space Segment/Navigation User Interfaces, Revision H, IRN-IS-200H-003, 28 July 2016.

Aircraft equipment information vulnerabilities (such as cybersecurity risks) have been present for digital systems since the development of the personal computer (PC) in the late 1970s and even longer for RF systems, and the advent of internet connectivity has substantially increased those risks. Typically, access to navigation receivers has been controlled such that they are considered to be vulnerable only to RF signals and OEM and/or aircraft operator controlled processes for maintenance and update. In some cases, aircraft GNSS receivers may be field-loadable by approved personnel, requiring physical access and a physical interface to the ground receivers. However, it is expected that

¹ [https://ics-cert.us-cert.gov/sites/default/files/documents/Improving the Operation and Development of Global Positioning System \(GPS\) Equipment Used by Critical Infrastructure S508C.pdf](https://ics-cert.us-cert.gov/sites/default/files/documents/Improving%20the%20Operation%20and%20Development%20of%20Global%20Positioning%20System%20(GPS)%20Equipment%20Used%20by%20Critical%20Infrastructure%20S508C.pdf)

not all aircraft in the future will rely on such physical isolation for the security of avionics. Internet and Wi-Fi connectivity have become popular as means for aircraft or equipment manufacturers to update the software of installed avionics, to update databases, or provide an alternate means of communicating with the flight crew or cabin (e.g. in-flight entertainment, weather, etc.).

In most countries, the State provides oversight of safety-of-flight systems (sometimes referred to as ‘authorised services’) which provide information to aircraft, such as ILS, VOR, GNSS and DME, to name a few. However, the State typically does not provide oversight of ‘non-trusted’ connectivity such as the internet, Wi-Fi, or manufacturer-supplied equipment interfaces which permit the input of externally supplied data into aircraft systems. A manufacturer may expose aircraft information vulnerabilities through the design of the equipment, or the equipment may become vulnerable as a result of being connected to a common interface. Therefore, it is important for manufacturers to consider aircraft information security risk mitigation strategies in their equipment design, particularly when the equipment is responsible for an interface between the aircraft and aircraft-external systems.

Apart from any specific aircraft-information-security-related performance requirements that are contained in the MOPS, it is recommended that manufacturers should consider a layered approach to aircraft information security risk mitigation that includes both technical (e.g. software, signal filtering) and physical strategies. From a technical perspective, for example, this could include signal spoofing detection capabilities or more stringent, multi-factored authentication techniques such as passwords, PINs, and digital certificates. And finally, but just as important, manufacturers should consider supply chain risk management; for example, if a manufacturer outsources the development of software code, are the contractor and its staff properly vetted?

Civil aviation authorities (CAAs) have a regulatory interest when an applicant’s design makes use of a non-trusted connection through which the installation can potentially introduce aircraft information security vulnerabilities. This requires the applicant to address not only the information security vulnerabilities and mitigation techniques for the new installation, but to also consider how vulnerabilities could propagate to existing downstream systems. Therefore, manufacturers are recommended to reference their equipment aircraft information security review and mitigation strategies in the installation manual of the equipment so that the applicant can consider them in meeting the regulatory requirements of the installation.

Table 2-14 to Table 2-20

The tables incorrectly reference and label RTCA document DO-160 Sections 16.5.1.2 and 16.6.1.2 regarding ‘2.1.1.7 Acquisition Time’ and ‘2.1.1.9 Reacquisition Time’. Change the table references as follows:

The MOPS initial acquisition time requirement (2.1.1.7) applies to both AC and DC equipment under abnormal operating conditions (DO-160E Sections 16.5.2 and 16.6.2) and the satellite reacquisition time requirement (2.1.1.9) applies to both AC and DC equipment under normal operating conditions (DO-160E Sections 16.5.1 and 16.6.1).

[Amdt ETSO/16]

APPENDIX 2 TO ETSO-2C204A – ADDITION TO RTCA DOCUMENT DO-229E

ED Decision 2020/011/R

Reserved.

[Amdt ETSO/16]

APPENDIX 3 TO ETSO-2C204A

ED Decision 2020/011/R

This Appendix describes the EASA modifications to RTCA document DO-229E, Section 2.

In Section 2.1.1.2, after the first sentence, add the following:

‘The demodulation of data from the GPS signals shall be restricted to the necessary subset of the data defined in Appendix II to IS-GPS-200D, “Navstar GPS Space Segment/Navigation User Interfaces”, December 2004, provided on RF link L1. The pseudo-ranging shall be performed on RF link L1 utilising the coarse/acquisition (C/A) code.’

This is to ensure that only the L1 NAV data, for which the SBAS provides corrections and integrity, is used, and that no CNAV data, which is defined in Appendix III to IS-GPS-200D, is used, for which the SBAS does not provide integrity.

[Amdt ETSO/16]

ETSO-2C205a

ED Decision 2020/011/R

CIRCUIT CARD ASSEMBLY (CCA) FUNCTIONAL CLASS DELTA EQUIPMENT USING THE SATELLITE-BASED AUGMENTATION SYSTEMS (SBAS) FOR NAVIGATION APPLICATIONS

1 Applicability

This ETSO provides the requirements which circuit card assembly (CCA) functional Class Delta-4 equipment using the satellite-based augmentation system (SBAS) for navigation applications, that are designed and manufactured on or after the date of this ETSO, must meet in order to be identified with the applicable ETSO marking.

ETSO-2C205a is intended as a means for manufacturers of end-use equipment to rationalise their [ETSO-C146e](#) application for a Class Delta-4 sensor by using an ETSO Delta-4 CCA for partial certification credit. ETSO-2C205a is only intended for navigation applications; it is not intended for non-navigation applications.

The standards in this ETSO apply to equipment that is intended to accept a desired flight path and provide deviation commands that are keyed to that path. Pilots and autopilots will use these deviations to guide the aircraft.

An ETSO-2C205a article has a limitation that requires the end-use equipment manufacturer to repeat selected detailed functional tests in the end-use equipment and complete the environmental qualification tests in RTCA document DO-229E (see paragraphs 3.2.2.1 and 3.2.2 below).

2 Procedures

2.1 General

The 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

The applicable standards are those provided for functional Class Delta-4 equipment in RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, dated 15 December 2016, Section 2, as amended by Appendices 1 and 3 to this ETSO standard. Class Delta-4 equipment is defined in DO-229E, Section 1.4.

3.1.2 Environmental Testing and Test Procedures

3.1.2.1 Environmental Testing

For the applicable environmental standards, see CS-ETSO, [Subpart A](#), paragraph 2.1.

Nevertheless, not all types of environmental test are required for this ETSO standard, as the ETSO article for this ETSO standard is a CCA that will be later integrated into an item of ETSO equipment. Therefore, a minimal set of the environmental test conditions of EUROCAE ED-14/RTCA document DO-160 has been defined (refer to Table 1) in order to verify the performance of the ETSOA article under this minimal set of conditions. The required performance under a particular environmental test is defined in the related test section in RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, dated 15 December 2016, Section 2.4.

This minimal set is defined in Table 1 below. The chosen test category, associated with the selectable parameters in the test conditions per EUROCAE ED-14/RTCA document DO-160, should be documented in the installation manual as limitations for the installation.

The test sections that are identified as optional are not required for an ETSO-2C205a application. Nevertheless, the ETSO CCA article can be subjected to these test conditions by the applicant on a voluntary basis. When optional sections are not tested, they shall be marked with 'X' in the environmental testing summary.

Table 1 — Environmental Qualification Testing minimum set for ETSO-2C205a

Environmental Test	EUROCAE ED-14/RTCA DO-160 Section	Requirement for ETSO-2C205a
Temperature	4.5	Mandatory If the performance of the module under environmental conditions is dependent on the end-user equipment, it is the responsibility of the applicant to adapt the EUROCAE ED-14/RTCA DO-160 high and low temperature values and temperature variation cycles to the intended installation context. For example, in the case of temperature testing (Section 4.0 of EUROCAE ED-14/RTCA DO-160), the temperature of the environment of the CCA (inside an item of equipment) may be much higher or lower than the equipment level condition expressed in the aforementioned Section 4.0. Therefore, the applicant may qualify their CCA functional sensor based on a chosen intended environment, and, finally, indicate in the installation manual the temperature range for which the correct operation of the CCA is guaranteed. The dissipation constraints required for the CCA and documented in the installation manual should be considered when establishing the temperature test set-up.

Altitude	4.6	Mandatory
Temperature Variation	5.0	Mandatory As for Section 4.5, if the performance of the CCA under environmental conditions is dependent on the end-user equipment, it is the responsibility of the applicant to adapt the EUROCAE ED-14/RTCA DO-160 high and low temperature values and temperature variation cycles to the intended CCA installation context. As for Section 4.5, for example, in the case of temperature testing (Section 4.0 of EUROCAE ED-14/RTCA DO-160), in which the temperature of the environment of the CCA (inside an item of equipment) may be much higher or lower than the equipment level condition as expressed in Section 4.0 of EUROCAE ED-14/RTCA DO-160, the applicant can qualify their CCA based on a chosen intended environment, and, finally, indicate in the installation manual the temperature range for which the correct operation of the CCA functional sensor is guaranteed.
Humidity	6.0	Mandatory
Shock (operational)	7.2	Optional
Shock (Crash Safety)	7.3	Optional
Vibration	8.0	Optional Note: The CCA <u>technology</u> should be assessed for further vibration qualification (EUROCAE ED-14/RTCA DO-160). This preliminary assessment could consider the technology diversity of the components of the CCA, as well as the integration density and number of layers of the circuit card. The assessment could be confirmed by tests conducted on a circuit card that is representative of the CCA <u>technology</u> used in the article under certification. This preliminary assessment of the CCA technology under vibration conditions does not constitute credit for the qualification testing of the CCA when it is integrated into the end-user equipment.
Explosion Atmosphere	9.0	Optional
Waterproof	10.0	Optional
Fluids Susceptibility	11.0	Optional
Sand and Dust	12.0	Optional
Fungus Resistance	13.0	Optional
Salt Fog	14.0	Optional
Magnetic Effect	15.0	Optional
Power Input	16.0	Mandatory for CCA interfaces that are directly connected to the aircraft power distribution system.
Voltage Spike	17.0	Mandatory for CCA interfaces that are directly connected to the aircraft power distribution system. Note: CCA interfaces that are not directly connected to the aircraft power distribution system will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.

Audio Frequency Conducted Susceptibility — Power Input	18.0	Mandatory for CCA interfaces that are directly connected to the aircraft power distribution system. Note: CCA interfaces that are not directly connected to the aircraft power distribution system will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Induced-Signal Susceptibility	19.0	Mandatory for CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Radio Frequency Susceptibility (radiated and conducted)	20.0	Mandatory for the conducted susceptibility of CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Emission of Radio Frequency Energy	21.0	Mandatory for the conducted emission of CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Lightning-Induced Transient Susceptibility	22.0	Mandatory for CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Lightning Direct Effects	23.0	Optional
Icing	24.0	Optional
Electrostatic Discharge (ESD)	25.0	Optional
Fire, Flammability	26.0	Mandatory for flammability (ED-14/DO-160 Section 26, Category C).

3.1.2.2 Environmental Test Procedures for End User

The end user of this ETSO article will be required to verify its performance after integration, and complete the environmental qualification testing after integration of the ETSO-2C205a CCA. In order to allow the end user to properly test the functionality of the CCA functional Class Delta equipment in environmental conditions, the applicant for the 'functional Class Delta ETSO article' shall provide the detailed functional test procedures to evaluate the required performance of the functional Class Delta equipment in compliance with RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, dated 15 December 2016, Section 2.4.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

A failure of the function defined in paragraph 3.1.1 of this ETSO is a:

- major failure condition for a loss of function and malfunction of en route, terminal, approach lateral navigation (LNAV), and approach LNAV/vertical navigation (VNAV) position data;
- major failure condition for a loss of function of approach localiser performance without vertical guidance (LP), and approach localiser performance with vertical guidance (LPV) position data; and
- hazardous failure condition for a malfunction of approach (LP and LPV) position data that results in misleading information.

3.2.2 Additional Specific

If the CCA functional Class Delta equipment can satisfy the requirements of RTCA document DO-229E only when used with a particular antenna, the use of that antenna (by part number) shall be a requirement on the installation.

This requirement shall be included in the installation manual as a limitation.

The applicant shall have all the data necessary to evaluate the geostationary (GEO) satellite bias as defined in RTCA document DO-229E, Section 2.1.4.1.5, available for review by EASA.

If the functional Class Delta equipment uses barometric-aiding to enhance the availability of FDE, then the equipment shall meet the requirements in RTCA document DO-229E, Appendix G.

The applicant shall provide to the end user the detailed functional test procedures of the functional Class Delta equipment for the end user to complete the environmental testing.

The intended installation environment and the associated installation constraints should be documented in the installation Manual.

Limitations:

The following specific limitations shall be documented in the IM and in the DDP of the CCA functional Class Delta equipment :

- ‘The manufacturer of the end-use equipment, using the <insert equipment model> Class Delta CCA, is required to perform the testing described in [ETSO-C146<latest revision> Appendix 1](#) with the Class Delta CCA installed in the end-use equipment.’
- ‘the manufacturer of end-use equipment is required to complete full environmental qualification at the end-use equipment level.’

4 Marking

4.1 General

See CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

The functional Class Delta equipment must be permanently and legibly marked with the operational equipment class (e.g. Class 4) as defined in Section 1.4.2 of RTCA document DO-229E. A marking of Class 4 indicates compliance with the Delta-4 requirements. The functional equipment class (e.g. Delta) defined in Section 1.4.1 of RTCA document DO-229E is not required to be marked.

It is sufficient to declare the proper functional equipment class in the declaration of design and performance (DDP).

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/16]

APPENDIX 1 TO ETSO-2C205A ADDITION TO RTCA DO-229E

ED Decision 2020/011/R

This Appendix describes the modifications and additions to RTCA document DO-229E that are required for compliance with this ETSO.

This Appendix adds a new Section 1.8.3, on cybersecurity and GNSS spoofing mitigation, to RTCA document DO-229E, and corrects a long-standing mistake in the Section 2.4 environmental requirement tables. The new section provides information for cybersecurity and GNSS spoofing mitigation to make RTCA document DO-229E consistent with the new RTCA MOPS template and RTCA document DO-253D, Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment, dated July 2017.

1.8.3 Cybersecurity and GNSS Spoofing Mitigation

This section contains information to address intentional interference with the GNSS. Spoofing is caused by RF waveforms that mimic true signals in some ways, but deny, degrade, disrupt, or deceive the operation of a receiver when they are processed. Spoofing may be unintentional, such as effects from the signals of a GNSS repeater, or may be intentional and even malicious. There are two classes of spoofing:

- Measurement spoofing introduces RF waveforms that cause the target receiver to produce incorrect measurements of the time of arrival or the frequency of arrival, or their rates of change;
- Data spoofing introduces incorrect digital data to the target receiver for its use in the processing of signals and the calculation of positioning, navigation and timing (PNT).

Either class of spoofing can cause a range of effects: from incorrect outputs of PNT to receiver malfunctions. The onset of effects can be instantaneous or delayed, and the effects can continue even after the spoofing has ended. Improperly used or improperly installed GNSS re-radiators act like spoofers. Re-radiators, replay and GNSS emulator devices can present misleading information to GNSS equipment and/or could cause lasting effects.

Equipment manufacturers should implement measures to mitigate the processing of erroneous data. Cross-checks of GNSS sensor data against independent position sources and/or other detection monitors using GNSS signal metrics or data checks can be implemented in the antenna, receiver, and/or through integration with other systems at the aircraft level. Data validity checks to recognise and reject measurement and data spoofing should be implemented in the receiver. Additional guidance and best practices related to GNSS equipment can be found in the U.S. Department of Homeland Security document ‘Improving the Operation and Development of Global Positioning System (GPS) Equipment Used by Critical Infrastructure’¹ and GLOBAL POSITIONING SYSTEMS DIRECTORATE SYSTEMS ENGINEERING & INTEGRATION: INTERFACE SPECIFICATION, IS-GPS-200, Navstar GPS Space Segment/Navigation User Interfaces, Revision H, IRN-IS-200H-003, 28 July 2016.

Aircraft equipment information vulnerabilities (such as cybersecurity risks) have been present for digital systems since the development of the personal computer (PC) in the late 1970s and even longer for RF systems, and the advent of internet connectivity has substantially increased those risks. Typically, access to navigation receivers has been controlled such that they are considered to be vulnerable only to RF signals and OEM and/or aircraft operator controlled processes for maintenance and update. In some cases, aircraft GNSS receivers may be field-loadable by approved personnel,

¹ [https://us-cert.cisa.gov/sites/default/files/documents/Improving_the_Operation_and_Development_of_Global_Positioning_System_\(GPS\)_Equipment_Used_by_Critical_Infrastructure_S508C.pdf](https://us-cert.cisa.gov/sites/default/files/documents/Improving_the_Operation_and_Development_of_Global_Positioning_System_(GPS)_Equipment_Used_by_Critical_Infrastructure_S508C.pdf)

requiring physical access and a physical interface to the ground receivers. However, it is expected that not all aircraft in the future will rely on such physical isolation for the security of avionics. Internet and Wi-Fi connectivity have become popular as a means for aircraft or equipment manufacturers to update the software of installed avionics, to update databases, or provide an alternate means of communicating with the flight crew or cabin (e.g. in-flight entertainment, weather, etc.).

In most countries, the State provides oversight of safety-of-flight systems (sometimes referred to as ‘authorised services’) which provide information to aircraft, such as ILS, VOR, GNSS, and DME, to name a few. However, the State typically does not provide oversight of ‘non-trusted’ connectivity such as the internet, Wi-Fi, or manufacturer-supplied equipment interfaces which permit the input of externally supplied data into aircraft systems. A manufacturer may expose aircraft information vulnerabilities through the design of the equipment, or the equipment may become vulnerable as a result of being connected to a common interface. Therefore, it is important for manufacturers to consider aircraft information security risk mitigation strategies in their equipment design, particularly when the equipment is responsible for an interface between the aircraft and aircraft-external systems.

Apart from any specific aircraft-information-security-related performance requirements that are contained in the MOPS, manufacturers are recommended to consider a layered approach to aircraft information security risk mitigation that includes both technical (e.g. software, signal filtering) and physical strategies. From a technical perspective, for example, this could include signal spoofing detection capabilities or more stringent, multi-factored authentication techniques such as passwords, PINs, and digital certificates. And finally, but just as important, manufacturers should consider supply chain risk management; for example, if a manufacturer outsources the development of software code, are the contractor and its staff properly vetted?

Civil aviation authorities (CAAs) have a regulatory interest when an applicant’s design makes use of a non-trusted connection through which the installation can potentially introduce aircraft information security vulnerabilities. This requires the applicant to address not only the information security vulnerabilities and mitigation techniques for the new installation, but to also consider how vulnerabilities could propagate to existing downstream systems. Therefore, manufacturers are recommended to reference their equipment aircraft information security review and mitigation strategies in the installation manual of the equipment so that the applicant can consider them in meeting the regulatory requirements of the installation.

Table 2-14 through Table 2-20

The tables incorrectly reference and label RTCA document DO-160 Sections 16.5.1.2 and 16.6.1.2 regarding ‘2.1.1.7 Acquisition Time’ and ‘2.1.1.9 Reacquisition Time’. Change the table references as follows:

The MOPS Initial Acquisition Time requirement (2.1.1.7) applies to both AC and DC equipment under abnormal operating conditions (DO-160E Sections 16.5.2 and 16.6.2), and the satellite reacquisition time requirement (2.1.1.9) applies to both AC and DC equipment under normal operating conditions (DO-160E Sections 16.5.1 and 16.6.1).

[Amdt ETSO/16]

APPENDIX 2 TO ETSO-2C205A

ED Decision 2020/011/R

Reserved.

[Amdt ETSO/16]

APPENDIX 3 TO ETSO-2C205A

ED Decision 2020/011/R

This Appendix describes the EASA modifications to RTCA document DO-229E, Section 2.

In Section 2.1.1.2, after the first sentence, add the following:

‘The demodulation of data from the GPS signals shall be restricted to the necessary subset of the data defined in Appendix II to IS-GPS-200D, “Navstar GPS Space Segment/Navigation User Interfaces”, December 2004, provided on RF link L1. The pseudo-ranging shall be performed on RF link L1 utilising the coarse/acquisition (C/A) code.’

This is to ensure that only the L1 NAV data, for which the SBAS provides corrections and integrity, is used, and that no CNAV data, which is defined in Appendix III to IS-GPS-200D, is used, for which the SBAS does not provide integrity.

[Amdt ETSO/16]

ETSO-2C206

ED Decision 2020/011/R

CIRCUIT CARD ASSEMBLY (CCA) FUNCTIONAL SENSORS USING THE AIRCRAFT-BASED AUGMENTATION FOR NAVIGATION AND NON-NAVIGATION POSITION/VELOCITY/TIME (PVT) OUTPUT

1 Applicability

This ETSO provides the requirements which circuit card assembly (CCA) functional sensors using aircraft-based augmentation for navigation and non-navigation position/velocity/time (PVT) output, that are designed and manufactured on or after the date of this ETSO, must meet in order to be identified with the applicable ETSO marking.

ETSO-2C206 is intended as a means for manufacturers of end-use equipment that incorporates a GNSS CCA to rationalise their [ETSO C196b](#) application for a GNSS PVT sensor by using an ETSO-authorised GNSS CCA for partial certification credit.

An ETSO-2C206 article has a limitation that requires the end-use equipment manufacturer to repeat selected detailed functional tests in the end-use equipment and complete the environmental qualification tests in RTCA document DO-316, Minimum Operational Performance Standards for Global Positioning System/Aircraft-Based Augmentation System Airborne Equipment, dated 14 April 2009 (see paragraphs 3.1.2.2 and 3.2.2 below).

This ETSO standard applies to equipment that is intended to provide PVT information for a navigation management unit application that outputs deviation commands keyed to a desired flight path, or a non-navigation application (such as automatic dependent surveillance — broadcast (ADS-B)). In navigation applications, pilots or autopilots will use the deviations output by the navigation management unit to guide the aircraft. In non-navigation applications, the PVT outputs will provide the necessary capability for the end-use equipment.

2 Procedures

2.1 General

The 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

The applicable standards are those provided for functional sensors in RTCA document DO-316, Minimum Operational Performance Standards for Global Positioning System/Aircraft-Based Augmentation System Airborne Equipment, dated 14 April 2009, Section 2.

3.1.2 Environmental Testing and Test Procedures

3.1.2.1 Environmental Testing

For the applicable environmental standards, see CS-ETSO, [Subpart A](#), paragraph 2.1.

Nevertheless, not all types of environmental test are required for this ETSO standard, as the ETSO article for this ETSO standard is a CCA that will be later integrated into an item of ETSO equipment. Therefore, a minimal set of the environmental test conditions of EUROCAE ED-14/RTCA document DO-160 has been defined (refer to Table 1) in order to verify the performance of the ETSOA article under this minimal set of conditions. The required performance under a particular environmental test is defined in the related test section in RTCA document DO-316, Minimum Operational Performance Standards for Global Positioning System/Aircraft Based Augmentation System Airborne Equipment, dated 14 April 2009, Section 2.2.

This minimal set is defined in Table 1 below. The chosen test category, associated with the selectable parameters in the test conditions per EUROCAE ED-14/RTCA document DO-160 should be documented in the installation manual as limitations for the installation.

The test sections that are identified as optional are not required for an ETSO-2C206 application. Nevertheless, the ETSO CCA article can be subjected to these test conditions by the applicant on a voluntary basis. When optional sections are not tested, they shall be marked with 'X' in the environmental testing summary.

Table 1 — Environmental Qualification Testing minimum set for ETSO-2C206

Environmental Test	EUROCAE ED-14/RTCA DO-160 Section	Requirement for ETSO-2C206
Temperature	4.5	Mandatory If the performance of the module under environmental conditions is dependent on the end-user equipment, it is the responsibility of the applicant to adapt the EUROCAE ED-14/RTCA DO-160 high and low temperature values and temperature variation cycles to the intended installation context. For example, in the case of temperature testing (Section 4.0 of EUROCAE ED-14/RTCA DO-160), the temperature of the environment of the CCA (inside an item of equipment) may be much higher or lower than the equipment level condition expressed in the aforementioned Section 4.0. Therefore, the applicant may qualify their CCA functional sensor based on a chosen intended environment, and, finally, indicate in the installation manual the temperature range for which the correct operation of the CCA is guaranteed. The dissipation constraints required for the CCA and documented in the installation manual should be considered when establishing the temperature test set-up.
Altitude	4.6	Mandatory

Temperature Variation	5.0	Mandatory As for Section 4.5, if the performance of the CCA under environmental conditions is dependent on the end-user equipment, it is the responsibility of the applicant to adapt the EUROCAE ED-14/RTCA DO-160 high and low temperature values and temperature variation cycles to the intended CCA installation context. As for Section 4.5, for example, in the case of temperature testing (Section 4.0 of EUROCAE ED-14/RTCA DO-160), where the temperature of the environment of the CCA (inside an item of equipment) may be much higher or lower than the equipment level condition as expressed in Section 4.0 of EUROCAE ED-14/RTCA DO-160, the applicant can qualify their CCA based on a chosen intended environment, and, finally, indicate in the installation manual the temperature range for which the correct operation of the CCA functional sensor is guaranteed.
Humidity	6.0	Mandatory
Shock (operational)	7.2	Optional
Shock (Crash Safety)	7.3	Optional
Vibration	8.0	Optional Note: The CCA <u>technology</u> should be assessed for further vibration qualification (ED-14/DO-160). This preliminary assessment could consider the technology diversity of the components of the CCA, as well as the integration density and number of layers of the circuit card. The assessment could be confirmed by tests conducted on a circuit card that is representative of the CCA <u>technology</u> used in the article under certification. This preliminary assessment of the CCA technology under vibration conditions does not constitute credit for the qualification testing of the CCA when it is integrated into the end-user equipment.
Explosion Atmosphere	9.0	Optional
Waterproof	10.0	Optional
Fluids Susceptibility	11.0	Optional
Sand and Dust	12.0	Optional
Fungus Resistance	13.0	Optional
Salt Fog	14.0	Optional
Magnetic Effect	15.0	Optional
Power Input	16.0	Mandatory for CCA interfaces that are directly connected to the aircraft power distribution system.
Voltage Spike	17.0	Mandatory for CCA interfaces that are directly connected to the aircraft power distribution system. Note: CCA interfaces that are not directly connected to the aircraft power distribution system will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.

Audio Frequency Conducted Susceptibility — Power Input	18.0	Mandatory for CCA interfaces that are directly connected to the aircraft power distribution system. Note: CCA interfaces that are not directly connected to the aircraft power distribution system will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Induced-Signal Susceptibility	19.0	Mandatory for CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Radio Frequency Susceptibility (radiated and conducted)	20.0	Mandatory for the conducted susceptibility of CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Emission of Radio Frequency Energy	21.0	Mandatory for the conducted emission of CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Lightning-Induced Transient Susceptibility	22.0	Mandatory for CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Lightning Direct Effects	23.0	Optional
Icing	24.0	Optional
Electrostatic Discharge (ESD)	25.0	Optional
Fire, Flammability	26.0	Mandatory for flammability (ED-14/DO-160 Section 26, Category C).

3.1.2.2 Environmental Test Procedures for End User

The end user of this ETSO article will be required to complete the environmental qualification testing after integration of the ETSO-2C206 CCA. In order to allow the end user to properly test the functionality of the CCA functional sensor in environmental conditions, the applicant for a 'CCA functional sensor' shall provide the detailed functional test procedures to evaluate the required performance of the CCA functional sensor in compliance with RTCA document DO-316, Minimum Operational Performance Standards for

Global Positioning System/Aircraft Based Augmentation System
Airborne Equipment, dated 14 April 2009, Section 2.2.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 — Specific

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

A failure of the function defined in paragraph 3.1.1 of this ETSO is a:

- major failure condition for a malfunction of oceanic/remote, en route, terminal navigation and lateral navigation (LNAV) approaches;
- minor failure condition for a loss of navigation in oceanic/remote, en route, terminal navigation and lateral navigation (LNAV) approaches.

3.2.2 Additional Specific

Barometric-aiding fault detection and exclusion (FDE)

If the CCA functional sensor uses barometric-aiding to enhance the availability of FDE, then the equipment shall meet the requirements in RTCA document DO-316, Appendix G.

The applicant shall provide to the end user the detailed functional test procedures of the CCA functional sensor for the end user to complete the environmental testing.

The intended installation environment and the associated installation constraints should be documented in the installation manual.

Limitations

The following specific limitations shall be documented in the installation manual and in the declaration of design and performance (DDP) of the CCA functional sensor:

- ‘The manufacturer of the end-use equipment, using the <insert equipment model> CCA functional sensor, is required to perform the testing described in ETSO-C196<latest revision> Appendix 1 with the CCA functional sensor installed in the end-use equipment.’
- ‘The manufacturer of end-use equipment is required to complete full environmental qualification at the end-use equipment level.’

4 Marking

4.1 General

See CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

None.

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/16]

ETSO-2C500a

ED Decision 2003/10/RM

MULTI-MODE RECEIVER (ILS/MLS/GPS)**1 Applicability**

This ETSO gives the requirements which multi-mode receivers (ILS/MLS/GPS) that are manufactured on or after the date of this ETSO must meet in order to be identified with 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-88 dated August 1997.

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.

ETSO-2C501

ED Decision 2003/10/RM

MODE S AIRCRAFT DATA LINK PROCESSOR**1 Applicability**

This ETSO gives the requirements which Mode S Aircraft Data Link Processors that are manufactured on or after the date of this ETSO must meet in order to be identified with 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-82A dated November 1999.

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

ETSO-2C502

ED Decision 2006/004/R

HELICOPTER CREW AND PASSENGER INTEGRATED IMMERSION SUITS**1 Applicability**

This ETSO gives the requirements which integrated immersion suits for use on helicopters, 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 [Appendix 1](#) to this ETSO.

3.1.2 Environmental Standard

None.

3.2 Specific

None.

4 Marking**4.1 General**

Marking is detailed in CS-ETSO [Subpart A](#) paragraph 1.2.

4.2 Specific

As given in [Appendix 1](#).

5 Availability of Referenced Document

See CS-ETSO [Subpart A](#) paragraph 3.

EN documents may be purchased from the European Committee for Standardisation (CEN), Rue de Stassart 36, B-1050 Brussels, Belgium or any CEN member.

[Amdt ETSO/1]

APPENDIX 1 TO ETSO-2C502 – EASA STANDARD FOR HELICOPTER CREW AND PASSENGER INTEGRATED IMMERSION SUITS

ED Decision 2006/004/R

1. Purpose

- 1.1 This specification prescribes the minimum standard of design and performance for helicopter crew and passenger integrated immersion suits.
- 1.2 An integrated immersion suit is defined as an immersion suit which incorporates the functionality of a lifejacket. The wearing of a separate lifejacket is not required.

2. Scope

- 2.1 This standard covers integrated immersion suits for use on helicopters.
- 2.2 The integrated suit shall comprise at least the following:-
 - a) A dry coverall
 - b) Hand and head coverings
- 2.3 Where applicable any additional or optional items designed to be used with the suit e.g. thermal liner, shall be considered as part of the integrated immersion suit as far as this specification is concerned.

3. Donning

- 3.1 It is assumed for the purpose of this specification that the suit is donned prior to boarding the aircraft.
- 3.2 The integrated suit and any attached equipment shall be capable of being donned without assistance and shall be capable of being sealed and adjusted by the wearer without assistance prior to boarding the aircraft.
- 3.3 Air retained inside the suit after donning which could adversely affect egress, the manoeuvrability or flotation attitude, shall be capable of being exhausted, either automatically or by the wearer.
- 3.4 It must be possible to complete all actions required to don the head covering required by paragraph 2.2(b) and seal the suit within 10 seconds. These actions shall be possible both when seated with harness fastened and when in the water with the suit inflated.
- 3.5 The wearer shall be able to complete all actions required to don the hand covering required by paragraph 2.2(b) when tested in accordance with paragraph 3.11.6.5 of EN ISO 15027-3:2002 except that this shall be demonstrated by each subject after immersion in water at a temperature no higher than 10°C (50°F) for a period of 3 minutes.

4. Freedom of movement

- 4.1 The integrated suit shall be designed to a standard which will allow the wearer to carry out all normal and emergency functions and movements necessary for the operation of a helicopter and its equipment.
- 4.2 The design of the integrated suit shall allow tailoring to fit the individual wearer or, where suits are not individually tailored, the size range must be satisfactory for all wearers whose significant body dimensions range from the 5th percentile female to the 95th percentile male, and adequate for most of the 5% at each extreme.

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- 4.3 The inflated suit shall not significantly hinder the boarding of a liferaft with the sprayhood deployed. This shall be demonstrated by testing to paragraph 3.4 of [Appendix 2](#).
- 4.4 The wearing of the integrated suit, inflated or uninflated, shall not prevent the wearer from assisting others while in the water nor from assisting them to board a liferaft from the water.
- 4.5 The integrated suit, when correctly donned and adjusted, shall not prevent the wearer from having an acceptable field of vision. This shall be demonstrated by testing to paragraph 3.7 of [Appendix 2](#).
5. Comfort
- 5.1 The design of the integrated suit shall minimise any discomfort to the wearer so as to avoid jeopardising safety. Particular attention should be given to the level of thermal comfort afforded the wearer on long into-sun flights in summer.
6. Compatibility
- 6.1 The integrated suit shall be designed, and the materials used in its construction chosen, to have no features which would be likely to have any detrimental effect on the operation of any helicopter or its equipment. In particular any part of the suit which might pose a snagging hazard during flight, emergency egress or recovery, shall be suitably covered, protected or restrained. All materials used shall be compatible with materials used in the construction of approved liferafts.
- 6.2 Any attached equipment shall not compromise the basic survival function of the suit by causing puncturing, fretting or distortion of the material, or changes in its mechanical properties.
7. Materials
- 7.1 All materials used shall be to an acceptable specification which shows the material to be suitable for its intended application. The materials used shall meet the requirements of paragraph 4.14 of EN ISO 15027-1:2002, with the exception of paragraph 4.14.3 of EN ISO 15027-3:2002 Resistance to Illumination Test.
- 7.2 The integrated suit and its equipment shall be so designed and constructed as to remain serviceable for the period between scheduled inspections. The choice of materials used shall be such that, when stowed in accordance with the relevant instructions, neither the suit nor its attached equipment shall be liable to become unserviceable through material deterioration or chafing, or from any other cause. Due consideration shall be taken of the possible temperature variations during stowage which may range between -30°C and +65°C (-22°F and +149°F). This shall be demonstrated by testing to paragraph 3.9 of EN ISO 15027-3:2002. The normal operating temperatures for the immersion suit shall be -5°C to +40°C (23°F to 104°F).
- 7.3 The outer fabric used in the construction of the suit shall be of low flammability. It shall not have a burn rate greater than 100mm/min (4in/min) when tested in accordance with the horizontal test of CS-25 Book 1 Appendix F Part 1 (b)(5) or other approved equivalent method.

8. Evacuation

- 8.1 A person wearing the uninflated suit shall be able to exit the helicopter through any Emergency Exit or Push-out Window down to the minimum acceptable size of 430mm x 355mm (17in x 14in). This action shall be possible in air or under water. This shall be demonstrated by testing to paragraph 3.3 of [Appendix 2](#).

9. Buoyancy and floating position

- 9.1 The trapped buoyancy due to the suit and recommended clothing, with the suit fully vented, shall be no more than 150N (33.7lbf) when measured in accordance with paragraph 3.11.7.2 of EN ISO 15027-3:2002.
- 9.2 The buoyancy of the inflated suit shall be sufficient to ensure that a person wearing clothing and the integrated suit shall have a floating position such that the angle between the body and the horizontal is not greater than 60°. This shall be demonstrated by testing to paragraph 3.6 of [Appendix 2](#).
- 9.3 The mouth must be at least 120mm (4.7in) above the waterline (mouth freeboard) and the nose freeboard shall not be less than the mouth freeboard, even when the wearer is incapacitated. This shall be demonstrated by testing to paragraph 3.5 of [Appendix 2](#).
- 9.4 The inflated suit shall allow the wearer to turn from a face down position into a stable face up floating position within 5 seconds. This shall be demonstrated by testing to paragraph 3.2 of [Appendix 2](#).

10. Breathing protection

- 10.1 A sprayhood shall be fitted.
- 10.1.1 The wearer shall be able to deploy the sprayhood within 20 seconds when wearing the inflated suit in or out of the water.
- 10.1.2 The sprayhood will not be considered suitable if it can in any way retain water when deployed.
- 10.1.3 The angles of vision shall not be unduly restricted, and the ability to swim and manoeuvre shall not be impaired with the sprayhood deployed.
- 10.1.4 The suit's light source shall not be masked by the presence of the sprayhood.
- 10.1.5 The materials used in the sprayhood's construction shall be compatible with those of the suit and shall in no way be able to cause damage to the buoyancy chambers or fabric of the suit or liferaft.
- 10.1.6 The sprayhood, whether stowed or deployed, should not cause inconvenience during winching or other rescue and recovery operations.
- 10.1.7 Means shall be provided to ensure that the level of carbon dioxide in the deployed sprayhood is within safe limits. This shall be demonstrated by testing to paragraph 6.10 of EN 396:1993 or equivalent.

11. Thermal protection

- 11.1 The suit shall provide the user with thermal protection in the water that at least satisfies the test requirements of paragraph 3.8 of EN ISO 15027-3:2002 as a class B suit system.

12. Water ingress

12.1 The integrated suit shall be so constructed that not more than 200g (7oz) of water shall leak into the suit when measured in accordance with paragraph 3.7 of EN ISO 15027-3:2002.

13. Conspicuity and location aids**13.1 Passenger Integrated Immersion Suits**

To facilitate search and rescue operations, those parts of the suit which will be visible when in the water shall be of a highly conspicuous colour and comply with paragraph 4.5 of EN ISO 15027-1:2002.

13.2 Crew Integrated Immersion Suits

Where possible integrated suits for crew use shall meet the requirements of 13.1. However, the choice of suit colour may vary to minimise the risk of the suit reflecting on surfaces within the flight deck.

13.3 A passive light system of retro-reflective material shall be provided. This shall conform to the technical specification detailed in IMO SOLAS 83, Chapter III, Resolution A.658(16), Annex 2 or equivalent. A minimum area of 300cm² (46in²) shall be provided, distributed in accordance with paragraph 4.12 of EN ISO 15027-1:2002.

13.4 The integrated suit shall be fitted with a flashing survivor locator light that meets the requirements of ETSO-C85a. The light shall flash at a rate between 50 and 70 flashes per minute. The location of the light shall be such that maximum practical conspicuity is achieved when in the water with the suit inflated. The light shall activate automatically and have a manually operated on/off switch.

13.5 A whistle shall be provided which complies with the requirements of paragraph 4.3 of EN394:1994 or equivalent.

14. Recoverability

14.1 The integrated suit must be fitted with a lifting becket which complies with the requirements of paragraph 4.15 of EN396:1993 or equivalent.

14.2 The inflated or uninflated suit shall not adversely affect recovery of the wearer by the use of a rescue strop with a circumference of 180cm (70in).

15. Group help

15.1 The integrated suit shall be equipped with a buddy line which complies with the requirements of paragraph 4.6 of EN394:1994 or equivalent.

16. Inflation system. The integrated suit must comply with this section unless it can, without additional inflation, meet the requirements of paragraphs 9.2 and 9.3 and maintain them for the duration of the test period of paragraph 17.2.

16.1 General

16.1.1 The integrated suit shall have two separate means of inflation. The primary means shall be a manually-initiated stored gas system together with a standby oral inflation system capable of repeated use. The required buoyancy shall be obtainable by either method.

16.1.2A means of releasing the pressure in the suit is required and shall be of a type capable of repeated use. Protection shall be provided against inadvertent deflation.

16.1.3After inflation by either method, it shall be possible to deflate the suit and then to reinflate it by using the standby system. The standby inflation system shall be readily accessible, simple and obvious in operation and it shall be impossible for any valve which may be used to be inadvertently left open. It shall be possible to "top up" the suit orally whilst in use and without loss of inflation pressure.

16.2 Stored Gas System

16.2.1Location of the actuating means of this type of system shall be such that it can be operated by either hand, in or out of the water. The method of releasing the stored gas into the suit shall be obvious; however, suitable marking shall be provided to advise the user.

16.2.2The amount of stored gas provided shall be capable of inflating the suit to achieve the correct buoyancy as specified in paragraph 9.3 within 5 seconds of actuation at +20°C (68°F).

16.2.3Adequate protection shall be provided to guard against any inadvertent initiation of an inflation when the wearer is passing through an emergency exit or when the suit is dropped from a height of 1.5m (5 feet).

16.2.4The force required to manually initiate inflation must be a minimum of 20N (4.5lbf) and a maximum of 120N (27lbf) when tested in accordance with paragraph 6.8.4 of EN396:1993 or equivalent.

16.3 Oral Inflation System

16.3.1The oral inflation tube shall comply with the requirements of paragraph 4.5 of EN396:1993 or equivalent.

16.3.2It shall be positioned such that it can readily be used in and out of the water. After use, the device shall return to a position such that it will not produce facial injuries during a jump into the water as specified in paragraph 3.1 of [Appendix 2](#).

17. Testing

17.1 Strength Pressure Test

The integrated suit shall have proof and ultimate factors of not less than 3 and 5 respectively on the pressure at which it is designed to be inflated by the primary means, at a stabilised ambient temperature of +45°C (113°F), and in no case shall the proof and ultimate pressures be less than 15kPa (2lbf/in²) and 25kPa (3.3lbf/in²) respectively.

17.2 Buoyancy

The integrated suit shall retain buoyancy after use of the primary inflation system to such an extent that after a period of 12 hours the requirements of paragraphs 3.5 and 3.6 of [Appendix 2](#) are still met.

17.3 Performance Tests

The performance of all integrated suits shall be tested in accordance with [Appendix 2](#).

18. Inspection Testing and Repair

- 18.1 The procedure for inspecting, testing and repairing integrated suits shall be established by the manufacturer and shall be capable of ensuring that all suits satisfy the requirements of this specification throughout their service lives. As part of the procedure, suits shall be inspected at intervals to ensure they are always ready for immediate and effective use in the water. Special attention shall be paid to seals and fasteners. Suits shall be required to be immediately removed from service for repair or replacement if damage or deterioration is discovered that may lead to the suit failing to satisfy a routine leak test when one is next carried out.
- 18.2 The procedures for servicing, inspection, repair and testing shall be described in the manufacturer's manual.
- 18.3 The frequency of servicing and inspections shall be agreed with the manufacturer holding design approval for the suit.

19. Marking

- 19.1 Each detachable part of the integrated suit assembly shall, where reasonably practicable, be marked with:-
- (a) The manufacturer's approved inspection stamp.
 - (b) The part number.
 - (c) Date of manufacture or batch record.
 - (d) Serial number
- 19.2 In the case of passenger integrated suits, the suit shall be marked with:-
- (a) Suit model designation
 - (b) The manufacturer's name and address
 - (c) Date of manufacture and Serial Number
 - (d) Date at which next scheduled service and overhaul are due
 - (e) Modification standard
- 19.3 In the case of crew integrated suits, the suit shall be marked with:-
- (a) The name of the crew member to whom it has been allocated
 - (b) Rank of crew member marked externally, e.g. epaulettes.
 - (c) Suit model designation
 - (d) The manufacturer's name and address
 - (e) Date of manufacture and Serial Number
 - (f) Date at which next scheduled service and overhaul are due
 - (g) Modification standard
- 19.4 The charged inflation cylinder shall be marked in accordance with paragraph 8.2 of EN396:1993 or equivalent, and include its date of manufacture.
- 19.5 When marking is not practicable alternative means must be agreed.

[Amdt ETSO/1]

APPENDIX 2 TO ETSO-2C502 – INTEGRATED IMMERSION SUIT SYSTEM PERFORMANCE TESTING

ED Decision 2006/004/R

1. Purpose

- 1.1 These tests are to demonstrate satisfactory performance of the integrated immersion suit system.

2. Test conditions

- 2.1 The following tests shall be conducted in calm water. The water temperature shall be $25\pm 2^{\circ}\text{C}$ ($77\pm 4^{\circ}\text{F}$).

2.2 Pass/fail criteria

All samples shall pass all objective tests to meet the requirements of [ETSO-2C502](#) Integrated Immersion Suits. However, due to the high variability between subjects and the difficulty in assessing some subjective measures, it is permitted that an integrated immersion suit does not completely meet the requirements of the following subjective tests in a single example and in no more than in one test subject. In these circumstances, two other subjects within the same weight category and with the same sex should be subjected to the same test. If this additional test is still not clearly passed then the integrated immersion suit shall be deemed to have failed, whilst if it is clearly passed then it may be deemed to have passed the test overall.

3. Performance tests

3.1 Jump Test.

Each test subject shall perform a jump test in accordance with paragraph 3.11.6.1 of EN ISO 15027-3:2002.

3.2 Turning Test

Each test subject shall perform a turning test in accordance with paragraph 3.11.6.3 of EN ISO 15027-3:2002.

3.3 Escape Test Underwater

Each test subject shall be required to swim through an opening not greater than 430mm x 355mm (17in x 14in) (minimum acceptable size of helicopter escape window) positioned with the top of the opening at least 300mm (12in) below the surface of the water with the suit uninflated. At least one of the subjects for this test shall be required to have a shoulder width measurement of at least 500mm (19.7in).

3.4 Swim Test

Each test subject wearing the integrated suit and clothing shall swim on their back for 20 minutes. The hands and arms shall be kept in the water even if not being used for propulsion. Each test subject shall then board a liferaft fitted with boarding facilities, without undue effort and without assistance, with the suit sealed, inflated and the sprayhood deployed. The pool used shall be of sufficient size and depth to prevent the subject gaining assistance by "pushing off" from the side or bottom while performing this test.

3.5 Freeboard

Immediately following the swim test, the clearance of each test subject's face above the water shall be measured, with the subject behaving normally and when simulating unconsciousness. The clearance of the mouth (mouth freeboard) shall be a minimum of 120mm (4.7in) above the waterline in both cases. It shall be established that the nose freeboard is not less than the mouth freeboard.

3.6 Floating position

The angle of the test subject's body shall be measured by an appropriate method. The angle between the body and the horizontal shall be recorded and shall not be greater than 60°.

3.7 Field of vision

The wearer's field of vision shall not be unduly restricted when tested in accordance with paragraph 3.11.6.6 of EN ISO 15027-3:2002

[Amdt ETSO/1]

ETSO-2C503

ED Decision 2006/004/R

HELICOPTER CREW AND PASSENGER INTEGRATED IMMERSION SUITS FOR OPERATIONS TO OR FROM HELIDECKS LOCATED IN A HOSTILE SEA AREA

1 Applicability

This ETSO gives the requirements which immersion suits for use on helicopters operating to or from helidecks located in a hostile sea area (as defined in JAR-OPS 3.480(a)(12)(ii)(a)), 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

This ETSO and the appendices refer to JAR-OPS 3 at Amendment 2 dated 1 January 2002.

3 Technical Conditions

3.1 Basic

3.1.1 Minimum Performance Standard

Standards set forth in [Appendix 1](#) to this ETSO.

3.1.2 Environmental Standard

None.

3.2 Specific

None.

4 Marking

4.1 General

Marking is detailed in CS-ETSO [Subpart A](#) paragraph 1.2.

4.2 Specific

As given in [Appendix 1](#).

5 Availability of Referenced Document

See CS-ETSO [Subpart A](#) paragraph 3.

EN documents may be purchased from the European Committee for Standardisation (CEN), Rue de Stassart 36, B-1050 Brussels, Belgium or any CEN member.

JAA documents may be purchased through Information Handling Services. Addresses of the worldwide IHS offices are listed on the JAA website (www.jaa.nl) and IHS's website (www.global.ihs.com)

[Amdt ETSO/1]

APPENDIX 1 TO ETSO-2C503 – EASA STANDARD FOR HELICOPTER CREW AND PASSENGER INTEGRATED IMMERSION SUITS FOR OPERATIONS TO OR FROM HELIDECKS LOCATED IN A HOSTILE SEA AREA

ED Decision 2006/004/R

1. Purpose

- 1.1 This specification prescribes the minimum standard of design and performance for helicopter crew and passenger immersion suits that are designed to be used with an approved lifejacket.

2. Scope

- 2.1 This standard covers immersion suits for use on helicopters operating to or from helidecks located in a hostile sea area (as defined in JAR-OPS 3.480(a)(12)(ii)(a)).
- 2.2 The immersion suit shall comprise at least the following:-
- a) A dry coverall
 - b) Hand and head coverings
- 2.3 Where applicable any additional or optional items designed to be used with the suit (but excluding the lifejacket) e.g. thermal liner, shall be considered as part of the immersion suit as far as this specification is concerned.

3. Donning

- 3.1 It is assumed for the purpose of this specification that the suit is donned prior to boarding the aircraft and is worn with an approved lifejacket.
- 3.2 The immersion suit and any attached equipment shall be capable of being donned without assistance and shall be capable of being sealed and adjusted by the wearer without assistance prior to boarding the aircraft.
- 3.3 Air retained inside the suit after donning which could adversely affect egress, the manoeuvrability or flotation attitude, shall be capable of being exhausted, either automatically or by the wearer.
- 3.4 It must be possible to complete all actions required to don the head covering required by paragraph 2.2(b) and seal the suit within 10 seconds. These actions shall be possible both when seated with harness fastened and wearing the uninflated lifejacket and when in the water while wearing the inflated lifejacket.
- 3.5 The wearer shall be able to complete all actions required to don the hand covering required by paragraph 2.2(b) when tested in accordance with paragraph 3.11.6.5 of EN ISO 15027-3:2002 except that this shall be demonstrated by each subject after immersion in water at a temperature no higher than 10°C (50°F) for a period of 3 minutes.

4. Freedom of movement

- 4.1 The immersion suit shall be designed to a standard which will allow the wearer to carry out all normal and emergency functions and movements necessary for the operation of a helicopter and its equipment.
- 4.2 The design of the immersion suit shall allow tailoring to fit the individual wearer or, where suits are not individually tailored, the size range must be satisfactory for all wearers whose significant body dimensions range from the 5th percentile female to the 95th percentile male, and adequate for most of the 5% at each extreme.

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- 4.3 The immersion suit, when correctly donned and adjusted, shall not prevent the wearer from having an acceptable field of vision. This shall be demonstrated by testing to paragraph 3.7 of [Appendix 2](#).
- 4.4 The immersion suit when worn with the inflated lifejacket shall allow the wearer to turn from a face down position into a stable face up floating position within 5 seconds. This shall be demonstrated by testing to paragraph 3.2 of [Appendix 2](#).
5. Comfort
- 5.1 The design of the immersion suit shall minimise any discomfort to the wearer so as to avoid jeopardising safety. Particular attention should be given to the level of thermal comfort afforded the wearer on long into-sun flights in summer.
6. Compatibility
- 6.1 Approval of an immersion suit to this specification shall take into account the compatibility between the suit and any approved lifejacket and sprayhood that is intended to be worn with it. The performance of the suit and lifejacket combination shall be tested in accordance with [Appendix 2](#) of this specification.
- 6.2 The immersion suit shall be tested with each type of lifejacket that the suit is designed to be compatible with. If it is to be approved for use with more than one type of lifejacket, the performance testing of [Appendix 2](#) shall be repeated with each additional type of lifejacket.
- 6.3 The immersion suit shall be designed, and the materials used in its construction chosen, to have no features which would be likely to have any detrimental effect on the operation of any helicopter or its equipment. In particular any part of the suit which might pose a snagging hazard during flight, emergency egress or recovery, shall be suitably covered, protected or restrained. All materials used shall be compatible with materials used in the construction of the appropriate approved lifejacket, sprayhood or liferaft.
- 6.4 Any attached equipment shall not compromise the basic survival function of the immersion suit by causing puncturing, fretting or distortion of the material, or changes in its mechanical properties.
7. Materials
- 7.1 All materials used shall be to an acceptable specification which shows the material to be suitable for its intended application. The materials used shall meet the requirements of paragraph 4.14 of EN ISO 15027-1:2002, with the exception of paragraph 4.14.3 of EN ISO 15027-3:2002 Resistance to illumination test.
- 7.2 The immersion suit and its equipment shall be so designed and constructed as to remain serviceable for the period between scheduled inspections. The choice of materials used shall be such that, when stowed in accordance with the relevant instructions, neither the immersion suit nor its attached equipment shall be liable to become unserviceable through material deterioration or chafing, or from any other cause. Due consideration shall be taken of the possible temperature variations during stowage which may range between -30°C and +65°C (-22°F and +149°F). This shall be demonstrated by testing to paragraph 3.9 of EN ISO 15027-3:2002. The normal operating temperatures for the immersion suit shall be -5°C to +40°C (23°F to 104°F).
- 7.3 The outer fabric used in the construction of the suit shall be of low flammability. It shall not have a burn rate greater than 100mm/min (4in/min) when tested in accordance with the horizontal test of JAR-25 Appendix F Part 1 or other approved equivalent method.

8. Buoyancy

8.1 The trapped buoyancy due to the suit and recommended clothing, with the suit fully vented, shall be no more than 150N (33.7lbf) when measured in accordance with paragraph 3.11.7.2 of EN ISO 15027-3:2002.

9. Thermal protection

9.1 The suit shall provide the user with thermal protection in the water that at least satisfies the test requirements of paragraph 3.8 of EN ISO 15027-3:2002 as a class B suit system.

10. Water ingress

10.1 The immersion suit shall be so constructed that not more than 200g (7oz) of water shall leak into the suit when measured in accordance with paragraph 3.7 of EN ISO 15027-3:2002.

11. Conspicuity**11.1 Passenger Immersion Suits**

To facilitate search and rescue operations, those parts of the suit which will be visible when in the water shall be of a highly conspicuous colour and comply with paragraph 4.5 of EN ISO 15027-1:2002.

11.2 Crew Immersion Suits

Where possible immersion suits for crew use shall meet the requirements of 11.1. However, the choice of suit colour may vary to minimise the risk of the suit reflecting on surfaces within the flight deck.

11.3 A passive light system of retro-reflective material shall be provided. This shall conform to the technical specification detailed in IMO SOLAS 83, Chapter III, Resolution A.658(16), Annex 2 or equivalent. A minimum area of 300cm² (46in²) shall be provided, distributed in accordance with paragraph 4.12 of EN ISO 15027-1:2002.

12. Inspection Testing and Repair

12.1 The procedure for inspecting, testing and repairing immersion suits shall be established by the manufacturer and shall be capable of ensuring that all suits satisfy the requirements of this specification throughout their service lives.

As part of the procedure, suits shall be inspected at intervals to ensure they are always ready for immediate and effective use in the water. Special attention shall be paid to seals and fasteners. Suits shall be required to be immediately removed from service for repair or replacement if damage or deterioration is discovered that may lead to the suit failing to satisfy a routine leak test when one is next carried out.

12.2 The procedures for servicing, inspection, repair and testing shall be described in the manufacturer's manual.

12.3 The frequency of servicing and inspections shall be agreed with the manufacturer holding design approval for the suit.

13. Marking

13.1 Each detachable part of the immersion suit assembly shall, where reasonably practicable, be marked with:-

- (a) The manufacturer's approved inspection stamp.
- (b) The part number.
- (c) Date of manufacture or batch record.
- (d) Serial number

13.2 In the case of passenger immersion suits, the immersion suit shall be marked with:-

- (a) Suit model designation
- (b) The manufacturer's name and address
- (c) Date of manufacture and Serial Number
- (d) Date at which next scheduled service and overhaul are due
- (e) Modification standard

13.3 In the case of crew immersion suits, the immersion suit shall be marked with:-

- (a) The name of the crew member to whom it has been allocated
- (b) Rank of crew member marked externally, e.g. epaulettes.
- (c) Suit model designation
- (d) The manufacturer's name and address
- (e) Date of manufacture and Serial Number
- (f) Date at which next scheduled service and overhaul are due
- (g) Modification standard

13.4 When marking is not practicable alternative means must be agreed.

[Amdt ETSO/1]

APPENDIX 2 TO ETSO-2C503 – IMMERSION SUIT / LIFEJACKET SYSTEM PERFORMANCE TESTING

ED Decision 2006/004/R

1. Purpose

- 1.1 These tests are to demonstrate satisfactory performance of the specified immersion suit/lifejacket combination which together make a unique safety system. They shall be carried out for every immersion suit/lifejacket combination for which approval is required to ensure compatibility for that combination.

2. Test conditions

- 2.1 The following tests shall be conducted in calm water. The water temperature shall be $25\pm 2^{\circ}\text{C}$ ($77\pm 4^{\circ}\text{F}$).

2.2 Pass/fail criteria

All samples shall pass all objective tests for the entire system to meet the requirements of [ETSO-2C503](#) Immersion Suits and [ETSO-2C504](#) Lifejackets. However, due to the high variability between subjects and the difficulty in assessing some subjective measures, it is permitted that an immersion suit / lifejacket combination does not completely meet the requirements of the following subjective tests in a single example and in no more than in one test subject. In these circumstances, two other subjects within the same weight category and with the same sex, should be subjected to the same test. If this additional test is still not clearly passed then the immersion suit / lifejacket combination shall be deemed to have failed, whilst if it is clearly passed then both items may be deemed to have passed the test overall when used in the tested combination.

3. Performance tests

3.1 Jump Test.

Each test subject shall perform a jump test in accordance with paragraph 3.11.6.1 of EN ISO 15027-3:2002.

3.2 Turning Test

Each test subject shall perform a turning test in accordance with paragraph 3.11.6.3 of EN ISO 15027-3:2002.

3.3 Escape Test Underwater

Each test subject shall be required to swim through an opening not greater than 430mm x 355mm (17in x 14in) (minimum acceptable size of helicopter escape window) positioned with the top of the opening at least 300mm (12in) below the surface of the water wearing the uninflated lifejacket. At least one of the subjects for this test shall be required to have a shoulder width measurement of at least 500mm (19.7in).

3.4 Swim Test

Each test subject wearing the immersion suit, clothing and inflated lifejacket shall swim on their back for 20 minutes. The hands and arms shall be kept in the water even if not being used for propulsion. Each test subject shall then board a liferaft fitted with boarding facilities, without undue effort and without assistance, with the suit sealed, the lifejacket inflated and the sprayhood deployed. The pool used shall be of sufficient size and depth to prevent the subject gaining assistance by "pushing off" from the side or bottom while performing this test.

3.5 Freeboard

Immediately following the swim test, the clearance of each test subject's face above the water shall be measured, with the subject behaving normally and when simulating unconsciousness. The clearance of the mouth (mouth freeboard) shall be a minimum of 120mm (4.7in) above the waterline in both cases. It shall be established that the nose freeboard is not less than the mouth freeboard.

3.6 Floating position

The angle of the test subject's body shall be measured by an appropriate method. The angle between the body and the horizontal shall be recorded and shall not be greater than 60°.

3.7 Field of vision

The wearer's field of vision shall not be unduly restricted when tested in accordance with paragraph 3.11.6.6 of EN ISO 15027-3:2002.

[Amdt ETSO/1]

ETSO-2C504

ED Decision 2006/004/R

HELICOPTER CONSTANT-WEAR LIFEJACKETS FOR OPERATIONS TO OR FROM HELIDECKS LOCATED IN A HOSTILE SEA AREA

1 Applicability

This ETSO gives the requirements which adult constant-wear lifejackets for use on helicopters operating to or from helidecks located in a hostile sea area (as defined in JAR-OPS 3.480(a)(12)(ii)(a)), 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

This ETSO and the appendices refer to JAR-OPS 3 at Amendment 2 dated 1 January 2002.

3 Technical Conditions

3.1 Basic

3.1.1 Minimum Performance Standard

Standards set forth in [Appendix 1](#) to this ETSO.

3.1.2 Environmental Standard

None.

3.2 Specific

None.

4 Marking

4.1 General

Marking is detailed in CS-ETSO [Subpart A](#) paragraph 1.2.

4.2 Specific

As given in [Appendix 1](#).

5 Availability of Referenced Document

See CS-ETSO [Subpart A](#) paragraph 3.

EN documents may be purchased from the European Committee for Standardisation (CEN), Rue de Stassart 36, B-1050 Brussels, Belgium or any CEN member.

JAA documents may be purchased through Information Handling Services. Addresses of the worldwide IHS offices are listed on the JAA website (www.jaa.nl) and IHS's website (www.global.ihs.com)

[Amdt ETSO/1]

APPENDIX 1 TO ETSO-2C504 – EASA STANDARD FOR HELICOPTER CONSTANT-WEAR LIFEJACKETS FOR OPERATIONS TO OR FROM HELIDECKS LOCATED IN A HOSTILE SEA AREA

ED Decision 2006/004/R

1. Purpose

- 1.1 This specification prescribes the minimum standard of design and performance for helicopter constant-wear lifejackets.

2. Scope

- 2.1 This standard covers adult constant-wear lifejackets for use on helicopters operating to or from helidecks located in a hostile sea area (as defined in JAR-OPS 3.480(a)(12)(ii)(a)). Such lifejackets may therefore be designed to be worn with or without an approved immersion suit.

3. Donning

- 3.1 The correct method of donning the lifejacket shall be self-evident and means shall be provided to indicate that the lifejacket lobe(s) are correctly oriented. The lifejacket should be fully adjustable for all likely wearers whose significant body dimensions range from the 5th percentile female to the 95th percentile male, and adequate for most of the 5% at each extreme. A means of adjustment to make the lifejacket fit securely shall be provided. The wearer shall be able to make any re-adjustment without removing the lifejacket.
- 3.2 Subsequent to proper donning, inadvertent release or loosening of the lifejacket such that its flotation characteristics are unacceptably altered, shall be prevented.
- 3.3 Means shall be provided as necessary in the design of the lifejacket, whether it is worn with or without an approved immersion suit, to prevent it from riding up the body of the wearer.

4. Freedom of movement

- 4.1 The uninflated lifejacket shall allow the wearer to carry out all normal and emergency functions and movements necessary for the operation of a helicopter and its equipment.
- 4.2 The wearing of the lifejacket inflated or uninflated shall not prevent the wearer from assisting others while in the water nor from assisting them to board a liferaft from the water.
- 4.3 The inflated lifejacket shall not significantly hinder the boarding of a liferaft with the sprayhood deployed. This shall be demonstrated by testing to paragraph 3.4 of [Appendix 2](#).

5. Compatibility

- 5.1 Approval of a lifejacket and sprayhood to this specification shall take into account the compatibility between the lifejacket and any approved immersion suit that is intended to be worn with it. The performance of the lifejacket and immersion suit combination shall be tested in accordance with [Appendix 2](#) of this specification.

- 5.2 Where a lifejacket is to be approved for use with an immersion suit(s) then it shall be tested with each type of immersion suit that the lifejacket is designed to be compatible with. If it is to be approved for use with more than one type of immersion suit, the performance testing of [Appendix 2](#) shall be repeated with each additional type of immersion suit.
- 5.3 The lifejacket and its attached equipment, including the sprayhood, shall be designed and the materials used in their construction chosen to have no features which would be likely to have any detrimental effect on the operation of any helicopter or its equipment. In particular any part of the lifejacket which might pose a snagging hazard during flight, emergency egress or recovery, shall be suitably covered, protected or restrained. All materials used shall be compatible with materials used in the construction of any approved immersion suit, or liferaft.
- 5.4 Any other attached equipment shall be demonstrated as having no adverse effects on the operation, life and performance of the lifejacket.
6. Materials
- 6.1 All materials used shall be to an acceptable specification which shows the material to be suitable for its intended application. Textile and fabric materials and components shall pass the test requirements of paragraph 4.3 of EN396:1993 or equivalent. Metal components shall pass the test requirements of paragraph 4.4 of EN396:1993 or equivalent.
- 6.2 The lifejacket and its equipment shall be so designed and constructed as to remain serviceable for the period between scheduled inspections. The choice of materials used shall be such that, when stowed in accordance with the relevant instructions, neither the lifejacket nor its attached equipment shall be liable to become unserviceable through material deterioration or chafing, or from any other likely cause. Due consideration shall be taken of the possible temperature variations during stowage which may range between -30°C and +65°C (-22°F and +149°F). This shall be demonstrated by testing to paragraph 6.1 of EN396:1993 or equivalent. The normal operating temperatures for the lifejacket shall be -5°C to +40°C (23°F to 104°F).
- 6.3 The materials used for the lifejacket's outer cover and its means of retention on the wearer shall be of low flammability. These materials shall not have a burn rate greater than 100mm/min (4in/min) when tested in accordance with the horizontal test of JAR 25 Appendix F Part 1 or other approved equivalent method.
7. Evacuation
- 7.1 A person wearing the uninflated lifejacket shall be able to exit the helicopter through any Emergency Exit or Push-out Window down to the minimum acceptable size of 430mm x 355mm (17in x 14in). This action shall be possible in air or under water. This shall be demonstrated by testing to paragraph 3.3 of [Appendix 2](#).
8. Buoyancy and floating position
- 8.1 The buoyancy of the inflated lifejacket shall be sufficient to ensure that a person wearing clothing and the inflated lifejacket shall have a floating position such that the angle between the body and the horizontal is not greater than 60°. This shall be demonstrated by testing to paragraph 3.6 of [Appendix 2](#).

- 8.2 The mouth must be at least 120mm (4.7in) above the waterline (mouth freeboard) and the nose freeboard shall not be less than the mouth freeboard, even when the wearer is incapacitated. This shall be demonstrated by testing to paragraph 3.5 of [Appendix 2](#).
- 8.3 The inflated lifejacket shall automatically turn an unconscious wearer from a face down position into the position required by paragraph 8.1 within 5 seconds. This shall be demonstrated by testing to paragraph 6.7.7 of EN 396:1993 or equivalent.
9. Breathing protection
- 9.1 The shape of the lifejacket shall not restrict breathing. When in the water the lifejacket shall not tend to channel water or spray into the wearer's face.
- 9.2 A sprayhood shall be fitted.
- 9.2.1 The wearer shall be able to deploy the sprayhood within 20 seconds when wearing the inflated lifejacket in or out of the water.
- 9.2.2 The sprayhood will not be considered suitable if it can in any way retain water when deployed.
- 9.2.3 The angles of vision shall not be unduly restricted, and the ability to swim and manoeuvre shall not be impaired by the lifejacket with the sprayhood deployed.
- 9.2.4 The lifejacket's light source shall not be masked by the presence of the sprayhood.
- 9.2.5 The materials used in the hood's construction shall be compatible with those of the lifejacket and shall in no way be able to cause damage to the buoyancy chambers or fabric of the lifejacket or liferaft.
- 9.2.6 The lifejacket and its sprayhood, whether stowed or deployed, should not cause inconvenience during winching or other rescue and recovery operations.
- 9.2.7 Means shall be provided to ensure that the level of carbon dioxide in the deployed sprayhood is within safe limits. This shall be demonstrated by testing to paragraph 6.10 of EN 396:1993 or equivalent.
10. Location aids
- 10.1 A passive light system of retro-reflective material shall be provided. This shall conform to the technical specification detailed in IMO SOLAS 83, Chapter III, Resolution A.658(16), Annex 2 or equivalent. A minimum area of 300cm² (46in²) shall be provided. This material shall be placed on surfaces which are normally above the water when the lifejacket is in use.
- 10.2 Each lifejacket shall be fitted with a flashing survivor locator light that meets the requirements of [ETSO-C85a](#). The light shall flash at a rate between 50 and 70 flashes per minute. The location of the light shall be such that maximum practical conspicuity is achieved with the lifejacket worn in the normal manner when in the water. The light shall activate automatically and have a manually operated on/off switch.
- 10.3 A whistle shall be provided which complies with the requirements of paragraph 4.3 of EN394:1994 or equivalent.

11. Recoverability

- 11.1 The lifejacket must be fitted with a lifting becket which complies with the requirements of paragraph 4.15 of EN396:1993 or equivalent.
- 11.2 The inflated or uninflated lifejacket shall not adversely affect recovery of the wearer by the use of a rescue strop with a circumference of 180cm (70in).

12. Group help

- 12.1 The lifejacket shall be equipped with a buddy line which complies with the requirements of paragraph 4.6 of EN394:1994 or equivalent.

13. Inflation system**13.1 General**

- 13.1.1 The lifejacket shall have two separate means of inflation, the primary means being a manually-initiated stored gas system and a standby oral inflation system capable of repeated use. The required buoyancy shall be obtainable by either method.
- 13.1.2 A means of releasing the pressure in the lifejacket is required and shall be of a type capable of repeated use. Protection shall be provided against inadvertent deflation.
- 13.1.3 After inflation by either method, it shall be possible to deflate the lifejacket and then to reinflate it by using the standby system. The standby inflation system shall be readily accessible, simple and obvious in operation and it shall be impossible for any valve which may be used to be inadvertently left open. It shall be possible to "top up" the lifejacket orally whilst in use and without loss of inflation pressure.

13.2 Stored Gas System

- 13.2.1 Location of the actuating means of this type of system shall be such that it can be operated by either hand, in or out of the water. The method of releasing the stored gas into the lifejacket shall be obvious; however, suitable marking shall be provided to advise the user.
- 13.2.2 The amount of stored gas provided shall be capable of inflating the lifejacket to achieve the correct buoyancy as specified in paragraph 8.2 within 5 seconds of actuation at +20°C (68°F).
- 13.2.3 Adequate protection shall be provided to guard against any inadvertent initiation of an inflation when the wearer is passing through an emergency exit or when the lifejacket is dropped from a height of 1.5m (5 feet).
- 13.2.4 The force required to manually initiate inflation must be a minimum of 20N (4.5lbf) and a maximum of 120N (27lbf) when tested in accordance with paragraph 6.8.4 of EN396:1993 or equivalent.

13.3 Oral Inflation System

- 13.3.1 The oral inflation tube shall comply with the requirements of paragraph 4.5 of EN396:1993 or equivalent.
- 13.3.2 It shall be positioned such that it can readily be used in and out of the water. After use, the device shall return to a position such that it will not produce facial injuries during a jump into the water as specified in paragraph 3.1 of [Appendix 2](#).

14. Testing

14.1 Strength Pressure Test

The lifejacket shall have proof and ultimate factors of not less than 3 and 5 respectively on the pressure at which it is designed to be inflated by the primary means, at a stabilised ambient temperature of +45°C (113°F), and in no case shall the proof and ultimate pressures be less than 15kPa (2lbf/in²) and 25kPa (3.3lbf/in²) respectively.

14.2 Buoyancy

The lifejacket shall retain buoyancy after use of the primary inflation system to such an extent that after a period of 12 hours the requirements of paragraphs 3.5 and 3.6 of [Appendix 2](#) are still met.

14.3 Performance Tests

All lifejackets shall be tested in accordance with [Appendix 2](#). For lifejackets not designed to be used with an immersion suit, the tests shall be carried out with the test subjects wearing only the stipulated clothing.

15. Inspection Testing and Repair

15.1 The procedure for inspecting, testing and repairing lifejackets shall be established by the manufacturer and shall be capable of ensuring that all lifejackets satisfy the requirements of this specification throughout their service lives.

15.2 The procedures for servicing, inspection, repair and testing shall be described in the manufacturer's manual.

15.3 The frequency of servicing and inspections shall be agreed with the manufacturer holding design approval for the lifejacket.

16. Markings

16.1 If lifejackets are designed or manufactured specifically for crew use or passenger use then they shall be marked accordingly.

16.2 Each detachable part of the lifejacket shall where practicable be marked with:-

- (a) The manufacturer's approved inspection stamp
- (b) The part number
- (c) Date of manufacture or batch record

N.B. Where marking is not practicable alternative means shall be agreed.

16.3 The lifejacket assembly shall be clearly marked with:-

- (a) The lifejacket model designation
- (b) The manufacturer's name and address
- (c) Date of manufacture
- (d) Serial number
- (e) Date at which next service and overhaul are due.

16.4 The charged inflation cylinder shall be marked in accordance with paragraph 8.2 of EN396:1993 or equivalent, and include its date of manufacture.

[Amdt ETSO/1]

APPENDIX 2 TO ETSO-2C504 – IMMERSION SUIT / LIFEJACKET SYSTEM PERFORMANCE TESTING

ED Decision 2006/004/R

1. Purpose

- 1.1 These tests are to demonstrate satisfactory performance of the specified immersion suit/lifejacket combination which together make a unique safety system. They shall be carried out for every immersion suit/lifejacket combination for which approval is required to ensure compatibility for that combination.

2. Test conditions

- 2.1 The following tests shall be conducted in calm water. The water temperature shall be $25\pm 2^{\circ}\text{C}$ ($77\pm 4^{\circ}\text{F}$).

2.2 Pass/fail criteria

All samples shall pass all objective tests for the entire system to meet the requirements of [ETSO-2C503](#) Immersion Suits and [ETSO-2C504](#) Lifejackets. However, due to the high variability between subjects and the difficulty in assessing some subjective measures, it is permitted that an immersion suit / lifejacket combination does not completely meet the requirements of the following subjective tests in a single example and in no more than in one test subject. In these circumstances, two other subjects within the same weight category and with the same sex, should be subjected to the same test. If this additional test is still not clearly passed then the immersion suit / lifejacket combination shall be deemed to have failed, whilst if it is clearly passed then both items may be deemed to have passed the test overall when used in the tested combination.

3. Performance tests

3.1 Jump Test.

Each test subject shall perform a jump test in accordance with paragraph 3.11.6.1 of EN ISO 15027-3:2002.

3.2 Turning Test

Each test subject shall perform a turning test in accordance with paragraph 3.11.6.3 of EN ISO 15027-3:2002.

3.3 Escape Test Underwater

Each test subject shall be required to swim through an opening not greater than 430mm x 355mm (17in x 14in) (minimum acceptable size of helicopter escape window) positioned with the top of the opening at least 300mm (12in) below the surface of the water wearing the uninflated lifejacket. At least one of the subjects for this test shall be required to have a shoulder width measurement of at least 500mm (19.7in).

3.4 Swim Test

Each test subject wearing the immersion suit, clothing and inflated lifejacket shall swim on their back for 20 minutes. The hands and arms shall be kept in the water even if not being used for propulsion. Each test subject shall then board a liferaft fitted with boarding facilities, without undue effort and without assistance, with the suit sealed, the lifejacket inflated and the sprayhood deployed. The pool used shall be of sufficient size and depth to prevent the subject gaining assistance by "pushing off" from the side or bottom while performing this test.

3.5 Freeboard

Immediately following the swim test, the clearance of each test subject's face above the water shall be measured, with the subject behaving normally and when simulating unconsciousness. The clearance of the mouth (mouth freeboard) shall be a minimum of 120mm (4.7in) above the waterline in both cases. It shall be established that the nose freeboard is not less than the mouth freeboard.

3.6 Floating position

The angle of the test subject's body shall be measured by an appropriate method. The angle between the body and the horizontal shall be recorded and shall not be greater than 60°.

3.7 Field of vision

The wearer's field of vision shall not be unduly restricted when tested in accordance with paragraph 3.11.6.6 of EN ISO 15027-3:2002

[Amdt ETSO/1]

ETSO-2C505

ED Decision 2006/004/R

HELICOPTER LIFERAFTS FOR OPERATIONS TO OR FROM HELIDECKS LOCATED IN A HOSTILE SEA AREA

1 Applicability

This ETSO gives the requirements which liferafts required to be carried on helicopters operating to or from helidecks located in a hostile sea area (as defined in JAR-OPS 3.480(a)(12)(ii)(a)), 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

This ETSO and the appendices refer to JAR-OPS 3 at Amendment 2 dated 1 January 2002.

3 Technical Conditions

3.1 Basic

3.1.1 Minimum Performance Standard

Standards set forth in [Appendix 1](#) to this ETSO.

3.1.2 Environmental Standard

None.

3.2 Specific

None.

4 Marking

4.1 General

Marking is detailed in CS-ETSO [Subpart A](#) paragraph 1.2.

4.2 Specific

As given in [Appendix 1](#).

5 Availability of Referenced Document

See CS-ETSO [Subpart A](#) paragraph 3.

JAA documents may be purchased through Information Handling Services. Addresses of the worldwide IHS offices are listed on the JAA website (www.jaa.nl) and IHS's website (www.global.ihs.com)

[Amdt ETSO/1]

APPENDIX 1 TO ETSO-2C505 – EASA STANDARD FOR HELICOPTER LIFERAFTS FOR OPERATIONS TO OR FROM HELIDECKS LOCATED IN A HOSTILE SEA AREA

ED Decision 2006/004/R

1. Purpose
 - 1.1 This standard provides the minimum performance standards for helicopter liferafts.
2. Scope
 - 2.1 This standard covers liferafts required to be carried on helicopters operating to or from helidecks located in a hostile sea area (as defined in JAR-OPS 3.480(a)(12)(ii)(a)).
3. General
 - 3.1 Approval of a liferaft in accordance with this Specification shall take into account the valise or container, the liferaft itself, and any attached or stowed equipment. The liferaft and its associated equipment shall be seaworthy and designed to maximise occupant survivability in all operating conditions.
 - 3.2 With the exception of its floor diaphragm, full inflation of the liferaft shall be achieved by the operation of a single device with the liferaft initially in any attitude. The operation to initiate the automatic inflation of the liferaft shall be within the capability of one person, either in or out of the water.
 - 3.3 Secondary inflatable compartments, e.g. canopy supports, boarding ramps and floor, shall be so designed and arranged that damage to them will not significantly affect the primary buoyancy of the liferaft.
 - 3.4 Provision shall be made to insulate those areas of the floor diaphragm that are in contact with the occupants of the liferaft. The insulation shall be at least equal to that given by a 25mm (1in) air cushion.
 - N.B. Where the insulation is provided by inflation of the floor diaphragm this Specification takes no account of its buoyancy.
 - 3.5 The attachment of all lines and equipment to the liferaft shall be such that failure or tearing off of the attachment will not damage any inflated compartment or the canopy.
 - 3.6 Retro-reflective Surfaces
 - 3.6.1 The liferaft shall be provided with flexible retro-reflective external surfaces, of a minimum total area of 0.15m² (250in²), for increased conspicuity and to enhance the effectiveness of search lights, during search and rescue operation.
 - 3.6.2 The arranged pattern of the retro-reflective material shall be generally as shown in Figure 1.
 - 3.6.3 The retro-reflective materials shall comply with the Technical Specification for Retro-Reflective Material for use on Life-Saving Appliances (IMO Resolution 658 (16) Annex 2), or equivalent.
 - 3.7 The requirements of this Specification, insofar as they are applicable, should be met for the normal and overload occupancy ratings of the liferaft.

4. Operation and Environment

- 4.1 The packed liferaft shall be suitable for fitment in an aircraft in accordance with the applicable aircraft installation requirements.
- 4.2 The method of packing the liferaft into its valise or container shall be such that the liferaft will successfully deploy in the correct attitude for boarding with a probability of not less than 0.90 under the conditions described in paragraph 16.
- 4.3 The packed liferaft shall be designed to inflate by means of its primary inflation system and be suitable for boarding in respect of buoyancy and stability within 30 seconds of the start of inflation, when soaked at all temperatures between -30°C and +65°C (-22°F and +149°F).
- 4.4 The liferaft, when packed in its valise or container shall be capable of withstanding temperatures of -30°C to +65°C (-22°F to +149°F) without any adverse effects for at least the period between inspections.
- 4.5 The liferaft in its container shall be capable of withstanding without significant deterioration such fluids and greases as it might come into contact with for at least the period between inspections. The liferaft when inflated shall withstand those fluids likely to be spread on the surface of the water in the event of an aircraft ditching. All materials used in construction of the liferaft and its equipment shall be suitably resistant to corrosion and fungus growth.

5. Buoyancy

- 5.1 The liferaft shall incorporate a minimum of two independent primary buoyancy chambers. With all chambers inflated to minimum design pressure the liferaft shall be capable of supporting its occupants up to the normal and overload rated occupancy in fresh water. The following minimum amount of freeboard shall be available: -
 - (a) 300mm (12in) at normal rated occupancy.
 - (b) 150mm (6in) at normal rated occupancy with the most critical chamber deflated.
 - (c) A positive freeboard at overload rated occupancy with the most critical chamber deflated.
- 5.2 The liferaft shall have a high level of tolerance to such accidental damage that may be incurred from contact with the exterior of the helicopter while the liferaft is on the water adjacent to the helicopter. This may be achieved by providing adequate redundancy or damage tolerance. To demonstrate adequate damage tolerance, the liferaft shall withstand puncture when subjected to a 0.794mm (1/32 inch) diameter, flat end metal point under a load of 45N (10lbf).

6. Occupancy Ratings

- 6.1 An average occupant weight of 90kg (200lb) shall be assumed to take account of the weight of the occupant's clothing with water saturation.
- 6.2 The normal rated capacity of the liferaft shall be taken as the number of occupants that can be accommodated when each occupant is provided with a minimum width of back support of 460mm (18ins) and a minimum of 0.33m² (3.6ft²) of floor area.
- 6.3 The minimum overload rating for the liferaft shall be the nearest whole number of occupants to the normal rated capacity times 1.50 with a minimum floor area of 0.22m² (2.4ft²).

7. Inflation Systems and Hand Pump

- 7.1 The primary inflation system shall meet all applicable equipment Specifications and shall be capable of meeting all performance and environmental criteria contained in this Specification. The primary inflation system shall be fully automatic subsequent to initiation. Aspirators shall be protected and designed to preclude ingestion of objects which may prevent the seating of the gas seal. Any water ingested via the aspirator, if used, shall not prejudice the operation of the inflation system and the liferaft's performance.
- 7.2 The inflation system shall be designed to prevent gas flow-back from a primary chamber or between primary chambers.
- 7.3 Protection shall be provided against chamber overpressure. Where this is by means of a relief valve the maximum hysteresis shall not exceed 20% of the valve's cracking pressure.
- 7.4 The means of activating the primary inflation system(s) shall be such that proper inflation of the liferaft can be achieved, even when the liferaft in its valise is submerged, by operating a single mechanism by the application of a force of $110 \pm 20\text{N}$ ($25 \pm 5\text{lbf}$).
- 7.5 Each inflation chamber shall also be provided with a means to enable inflation using a hand operated pump.
- 7.6 The function of every valve fitted in the surface of the liferaft shall be clearly marked in the vicinity of the valve. All such valves shall be located to enable their operation and observation to be carried out by occupants in the liferaft.
- 7.7 The method of operation and positioning of valves shall be such that they will not be operated inadvertently, and such as to minimise the risk of injury to occupants when boarding the liferaft.
- 7.8 Inflation valves to be used with hand operated pumps shall be of the non-metallic friction fit type with a minimum inside diameter of 16mm (5/8in). They shall be fitted with a non-return valve, be located so as to facilitate inflation by hand pump, and shall not interfere with the comfort of the occupants.
- 7.9 Hand-operated inflation pumps shall be capable of easy connection to and disconnection from each inflation valve and of maintaining each inflated compartment at the minimum design pressure.
- 7.10 Hand pumps shall have a minimum displacement of air of 0.5litres (32in^3) for each complete cycle of operation, and shall have a means of being attached to the liferaft when stowed and during operation at each inflation point.

8. Strength

- 8.1 All materials, compartments, valves, attached equipment, and seams shall be of sufficient strength and durability to preclude premature failure during operation.
- 8.2 All inflated fabric compartments shall have minimum proof and ultimate strength factors of 2.0 and 3.0 respectively based on the maximum relief value of the pressure relief valves fitted to the primary buoyancy chambers. The design condition shall be assessed at a temperature of $+45^\circ\text{C}$ (113°F) and in no case should the proof pressure be less than 20kN/m^2 (3lbf/in^2).

- 8.3 It shall be demonstrated that all fabricated material joints are of sufficient strength and integrity to achieve a declared absolute life. Guidance shall be given in the appropriate manuals regarding the inspection, maintenance and repair information necessary to maintain the serviceability of the liferaft between servicing.

9. Attached Equipment

9.1 General.

Any equipment attached to the liferaft (including that required by JAR-OPS 3) shall be of such design and location that it will not interfere with the liferaft's operation and performance in any way. The attachment shall be such that the equipment will be retained if liferaft inflation occurs in the upright or inverted position.

9.2 Painter Line

9.2.1 A painter line which can be easily attached to the aircraft shall be provided. The line shall be of a length which is compatible with the operation and inflation of the liferaft, but shall be not less than 6m (20ft) nor greater than 20m (65ft) with the inflation initiation point at least 4.5m (15ft) from the free end of the line. The painter line shall be distinctly coloured to indicate to the person inflating the liferaft the position of the inflation initiation point within 3m (10ft).

N.B. The painter line should be a minimum of 9.5mm (3/8in) diameter under load to provide satisfactory graspability.

9.2.2 The painter line shall be manufactured from a material that will float, has resistance to rotting, and has a minimum breaking strength of 5300N (1200lbf). The attachment of the line to the liferaft shall be designed to release the liferaft without damage in the event of either the line being loaded to or beyond its ultimate strength value or the line being loaded to 0.75 times the load required to submerge the liferaft with the critical chamber deflated, whichever is the lower.

9.2.3 The location of the painter line attachment to the liferaft shall be such that it is readily accessible to the occupants of the liferaft and can be easily severed with the knife provided.

9.3 Sea Anchor

9.3.1 A sea anchor, which is permanently attached to the liferaft and is readily accessible to the occupants under all conditions, shall be provided.

9.3.2 Where the sea anchor is a trailing anchor device it must comply with the following:

- (a) The anchor shall have a minimum effective area equivalent to 0.8m² (1200in²).
- (b) The anchor shall be attached to the liferaft by a line of 10.5m (35ft) minimum length with a minimum breaking strength of 2200N (500lbf). Attachment of the sea anchor to the liferaft shall be so designed that the liferaft will be released without damage in the event of the line being loaded to or beyond its ultimate strength.
- (c) The anchor attachment line assembly shall include a swivel link with a strength at least equal to the strength of the anchor attachment line.
- (d) The anchor shall be arranged to minimise the risk of entanglement.

9.3.3 The location of the sea anchor attachment point on the liferaft shall be such that the deployed line does not interfere with boarding or with the operation and manipulation of the painter line.

9.4 Rescue Line and 'Quoit'

9.4.1 At least one rot-resistant rescue line, which will float and of not less than 23m (75ft) in length, shall be provided to enable a survivor to be hauled to the boarding point. It shall be attached to the liferaft in the vicinity of, and accessible from, the primary boarding point. Attached to the free end of the line shall be a floatable device (quoit) of suitable size to be grasped by a survivor in the water.

9.4.2 The rescue line facility shall have a minimum breaking strength of 1300N (300lbf). The line attachment to the liferaft shall withstand 1.5 times the line's minimum breaking strength.

9.5 Lights

The liferaft shall be fitted with an internal and external light source.

9.5.1 Internal Light

9.5.1.1 The internal light shall have an output sufficient to enable all printed instructions on the liferaft's internal surfaces or attached equipment to be read in the hours of darkness by a person with normal eyesight. The internal light source shall have an effective output of at least 1.0 lumen for a continuous period of not less than 12 hours.

9.5.1.2 The light shall be capable of being switched on and off by the occupants of the liferaft in all appropriate environmental conditions.

9.5.2 External Light

9.5.2.1 The light shall be fitted to the canopy in such a way as to provide maximum practical conspicuity for search and rescue operations and shall have:

- (i) a vertical light beam with a divergence of at least 5° above the vertical axis of the light fitting; and
- (ii) a horizontal light beam that is radially continuous and have an emission angle of at least 5° above the horizontal plane of the light bulb element.

9.5.2.2 The light shall be switched on automatically as soon as the liferaft is inflated on water.

9.5.2.3 The light shall be capable of being switched on and off by the occupants of the liferaft in all appropriate environmental conditions.

9.5.2.4 Output of the light shall be such that it is visible at night in clear atmospheric conditions at a distance of not less than 2 nautical miles, for a continuous period of not less than 12 hours.

9.5.2.5 If the light is a flashing beacon, the flash rate shall be between 50 and 70 flashes per minute, with an interval between flashes of 1.0 ± 0.15 second.

9.6 Knife

9.6.1 A knife which will float shall be provided and located in a position inside the liferaft to enable it to be readily used for cutting the painter line. The knife shall be suitably sheathed and attached to the liferaft by a line of sufficient length to facilitate its use without difficulty.

9.6.2 The shape of the knife shall be such that it will not damage the liferaft's fabric if dropped inside the liferaft.

10. Canopy

10.1 A canopy, covering the total occupiable area of the liferaft, and supported above the heads of seated occupants shall be provided. If the primary inflation system is used to deploy the canopy via a primary buoyancy chamber the canopy support system shall remain inflated in the event of damage to the buoyancy chamber. The canopy support system shall include a facility for inflation by means of the hand operated pump provided.

10.2 The canopy fitted to liferafts with a normal rated occupancy of more than 10 persons shall include a minimum of 2 entry points. Liferafts with a normal occupancy rating of 10 persons or less need only be provided with 1 entry point. The size and positioning of liferaft entry facilities shall be agreed with the Authority.

10.3 Each canopy entry point shall have a closing flap which can easily be closed or opened by the occupants. The flap shall be capable of being secured in a fully open or closed position or in intermediate positions. Where two entry facilities are provided they shall be positioned 180° apart. The painter line attachment and location of the knife shall be adjacent to one entry point.

10.4 The canopy, with the flaps open or closed, shall be capable of withstanding winds of 60 km/h (40 mph) with gusts of 90 km/h (60 mph). With the flaps closed the occupants shall be adequately protected from wind, rain, spray and breaking waves.

10.5 A facility should be provided for the erection of a radio transmitting aerial.

10.6 The deployed canopy shall be able to withstand without damage or permanent collapse the impact of a jump by a person of weight 90kg (200lb) from a height of 3m (10ft) above water level on to the top of the canopy.

10.7 The canopy should remain usable in the event of deflation of the most critical buoyancy chamber.

11. Life Lines and Grab Lines

11.1 Life lines of a colour contrasting to that of the liferaft shall be provided around the external periphery of the buoyancy chambers. The lines shall be easily identified and readily available to support survivors in the water.

11.2 Grab lines of a colour contrasting to that of the liferaft shall be provided around the internal periphery of the buoyancy chambers. The lines shall facilitate use by the occupants to support themselves.

11.3 Life lines, grab lines and their attachments shall be capable of withstanding a minimum load of 2200N (500lbf).

12. Boarding Facilities

- 12.1 A boarding facility shall be provided at each entry point, which is self-erecting during the inflation of the liferaft and remains continuously available.
- 12.2 The design of the boarding aid(s) shall be such that a 90kg (200lb) fully clothed person wearing a fully inflated lifejacket can board the liferaft without assistance. It shall also be possible for the liferaft occupants to retrieve unconscious survivors from the water with the aid of the boarding facility.
- 12.3 The strength of attachment of an inflated boarding facility to the liferaft's structure shall be such that excessive load on the facility will not prejudice the integrity of the primary buoyancy chamber.
- 12.4 Markings shall be provided on the external surfaces of the liferaft to indicate to survivors in the water the location of the boarding facility and, if appropriate, the best method of use.

13. Righting

- 13.1 The liferaft shall be fully reversible unless it can be demonstrated that it is self righting in the fully inflated condition.

14. Valise or Container

- 14.1 The liferaft shall be packed into a valise or container which in turn will be stowed and restrained on board the aircraft. The material used for the construction of the valise or container shall be of low flammability and have a burn rate not greater than 100mm/min (4in/min) when tested in accordance with the horizontal test of JAR 25 Appendix F Part 1 or other approved equivalent method. It shall be durable and chafe resistant. The liferaft packed and ready for stowage shall not support combustion, nor shall it be likely to be rendered unserviceable by inadvertent contact with a lighted match or cigarette.
 - 14.2 The packed liferaft shall be capable of being dropped from a height of 3m (10ft) on to a hard surface without adversely affecting the performance of the liferaft as prescribed by this Specification.
 - 14.3 The valise or container shall include suitable lifting handles so the packed liferaft can be moved within the aircraft.
 - 14.4 The packed liferaft shall have a positive buoyancy in fresh water at a temperature of +20°C (68°F). This shall be demonstrated and the buoyancy value established.
 - 14.5 The external dimensions of the packed valise/container shall be established.
 - 14.6 Closing of the valise or container shall be by lacing with cord of a minimum breaking strength of 220N (50lbf) or by equivalent means.
 - 14.7 Where automatic launching of liferafts is not possible, the weight and dimensions of the packed valise or container shall be such that it can be easily moved to, and launched from, any prescribed ditching emergency exit by one person (male or female).
- N.B. It is recommended that the maximum weight should not exceed 36kg (80lb).

15. Materials and Processes

- 15.1 All materials used shall be to an acceptable Specification which shows the material to be suitable for its intended application and compatible with other materials used in the liferaft's construction.
- 15.2 The choice of materials and protective treatments shall be such that, during the period between inspections, corrosion or deterioration will not render the liferaft unserviceable.
- 15.3 The liferaft when fully equipped and stowed in the aircraft shall not cause more than 1° deflection of an aircraft compass reading at a distance of 300mm (1ft).

16. Seaworthiness

- 16.1 The liferaft and its equipment shall be capable of withstanding a marine environment in accordance with this Specification for a minimum period of 14 days when occupied to its prescribed maximum overload rating.

N.B. A shorter time may be agreed between the operator and the Authority for operations within helicopter SAR coverage and where all aircraft occupants wear survival suits.

- 16.2 The liferaft and equipment shall be capable of withstanding, without malfunction, sea and wind conditions of at least Sea State 6 and 60km/h (40mph) respectively.
- 16.3 The design of the liferaft shall be such that the possibility of the liferaft overturning in any sea or wind condition up to the maximum of paragraph 16.2 is minimised. Any stabilising equipment, e.g. stabilising keels or equivalent, shall be effective by the time the liferaft is ready for boarding, and shall remain automatically effective all the time the liferaft is floating.
- 16.4 Means shall be provided to enable the occupants (wearing cover-all immersion suits and inflated lifejackets) to propel the liferaft over short distances.

17. Tests

- 17.1 A liferaft of the type for which approval is sought shall be tested in both calm and disturbed water (e.g. in a swimming pool and in choppy sea or simulated choppy sea conditions). The Manufacturer's evaluation schedule for the liferaft to show compliance with this Specification shall be agreed with the Authority and shall include the following tests or demonstrations.

17.1.1 Inflation Tests

With the valised liferaft floating in the water, operation of the primary inflation system shall be demonstrated as being in compliance with paragraph 7 by a person in the water wearing a lifejacket. A sufficient number of tests shall be carried out to show compliance with paragraph 4.2. Connection, disconnection and satisfactory operation of the hand operated pump shall also be demonstrated.

17.1.2 Freeboard Measurement (Buoyancy)

The liferaft shall be demonstrated to comply with paragraphs 5 and 6 for all prescribed conditions of occupancy and inflation appropriate to the intended application of the liferaft.

17.1.3 Boarding

Compliance with the requirements of paragraph 12 shall be demonstrated by male and female subjects for each boarding facility fitted to the liferaft.

17.1.4 Propulsion

With the liferaft fully inflated and overloaded to the prescribed rating the practicability of its propulsion over short distances, using the paddles or other equipment provided, shall be demonstrated.

17.1.5 Jump Test

Tests shall be made in accordance with the requirements of paragraph 10.7. This test can be simulated by using a weighted bag or equivalent weight.

17.1.6 Righting

Righting of the liferaft shall be demonstrated both fully inflated and with the most critical primary buoyancy chamber deflated in accordance with paragraph 5.1(b).

17.1.7 Strength Test (Refer to paragraph 8.2).

17.1.7.1 A proof pressure test shall be carried out on all inflated fabric components.

17.1.7.2 An ultimate pressure test shall be carried out on the most critical section of all primary buoyancy chambers.

17.1.8 Seaworthiness

Sufficient tests shall be completed to demonstrate that the liferaft can provide a survival capability when subjected to the most adverse combination of temperature, sea and wind states defined in this Specification.

18. Colour, Operational Markings, and Packaging

18.1 The predominant colour of the liferaft shall be highly conspicuous.

18.2 The valise or container in which the liferaft is to be kept whilst on board the aircraft shall be approved as part of the liferaft's general assembly. The valise or container shall be clearly marked to the effect that a liferaft is contained therein. The method of operating and any precautionary information shall be clearly marked.

18.3 Instructions relating to boarding and operation of all equipment shall be provided with the liferaft, shall be bold and readable in low levels of illumination, and shall be kept to a minimum with the purpose of achieving speed of correct operation with minimum confusion.

19. Marking

19.1 Each detachable part of the liferaft shall where practicable be marked with:

- (a) The manufacturer's approved inspection stamp.
- (b) The part number.
- (c) Date of manufacture or batch record.

N.B. Where marking is not practicable alternative means may be agreed with the Authority.

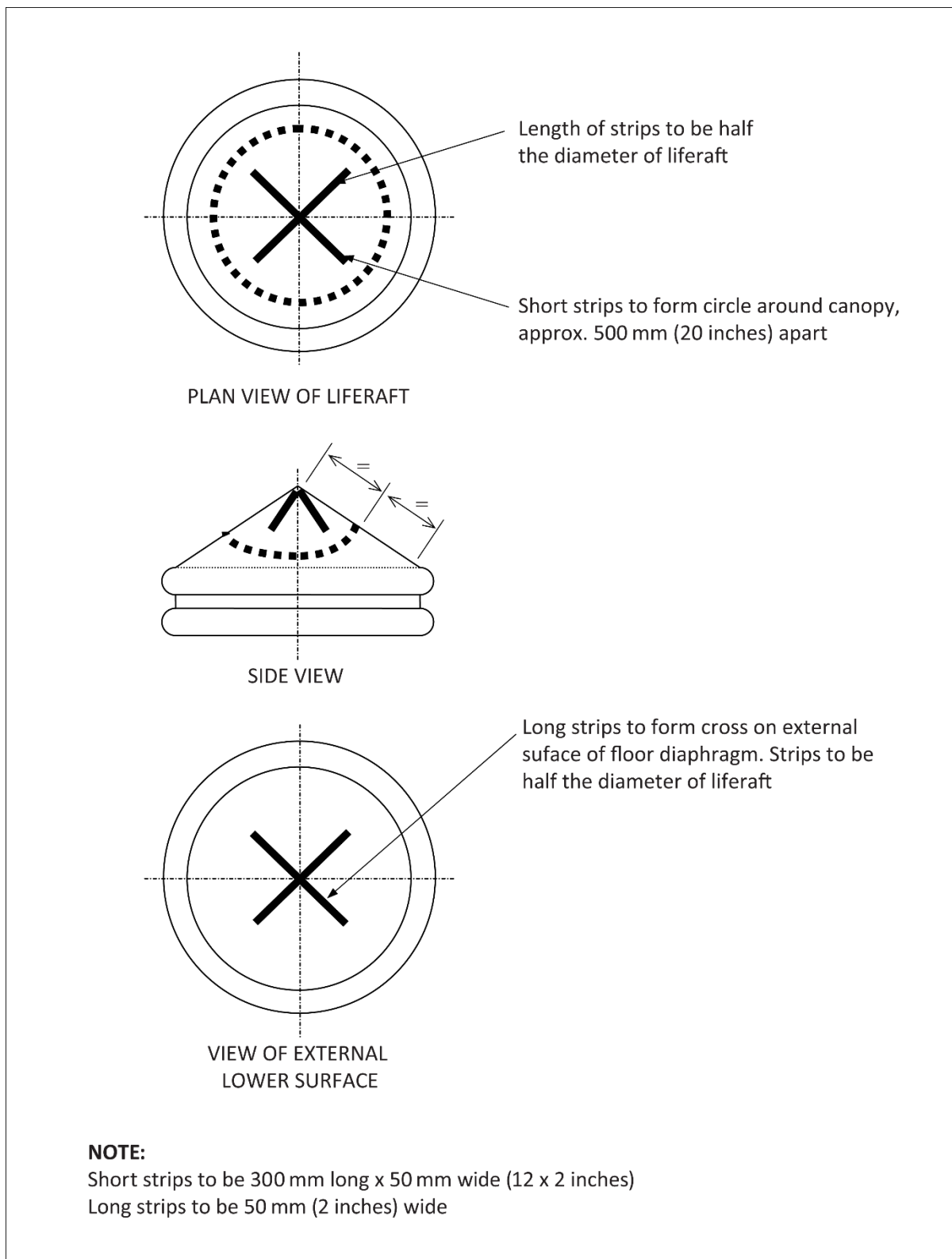
19.2 The liferaft assembly shall be marked with:

- (a) The liferaft model designation.
- (b) The manufacturer's name and address.
- (c) Date of manufacture.
- (d) Serial Number.
- (e) Date at which next service and overhaul are due.

19.3 The charged inflation cylinder shall be marked with its weight and the weight of charge.

19.4 All markings prescribed in 7.6, 12.4, 18.2, 18.3, 19.1, 19.2 and 19.3 shall be made such that they remain legible.

Figure 1 TYPICAL LIFERAFT - ARRANGEMENT OF RETRO-REFLECTIVE TAPE



[Amdt ETSO/1]

ETSO-2C509

ED Decision 2007/017/R

LIGHT AVIATION SECONDARY SURVEILLANCE TRANSPONDER (LAST)**1 Applicability**

This ETSO gives the requirements which light aviation secondary surveillance transponders (LAST) that are manufactured on or after the date of this ETSO must meet in order to be identified with applicable ETSO marking. The use of those transponders is restricted to cruising speed up to 175 kts, altitude up to 15000 ft and non diversity operation.

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**

Standard given in EUROCAE ED-115: „Minimum Performance Specification for Light Aviation Secondary Surveillance Transponders”.

The following functionalities, capabilities, variants and options specified in ED-115 are not applicable for an ETSO authorised LAST:

1.1 Note 2 (low power, non ICAO compliant)**1.4.2.1 Transponder Functionality**

- a) Level 1 Surveillance only

2.11.1 LAST Capabilities

- a) Lc0 Mode A/C only transponder

2.11.2 LAST Variants

- a) V1 (Self-contained removable LAST)

Paragraph 1.2 of ED-115 is not a requirement (guidance only).

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

Additional requirements for labeling are given in EUROCAE ED-115 paragraph 1.4.2.2.

5 Availability of Referenced Document

See CS-ETSO [Subpart A](#) paragraph 3.

[Amdt ETSO/2]

ETSO-C2C512

ED Decision 2008/012/R

PORTABLE GASEOUS OXYGEN SUPPLY (PGOS)**1 Applicability**

This ETSO gives the requirements which the Portable Gaseous Oxygen Supply that are manufactured on or after the date of this ETSO must meet in order to be identified with 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 (SAE), Inc, Document Aerospace Standard (AS) no AS 1046, “Minimum Standard for Portable Gaseous Oxygen Equipment”, Rev. B, dated 13 September 1989.

3.1.2 Environmental Standard

The equipment must be tested according to the applicable environmental standards contained in EUROCAE ED-14E (RTCA/DO-160E) “Environmental Conditions and Test Procedures for Airborne Equipment” from March 2005.

3.1.3 Computer Software

None.

3.2 Specific**3.2.1 Proof and Ultimate Strength Factors**

For proof and ultimate strength factors CS 25.1453(a) shall apply.

4 Marking**4.1 General**

Marking is detailed in CS-ETSO [Subpart A](#) paragraph 1.2.

4.2 Specific

As per AS 1046 Rev. B, dated 13 September 1989.

5 Availability of Referenced Document

See CS-ETSO [Subpart A](#) paragraph 3

[Amdt ETSO/3]

ETSO-2C513

ED Decision 2008/012/R

TOW RELEASE**1 Applicability**

This ETSO specifies the requirements which Tow Releases 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**

Standard given in the Minimum Performance Standard for Tow Release is given in the [Appendix 1](#).

3.1.2 Environmental Standard

The equipment must be tested according to the applicable environmental standards contained in EUROCAE ED-14E (RTCA/DO-160E) “Environmental Conditions and Test Procedures for Airborne Equipment” from March 2005.

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.

A copy of the reference LN (Luftfahrt-Norm) may be obtained from the web-site: www.normung.din.de

[Amdt ETSO/3]

APPENDIX 1 TO ETSO-2C513 – TOW RELEASE

ED Decision 2008/012/R

1 GENERAL

1.1 Type and applicability of airworthiness requirements

These airworthiness requirements for tow releases ([ETSO-2C513](#)) are valid for proof of airworthiness of tow releases that are used for:

- a) towing steerable or non-steerable tow or built into such tow;
- b) or for towing by winch or motor vehicle.

Note: Gliders and powered gliders are examples of steerable tows.

Banners are examples of non-steerable tows.

All the individual specifications listed below for ensuring the airworthiness of tow releases are minimum requirements that have been derived from operating experience and have been quantified as practical numerical values.

Deviations from these requirements may be approved or requested by the Agency, if justified by new findings or safety considerations.

1.2 Type approval

1.2.1. A tow release type can be approved on application in the form of an ETSO entitlement, provided that the airworthiness requirements are fully met, or, in the event of non-compliance of one or more requirements, if proof is provided that an equivalent safety level is achieved.

The decision of the Agency is final.

1.2.2. The burden of proof is borne by the applicant, who also has to compile the type documentation.

1.2.3. The type documentation includes all the documentation necessary for the design specification of the tow release and all its design features that are subject matters of this ETSO.

2. DESIGN AND CONSTRUCTION

2.1 Materials

The suitability and reliability of the materials used must be shown based on operating experience or materials testing.

All materials used for stressed parts must correspond to descriptions and specifications recognized by the Agency.

2.2 Protection of parts

Each part of the load transmitting assembly must

- a) be protected as fully as possible against influences that could cause damage or diminish strength during operation, including corrosion and wear;
- b) and designed in such a way that:
 - no water can be collected and that;
 - any dirt inside the tow release can be removed without disassembly.

2.3 Securing connecting elements

Accepted security devices must be used for all non permanent connecting elements of the tow release.

2.4 Connecting ring pair

For each tow release with a hook, a connecting ring pair according to LN (Luftfahrt-Norm) 65091 in the current valid version must be used.

2.5 Attachment to the aircraft

The tow release must be designed to be attached to the aircraft using non permanent connecting elements.

2.6 Special requirements

2.6.1 Tow releases with a moveable or fixed ring jaw must be designed in such a way that it is impossible to hook up the large oval ring of the connecting ring pair. It must be also impossible for the connecting ring pair to jam behind or either side of the hook.

2.6.2 It must not be possible, in any operating state, for the connecting ring pair to jam in the tow release jaw and thus inhibit the release.

2.6.3 Tow releases installed near the centre of gravity of the aircraft must have a mean for automatic release.

2.7 Long-term performance

The documentation must include proof of at least 10,000 actuations of the tow release under operating conditions. No damage should occur during this time.

3. STRENGTH**3.1 Strength calculations**

Load tests according to § 4.2.5 and § 4.2.6 must show that the strength of the tow release is adequate to withstand any loads that may be put on it in any operating state that experience has shown may occur.

3.2 Criteria for sufficient dimensioning and safety factor

3.2.1 The strength requirements are specified by the safe test load (the maximum expected cable load during operation) and the calculated breaking load (the maximum cable load multiplied by the specified safety factor) defined in § 3.3.

These loads are specified as limiting values in the test schedules for the functional tests.

3.2.2 A safety factor of 1.5 is specified.

The unit must be able to:

- a) accept the safe test load without permanent damage in the form of deformation, notches, cracks, etc.;
- b) withstand the calculated breaking load without failure for at least 3 seconds.

3.3 Safe test load

Tow releases used for the purposes as listed in § 1.1 must be designed for a safe test load $L_{\max}$ N that is derived as follows from CS 22.581 and CS 22.583:

$$L_{\max} = 1.2 \times 1.3 \times m \times 9.81 \text{ [N]}$$

where

1.2 and 1.3: safety factors

m: max. take-off weight

9.81 m/s²: gravitational acceleration/conversion to Newton

Note: For a maximum towed mass of, for instance, 850 kg the safe test load is thus:

$$L_{\max} = 1.2 \times 1.3 \times 850 \times 9.81 = 13,008 \text{ N} = L_{\max}$$

In-line weak links are ignored when determining the safe test load.

4. OPERATING BEHAVIOUR

4.1 Performance under load

4.1.1 Safe operating range

Within the limits of cable loads and cable angles specified in § 5.1, every tow release must be able both to withstand the resultant load without impairing operational reliability and to release reliably.

4.1.2 Automatic release angle

For tow releases for installation in gliders or powered gliders for towing by winch or motor vehicle the tow cable must release reliably at the automatic release angle specified in § 5.1.

4.1.3 Release force

When loading the hook of the tow release within the limits specified for cable loads and cable angles, the maximum permissible release FK measured at the release lever with a reference length l of 68 mm (see Fig. 1) must lie between 60 and 140 N.

4.2 Functional tests

4.2.1 Type of tests

The aim of the functional tests using a suitable test rig is to prove that the tow release for which type approval is to be granted meets the requirements as listed above in § 4.1.1 to § 4.1.3.

The available restoring force after releasing the tow cable must be measured according to § 4.2.4.

Note: Type testing of a tow release should include its use in actual flight operations in order to gain more information on its operating performance.

4.2.2 Load schedule

Test loads must be applied according to the load schedule in Fig. 1

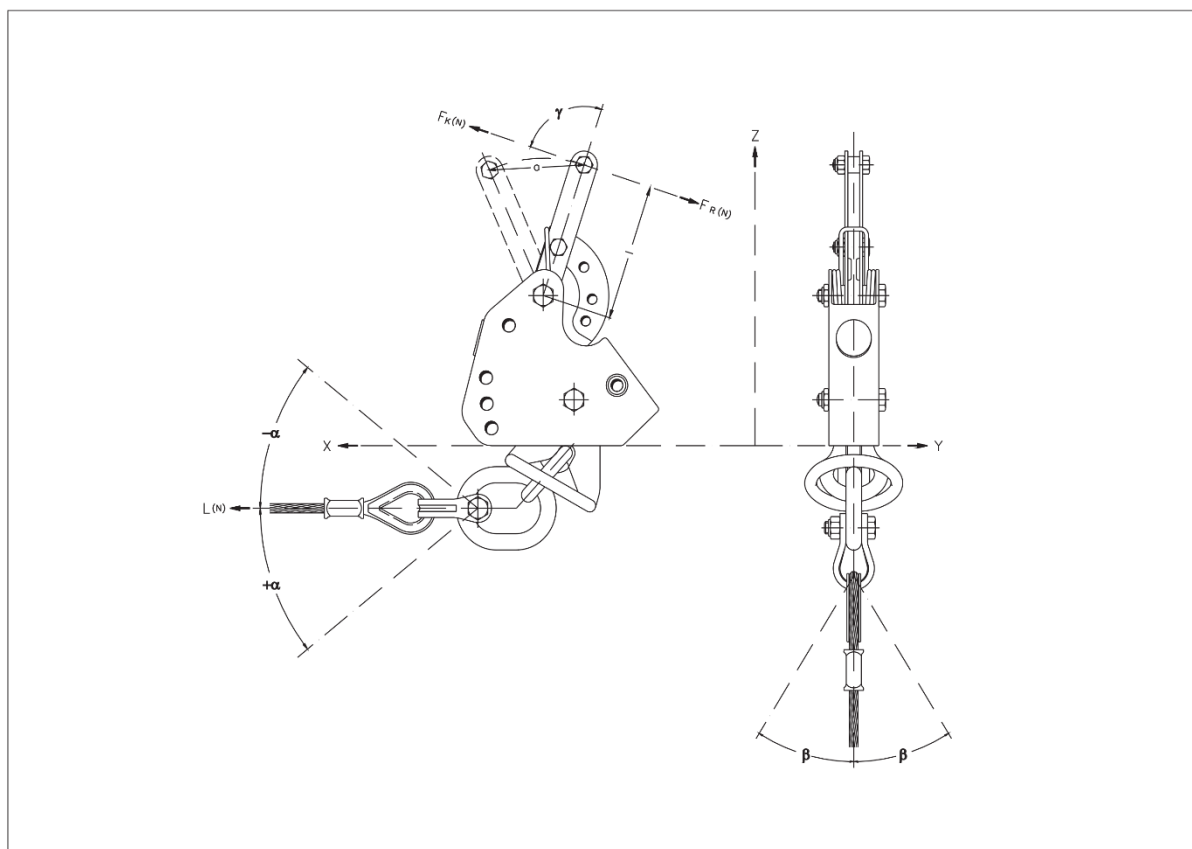


Fig. 1: Load schedule

- x-axis = Longitudinal axis (in flight direction)
- y-axis = Lateral axis (in wing span direction)
- z-axis = Vertical axis
- L = Cable load in N
- l = Original lever length of type in mm
- F_K = Release force of release lever in N
- F_R = Restoring force in N
- α = Angle between L and x-y plane
- a = Travel of release lever
- β = Angle between L and x-z plane between stops in mm

The normal or 0-degrees cable angle is parallel to the x-y plane

4.2.3 Test rig

Using only the bore holes and bearing surface provided for installation in the aircraft, mount the tow release in a suitable test rig in such a way that the cable loads can be applied via the connecting ring pair for all specified load angles and that in each case the required release force F_K can be measured at the release lever.

In addition, for tow releases with automatic release (so-called safety tow releases), the cable angle and the magnitude of the cable load that results in automatic release must be measured.

4.2.4 Measurement of the restoring force

Measure the restoring force as follows prior to the start of the actual functional tests:

- a) Fully open the unloaded tow release mounted in the test rig using the release lever (lever length $l = 68 \text{ mm}$).
- b) Measure the restoring force between the release lever stops, in relation to the release travel a.

Enter the measurement results in a diagram.

The restoring force FR must not be greater than 100 N nor less than 60 N.

4.2.5 Test schedules and determination of the load diagram:

Tow releases for aero tow of steerable and non-steerable tows (use according to § 1.1.a)

- a) Test up to safe test load

With the tow release mounted in the test rig, load the hook via the connecting ring pair according to the cable (test) load schedule in Table 1.

- Apply the load at a rate of 300 N/s.
- Apply the load for 5 seconds at each load stage and measure the release force FK using a reference release lever length of $l = 68 \text{ mm}$.
- Disassembly test

Disassemble the tow release completely on completion of the load test. Inspect the tow release to ensure that

- no part of it is permanently deformed and that no notches, cracks, etc., have appeared and that
- on reassembly the tow release is once again fully functional.

Table 1

Cable (test) Load L		Cable angle α	$\pm\beta$	Cable (test) Load L		Cable angle α	$\pm\beta$
N		Degress	Degrees	N		Degress	Degrees
1500		-45	0	1500		+30	0
6000		-45	0	6000		+30	0
7500		-45	0	7500		+30	0
9000		-45	0	9000		+30	0
11700		-45	0				
				0,80	Lmax	+30	0
	Lmax	-45	0	0,60	Lmax	+30	30
0,60	Lmax	-45	30	0,80	Lmax	+30	30
0,80	Lmax	-45	30	0,60	Lmax	+30	45
0,60	Lmax	-45	45	0,80	Lmax	+30	45
0,80	Lmax	-45	45	1500		+45	0
				6000		+45	0

1500		-30	0	7500		+45	0
6000		-30	0	9000		+45	0
7500		-30	0	11700		+45	0
9000		-30	0				
					Lmax	+45	0
0,80	Lmax	-30	0	0,60	Lmax	+45	30
0,60	Lmax	-30	30	0,80	Lmax	+45	30
0,80	Lmax	-30	30	0,60	Lmax	+45	45
0,60	Lmax	-30	45	0,80	Lmax	+45	45
0,80	Lmax	-30	45	0,80	Lmax	+30	60
				0,80	Lmax	+30	75
1500		0	0	0,80	Lmax	+45	60
6000		0	0	0,80	Lmax	+45	75
7500		0	0	0,80	Lmax	+60	0
9000		0	0	0,80	Lmax	+60	30
11700		0	0	0,80	Lmax	+60	45
Lmax		0	0	0,80	Lmax	+60	60
				0,80	Lmax	+60	75
1500		0	30				
6000		0	30	9000		+60	87
7500		0	30	11700		+60	87
9000		0	30	Lmax		+60	87
11700		0	30	0,40	Lmax	+120	0
Lmax		0	30	0,40	Lmax	-120	0
1500		0	45				
6000		0	45				
7500		0	45				
9000		0	45				
11700		0	45				
Lmax		0	45				
0,60	Lmax	0	90				
0,80	Lmax	0	90				

b) Test to calculated breaking load

Subsequent to the disassembly test and with the tow release remounted in the test rig, load the hook via the connecting ring pair up to the calculated breaking load with cable angles

$\alpha = 0$ degrees and $\beta = 0$ degrees.

Maintain the calculated breaking load for 3 seconds. Then release and measure the release force F_K . Then disassemble the tow release completely and inspect it for any permanent deformation, notches, cracks, etc.

4.2.6 Test schedules and determination of the load diagram:

Tow release for installation in gliders or powered gliders for towing by winch or motor vehicle (use according to § 1.1.b)

a) Test up to safe test load

With the tow release mounted in the test rig, load the hook via the connecting ring pair according to the cable (test) load schedule in Table 2.

- Apply the load at a rate of 300 N/s.
- Apply the load for 5 seconds at each load stage and measure the release force FK using a reference release lever length of $l = 68 \text{ mm}$.

Automatic release of the tow release is not allowed during this test schedule.

Table 2

Cable (test) Load L			Cable (test) Load L			
	Cable angle α	$\pm\beta$		Cable angle α	$\pm\beta$	
N	Degress	Degrees	N	Degress	Degrees	
1500	0	0	1500	+45	0	
6000	0	0	6000	+45	0	
7500	0	0	7500	+45	0	
9000	0	0	9000	+45	0	
11700	0	0				
Lmax	0	0	0,80	Lmax	+45	0
1500	0	30	1500	+45	30	
6000	0	30	6000	+45	30	
7500	0	30	7500	+45	30	
9000	0	30	9000	+45	30	
11700	0	30	11700	+45	30	
			Lmax	+45	30	
Lmax	0	30				
			1500	+45	45	
1500	0	45	6000	+45	45	
6000	0	45	7500	+45	45	
7500	0	45	9000	+45	45	
9000	0	45	0,80	Lmax	+45	45
11700	0	45				
			1500	+45	60	
Lmax	0	45	6000	+45	60	
			7500	+45	60	
1500	+30	0	9000	+45	60	
6000	+30	0	11700	+45	60	
7500	+30	0	Lmax	+45	60	
9000	+30	0				
0,80	Lmax	+30	1500	+45	75	
			6000	+45	75	
1500	+30	30	7500	+45	75	

6000		+30	30	9000		+45	75
7500		+30	30	11700		+45	75
9000		+30	30		Lmax	+45	75
11700		+30	30	0,60	Lmax	+60	0
	Lmax	+30	30	0,80	Lmax	+60	0
				0,60	Lmax	+60	30
0,60	Lmax	+30	45	0,80	Lmax	+60	30
0,80	Lmax	+30	45				
0,60	Lmax	+30	60	1500		+60	45
0,80	Lmax	+30	60	6000		+60	45
				7500		+60	45
1500		+30	75	9000		+60	45
6000		+30	75	11700		+60	45
7500		+30	75		Lmax	+60	45
9000		+30	75				
11700		+30	75				
	Lmax	+30	75				

Table 2 (cont.)

Cable (test) load L		Cable angle α	$\pm\beta$
N		Degress	Degrees
0,60	Lmax	+60	60
0,80	Lmax	+60	60
1500		+60	75
6000		+60	75
7500		+60	75
9000		+60	75
11700		+60	75
	Lmax	+60	75
11700		+60	87
	Lmax	+60	87
1500		+75	0
6000		+75	0
7500		+75	0
9000		+75	0
11700		+75	0
	Lmax	+75	0
0,60	Lmax	+75	30
0,80	Lmax	+75	30
0,60	Lmax	+75	45
0,80	Lmax	+75	45

0,60	Lmax	+75	60
0,80	Lmax	+75	60
0,80	Lmax	0	75
1500		0	87
6000		0	87
7500		0	87
9000		0	87
11700		0	87
	Lmax	0	87

– Disassembly test

Disassemble the tow release completely on completion of the load test. Inspection the tow release to ensure that

- no part of it is permanently deformed and that no notches, cracks, etc., have appeared and that
- on reassembly the tow release is once again fully functional.

b) Determining the angle for automatic release

- With the tow release mounted in the test rig, load the hook via the connecting ring pair according to the cable (test) load schedule in Table 3.
- At each load stage measure the angle β s, at which release occurs automatically.

Table 3

Cable (test) load L	Cable angle β		Cable (test) load L	Cable angle α
N	Degress		N	Degress
20	0		100	75
20	45		150	0
20	75		150	45
30	0		150	75
30	45		500	0
30	75		500	30
40	0		500	45
40	45		500	60
40	75		500	75
50	0		1000	0
50	45		1000	0
50	75		2000	0
100	0		2000	60
100	45		3000	0
			3000	80

c) Test to calculated breaking load

On completion of the load test according to a) with subsequent disassembly test and the determination of the angle at which automatic release occurs according to b), remount the tow release in the test rig and load the hook via the connecting ring pair up to the calculated breaking load with cable angles $\alpha = 0$ degrees and $\beta = 0$ degrees.

Maintain the calculated breaking load for 3 seconds. Then release and measure the release force F_k . Then disassemble the tow release completely and inspect it for any permanent deformation, notches, cracks, etc.

5. OPERATING LIMITS, MARKINGS AND DOCUMENTATION

5.1 Operating limits

5.1.1 The operating limits listed in § 4.2.5 and § 4.2.6 must be specified for every tow release and be provided to the holder of the aircraft in which a tow release of the type in question is being installed (see also Table 4).

Table 4

Tow release according to §	1.1.a)	1.1.b)
Cable angle at which the tow cable can be reliably released		
α (upwards)	-90°	-, -
α (downwards)	+90°	+75°
β (to either side)	0-87°	0-87°
Maximum permissible cable load at which the tow cable can be reliably released		
$L_{\max}$	Cable load	Cable load
Automatic release angle		
α_s	-, -	75°-90°

5.2 Operating and maintenance documentation

5.2.1 On delivery, each tow release must be accompanied by operating and maintenance documentation. This documentation must contain all the information necessary to maintain the tow release in a fully operational condition.

5.2.2 A copy of the service and maintenance documentation must be shown to the Agency.

5.2.3 All the information in § 5.1 and any further information necessary for safe and reliable operation of the tow release must be included in the operating documentation.

5.2.4 As a minimum, the maintenance documentation must cover the following:

- Installation of the tow release in the aircraft
- Set-up data necessary for the safe and reliable functioning of the tow release
- Checks and tests to be carried out after installation
- Cleaning and care of the tow release
- Detailed description and frequency of maintenance work (inspection schedules)

[Amdt ETSO/3]

ETSO-2C514a

ED Decision 2018/002/R

**AIRBORNE SYSTEMS FOR NON REQUIRED TELECOMMUNICATION SERVICES (IN
NON AERONAUTICAL FREQUENCY BANDS) (ASNRT)****1 Applicability**

This ETSO provides the requirements which Airborne Systems to be installed on Aircraft for Non Required Telecommunication Services (in Non Aeronautical Frequency Bands) (ASNRT) that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with applicable ETSO marking.

Note: An antenna alone without an ASNRT controller does not fall under this standard.

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](#).

3.1.2 Environmental Standard

Equipment providing telecommunication services shall be tested in accordance with Appendix 1, Chapter 4 of this ETSO.

3.1.3 Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO Subpart A, paragraph 2.3.

3.2 Specific

None.

3.2.1 Failure Condition Classification

See CS-ETSO Subpart A, paragraph 2.4.

4 Marking**4.1 General**

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

4.2 Specific

The label shall indicate the communication system or network used.

5 Availability of Referenced Document

See CS-ETSO, Subpart A, paragraph 3.

[Amdt ETSO/3]

[Amdt ETSO/13]

APPENDIX 1 TO ETSO-2C514A – AIRBORNE SYSTEMS FOR NON REQUIRED TELECOMMUNICATION SERVICES (IN NON AERONAUTICAL FREQUENCY BANDS) (ASNRT)

ED Decision 2018/002/R

1. GENERAL

PURPOSE AND SCOPE

This minimum operational performance specification defines the minimum performance expected from an Airborne System to be installed on Aircraft for Non Required Telecommunication Services in Non Aeronautical Frequency Bands (ASNRT). The performance of specific equipment may be enhanced or superior to this specification depending on the intended application and configuration.

Chapter 1 describes typical equipment applications and operational objectives and is the basis for the performance criteria specified in Chapter 2 and Chapter 3. Definitions essential to proper understanding of this document are also provided in Chapter 1.

Chapter 2 contains general design requirements.

Chapter 3 contains the minimum performance specification for the equipment, defining performance under standard operating conditions.

Chapter 4 prescribes the environmental test conditions which provide a laboratory means of determining the performance characteristics of the equipment under conditions representative of those which may be encountered in actual operations.

Chapter 5 specifies the performance of the equipment and gives guidance for the installation.

APPLICATION

Compliance with this minimum operational performance specification by manufacturers, installers and users is recommended as a means of ensuring that the equipment will satisfactorily perform its intended functions under the conditions normally encountered in routine aircraft operations.

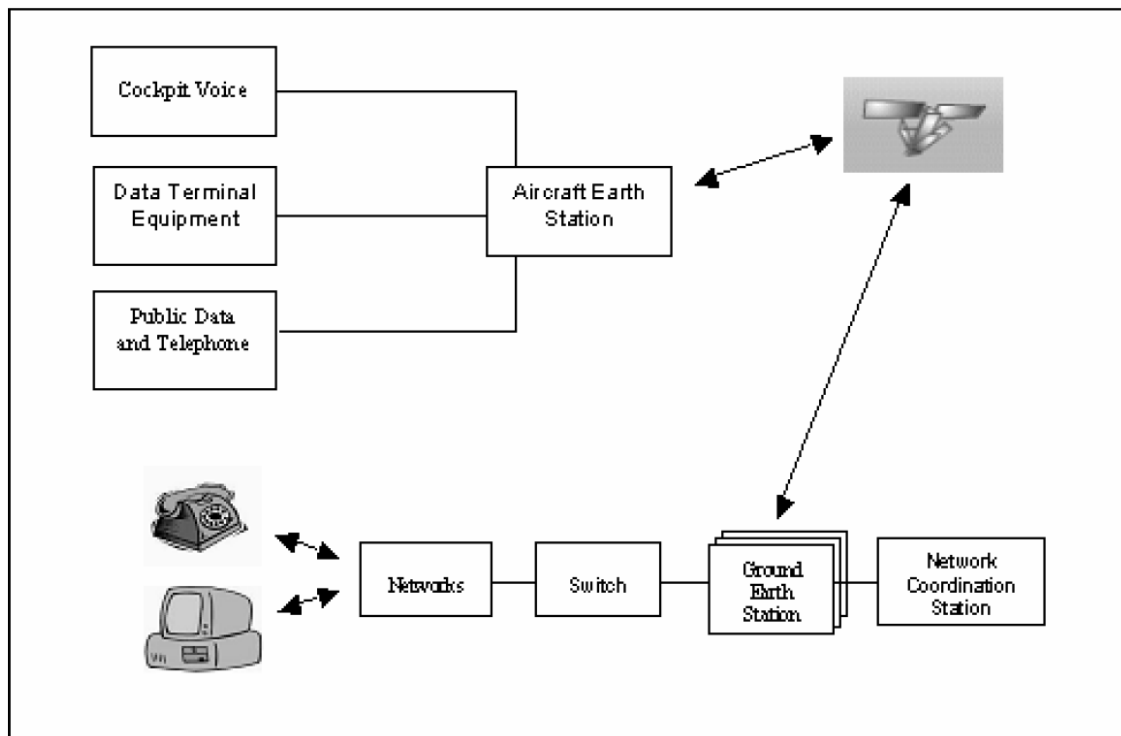
This specification does not cover telecommunication aspects. It is the responsibility of the manufacturer as well as the operator to obtain the necessary approvals from the responsible telecommunication authority and from the network provider, if applicable.

DESCRIPTION OF SYSTEM

The purpose of the Airborne System for Non-Required Telecommunication Services (ASNRT) is to provide flight crew and passengers with additional air- ground / air-air voice and data communication service. The system does not support safety related applications like Air Traffic Service (ATS).

It consists of electronic on board equipment which is not required for any phase of flight by any aviation rule. It is normally not connected to, nor interacts with, any aircraft system except the intercom, electrical power and mechanical mounting. In special cases it may be useful to establish additional interfaces to other systems. Examples are communication management Systems for transmission of data such as position, heading, etc. as well as company data. Furthermore, it might be useful to connect the ASNRT to devices serving as antenna steering units.

The following drawing shows an example of such a system utilizing the Iridium satellite network. It does not define a requirement.



Example Block Diagram: Airborne System for Non-Required Communication Services using the IRIDIUM satellite network

2. GENERAL DESIGN REQUIREMENTS

AIRWORTHINESS

The equipment shall not, under either normal or failure conditions, impair the airworthiness of the aircraft in which it is installed.

OPERATION OF CONTROLS

None of the possible positions, combinations and sequences of the controls intended for use during flight, shall result in a condition whose presence or continuation would be detrimental to the continued safe operation of the aircraft.

Operating the system shall not significantly affect the workload of the air crew.

The issuance of a radio or telecommunication station license in accordance with national regulations is mandatory. For non-aviation services which are not covered by EASA ETSOs, an European Norm (EN) standard is the appropriate definition for the transmission characteristic for a specific service in Europe. The EN applicable standard should be identified in the installation manual and DDP.

DESIGN CONSIDERATIONS

Controls and indicators intended for use by flight crew shall be of suitable design for the intended cockpit environment / philosophy (e.g. size, readability, illumination).

If an ASNRT equipment is integrated with a required A/C system, the ASNRT equipment shall not adversely affect the safety of the aircraft or its occupants, or the proper functioning of required equipment or systems under all foreseeable conditions.

EFFECTS OF TESTS

Unless otherwise provided, the design of the equipment shall be such that, subsequent to the application of the specific tests, no condition exists which would be detrimental to the continued safe operation of the aircraft.

AIRCRAFT EQUIPMENT INFORMATION VULNERABILITIES

If the equipment interfaces with aircraft busses and has connectivity to non-governmental services (e.g., Wi-Fi, Internet, etc.), the manufacturer may expose aircraft information vulnerability (such as cybersecurity risks) through equipment design, or become vulnerable as a result of being connected to a common interface. Therefore, it is important that manufacturers consider aircraft information security risk mitigation strategies in their equipment design, particularly when the equipment is responsible for an interface between the aircraft and aircraft-external systems.

It is recommended that manufacturers look at a layered approach to aircraft information security risk mitigation that includes both technical (e.g., software, signal filtering) and physical strategies. From a technical perspective, for example, this could include signal spoofing detection capabilities or more stringent, multi-factored authentication techniques such as passwords, PINs, and digital certificates. From a physical perspective, for example, such as in an in-flight entertainment system in the cabin, a manufacturer could consider connectors that require special tools to remove them to prevent passenger tampering. And finally, but just as important, manufacturers should consider supply chain risk management; for example, if a manufacturer is outsourcing software code development, are the contractor and its staff properly vetted?

Civil Aviation Authorities (CAAs) have a regulatory interest when an applicant's design makes use of a non-trusted connectivity where the installation can potentially introduce aircraft information security vulnerability. This requires the applicant to address not only the information security vulnerabilities and mitigation techniques for the new installation, but to also consider how vulnerability could propagate to existing downstream systems. Therefore, it is recommended that manufacturers reference their equipment aircraft information security review and mitigation strategies in the equipment's installation manual so that the applicant can consider them in meeting the installation regulatory requirements.

3. MINIMUM PERFORMANCE SPECIFICATION UNDER STANDARD CONDITIONS

GENERAL

The Aeronautical System for Non-Required Telecommunication Services (ASNRT) must meet the basic requirement not to interfere with on-board systems.

It must be ensured that the equipment can neither become a source of danger in itself nor threaten the proper functioning of any essential system or service.

Note: It is assumed that the manufacturer will also consult the telecommunication administration and (if applicable) the network provider as early as possible for approval of the technical parameters and requirements for the usage of the equipment.

SYSTEM SPECIFIC PARAMETERS

If appropriate, the manufacturer shall define details to show compliance with the 'GENERAL' subpart of this document.

A set of technical parameters showing that the system performs its intended functions shall be declared by the manufacturer. This set of data should include the quality, availability and

reliability of the information channel and all the requirements which may be defined by the telecommunication administration or network provider for such equipment. However, when agreed by EASA, compliance demonstration is only necessary for a very basic requirement like “communication link established”.

If the system interfaces to other on board equipment, compliance with the interface related requirements for that equipment has to be shown in order to exclude adverse effects on connected systems and the aircraft itself. In case of the intercom system electrical interface related parts of RTCA DO-214, or later revisions, (Audio Systems Characteristics and Minimum Operational Performance Standards for Aircraft Audio Systems and Equipment) Section 2.4 apply.

Means to disconnect the equipment from power bus or other systems (if applicable) shall be provided (i.e. Master Switch) for the case of unexpected interference, fire, smoke or other hazards.

Note: Compliance with this requirement can be achieved by the design of the equipment itself or by measures described in the Installation Manual.

CLASSES OF EQUIPMENT

There are two classes defined in accordance with technical means to ensure the proper operation of the equipment. There may be additional operational requirements which are not covered by this specification.

- Class 1: Equipment with the operation restriction to parked and (air-) taxiing aircraft:
Technical means shall be provided to ensure that the equipment cannot be operated during other phases of flight (eg. by connection to sensors for airspeed, weight on wheels, etc.).
Note: Equipment which can, due to interference problems, only be allowed to operate in a parked aircraft with engines and other systems switched off, is not in the scope of this specification.
- Class 2: Equipment for operation during all phases of flight:
The manufacturer shall obtain concurrence for the intended operation from the telecommunication authority or network provider (if applicable) before applying for an airworthiness approval.

4. MINIMUM PERFORMANCE SPECIFICATION UNDER ENVIRONMENTAL TEST CONDITIONS

INTRODUCTION

The environmental tests and performance requirements described in this chapter provide a laboratory means of determining the performance characteristics of the equipment under conditions representative of those which may be encountered in actual operations.

The Airborne System for Non-Required Telecommunication Services in Non Aeronautical Frequency Bands (ASNRT) needs to comply with environmental tests so far as it is necessary to ensure that the equipment cannot become a source of danger under environmental conditions.

Some of the tests contained in this chapter are identified with the phrase 'if required'. They do not have to be performed unless the manufacturer wishes to qualify the equipment to these additional environmental conditions or if requested by EASA.

Unless otherwise specified, the test procedures applicable to a determination of equipment performance under environmental test conditions are specified in [ETSO-2C514](#) paragraph 3.1.2

EQUIPMENT PERFORMANCE COMPLIANCE

The performance requirements as defined in chapter 3 are not required to be tested under all of the conditions specified in CS-ETSO Subpart A paragraph 2.1.

When exposed to high temperature and/or pressure as well as power input and voltage spike test, it shall be ensured that there is no risk of fire, smoke or similar induced by the equipment.

During all shock and vibration tests the equipment shall remain in its mounting and no part of the equipment or its mounting shall become detached and free of the shock test table.

Direct lightning tests for antennas or other equipment to be mounted outside the aircraft are only intended to ensure that a lightning strike is already blocked at the antenna itself and cannot influence other installations or the aircraft itself.

PERFORMANCE TESTS

The equipment is sorted into two categories. Category 1 is for devices which are to be installed inside the aircraft, e.g. in the avionics bay. Category 2 covers subsystems to be installed outside, especially antennas.

EUROCAED-14/RTCA-DO160 Test	Section	Category 1	Category 2
Temperature and Altitude	4	+	+
Temperature Variation	5.0	-	-
Humidity	6.0	-	-
Operational Shocks and Crash Safety	7.0	+	+
Vibration	8.0	+	+
Explosion Proofness	9.0	-	-
Water proofness	10.0	-	-
Fluids Susceptibility	11.0	-	-
Sand and Dust	12.0	-	-
Fungus Resistance	13.0	-	-
Salt Spray	14.0	-	-
Magnetic Effect	15.0	+	+(1)
Power Input	16.0	+	-
Voltage Spike	17.0	+	-
Audio Frequency Cond. Susceptibility	18.0	-	-
Induced Signal Susceptibility	19.0	-	-
Radio Frequency Susceptibility	20.0	-	-
Emission of Radio Frequency Energy	21.0	+	+(1),(3)
Lightning Induced Transient Susceptibility	22.0	-	-
Lightning Direct Effects	23.0	-	+(2)
Icing	24.0	-	-
Electrostatic Discharge	25.0	+	+
Fire, Flammability	26.0	+	-

+ mandatory test

- if required

(1) active antenna only

(2) This test can be omitted if compliance with the requirement is ensured by other means

(3) non intended radiation

The tests marked with “if required” may become mandatory in case of specific technical reasons. This shall be agreed with EASA.

Note: the table above is based on ED-14G / DO-160G. When test conditions or test levels are reevaluated, CS-ETSO requires compliance with ED-14G / RTCA-DO160G or later revisions as endorsed by CS-ETSO paragraph 2.1.

5. INSTALLED EQUIPMENT PERFORMANCE

The material contained in the following paragraphs is intended as guidance material only and does not have direct significance in the type certification of the equipment concerned. The aircraft installation must comply with the applicable airworthiness requirements and needs to be agreed by EASA.

EQUIPMENT INSTALLATION

Special care should be taken in selecting the antenna installation location in relation to other receiving and transmitting RF systems. A non-interference demonstration is required. Aircraft lightning zones and system lightning protection have to be determined. Additionally, for satellite systems a free sight to the sky is necessary for good system performance. Covering the antenna by structural elements will directly influence the installed communication performance. The interface to the on-board intercom or other systems shall be installed in a manner so that a malfunction of the communication system does not cause conditions which prevent the safe continuation of the flight. The equipment shall be installed in accordance with the manufacturer’s installation instructions.

If the ASNRT equipment contains a memory retention device which is a rechargeable lithium battery, the flammability risk must be addressed. Installed ASNRT equipment employing a rechargeable lithium battery must ensure the lithium ion battery meet airworthiness standards appropriate for the battery size and intended function.

OPERATING RESTRICTIONS

All operation restrictions which are defined e.g. by the rules of telecommunication authority and/or network provider should be enforced by technical provisions and procedures stated in the installation manual as well as the operation manual.

[Amdt ETSO/3]

[Amdt ETSO/13]

ETSO-2C515 A1

ED Decision 2020/011/R

AIRCRAFT HALOCARBON CLEAN AGENT HANDHELD FIRE EXTINGUISHER**1 Applicability**

This ETSO provides the requirements which an aircraft halocarbon clean agent handheld fire extinguisher that is designed and 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**

The 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**

The applicable standards are those provided in SAE International's Aerospace Standard AS6271, Halocarbon Clean Agent Hand-Held Fire Extinguisher, issued in January 2013, as amended by Appendices [1](#) and [2](#) to this ETSO.

3.1.2 Environmental Standard

Refer to the environmental qualification requirements specified in ANSI/UL 2129.

3.1.3 Software

None.

3.1.4 Airborne Electronic Hardware

None.

3.2 Specific**3.2.1 Failure Condition Classification**

A failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a minor failure condition.

4 Marking**4.1 General**

See CS-ETSO, Subpart A, paragraph 1.2.

4.2 Specific

The fire extinguisher type, as specified in paragraph 3.1 of AS6271, shall be marked on the article.

In addition, the fire extinguisher rating, as specified in ANSI/UL 711, shall be marked on the article.

5 Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

[Amdt ETSO/11]

[Amdt ETSO/16]

APPENDIX 1 TO ETSO-2C515 A1 – HALOCARBON CLEAN AGENT HANDHELD FIRE EXTINGUISHER

ED Decision 2020/011/R

This Appendix prescribes the minimum performance standards (MPS) for aircraft handheld fire extinguishers. The applicable standard is SAE AS6271 'Halocarbon Clean Agent Hand-Held Fire Extinguisher', issued in January 2013. EASA has revised it as follows:

1. On page 4, replace paragraph 3.2 with the following:

'Halocarbon clean agents shall be registered according to REACH¹ for use in a fire extinguisher to be sold in the European Union (EU). REACH is the EU Regulation on chemicals and their safe use. REACH applies to substances manufactured or imported into the EU in quantities of 1 ton or more per year (see 2.1.7).'

2. On page 5, replace paragraph 4.1.1 with the following:

'The fire extinguisher/mounting bracket assembly shall be shown to withstand without failure the highest ultimate inertia force/load, applied to all on-axis (X, Y, Z) orientations, specified in the Certification Specifications (CS) applicable to the specific aircraft type or types on which the fire extinguisher is suitable to be installed. The ultimate inertia forces/loads shall be increased, if necessary, to meet the aircraft manufacturer's specifications for flight and ground loads accordingly. A fitting factor of 1.33 as specified in C2X.561 shall be included to address wear and tear through frequent removal of the fire extinguisher from its mounting bracket. In addition, the manufacturer shall provide an Interface Control Drawing (ICD) specifying for the fire extinguisher/mounting bracket assembly:

- the ultimate inertia force/loads shown during qualification,
- the mounting orientations (X, Y, Z) for installation,
- the interface loads and the specified means of attachment for installation,
- the Certification Specification(s) (e.g. CS 25.561) including the amendment for which the assembly is demonstrated to be compliant.'

3. On page 5, add a note to paragraph 5.2.2:

'Note: If the proposed agent was already proven to pass the seat/toxicity test of the MPS in combination with another fire extinguisher, that test would not need to be repeated for the proposed fire extinguisher/agent combination.'

[Amdt ETSO/16]

¹ Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC (OJ L 396, 30.12.2006, p. 1).

APPENDIX 2 TO ETSO-2C515 A1 – HALOCARBON CLEAN AGENT HANDHELD FIRE EXTINGUISHER

ED Decision 2020/011/R

This Appendix prescribes the minimum performance standards (MPS) for aircraft handheld fire extinguishers. As referred to in SAE AS6271, the applicable standard is ANSI/UL 2129 'Halocarbon Clean Agent Hand-Held Fire Extinguisher', issued in February 2005. EASA has revised it as follows:

1. On page 9, replace paragraph 6.8 with the following:
'An extinguisher shall operate as intended at temperatures from -40°C to 49°C as required per UL2129. Ground survival temperature of the unit shall be -54°C up to 85°C (refer to EUROCAE ED-14/RTCA document DO-160 revisions defined in CS-ETSO, [Subpart A](#), paragraph 2.1, ground survival temperature).'
2. On page 12, replace the first phrase of paragraph 12.4 with the following:
'The maximum indicated gauge pressure shall be between 150 and 250 % of the indicated charging pressure specified by the manufacturer (at either 20° or 21°C).'
3. On page 12, replace paragraph 12.5 with the following:
'The mark used to indicate the charging pressure at the charging temperature (at either 20°C or at 21°C) as specified by the manufacturer shall be a minimum of 0.6-mm wide and not more than 1.0-mm wide.'
4. On page 12, disregard paragraphs 12.6 and 12.7.

[Amdt ETSO/16]

ETSO-2C517

ED Decision 2020/011/R

AUTOMATIC DEPLOYABLE FLIGHT RECORDER (ADFR) SYSTEMS FOR LARGE AEROPLANES

1 Applicability

This ETSO provides the requirements which automatic deployable flight recorder (AFDR) systems intended for installation in large aeroplanes that are designed and 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

The 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

The applicable standards are those provided in EUROCAE ED-112A, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, Section 3, as amended by Appendix 1 to this ETSO.

The ADFR system shall also be approved in accordance with the latest revision of the ETSO that is applicable to the supported function:

ETSO-(2)C123()	Cockpit Voice Recorder Systems
ETSO-(2)C124()	Flight Data Recorder Systems
ETSO-(2)C176()	Aircraft Cockpit Image Recorder Systems
ETSO-(2)C177()	Data Link Recorder Equipment

The emergency locator transmitter fitted to the ADFR shall be approved as a minimum in accordance with ETSO-C126c, Type ELT(AD) Class 0 or 1, with capabilities C (Crash resistance), H1 (121.5MHz homing) and be of any generation (capability T.001 or T.018).

3.1.2 Environmental Standard

See CS-ETSO, [Subpart A](#), paragraph 2.1, and EUROCAE ED-112A as amended by Appendix 1 to this ETSO.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific

3.2.1 Failure Condition Classification

See CS-ETSO, [Subpart A](#), paragraph 2.4.

A failure of the ADFR to deploy when required is classified as a minor failure condition.

An unintended deployment of the ADFR is classified as not less than a major failure condition.

Note: The classification of the unintended deployment of the ADFR is driven by the risk to the people on the ground. The unintended deployment of the ADFR may also damage the aircraft. Assessing this impact when installing the article on an aircraft may result in a more stringent classification.

4 Marking

4.1 General

See CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

4.2.1 Lettering identification

The equipment shall comply with the identification requirement in EUROCAE ED-112A, Section 3-1, paragraph 3-1.8.3 as amended by Appendix 1 to this ETSO.

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/16]

APPENDIX 1 TO ETSO-2C517 – MINIMUM OPERATIONAL PERFORMANCE STANDARD (MOPS) FOR AUTOMATIC DEPLOYABLE FLIGHT RECORDER (ADFR) SYSTEMS

ED Decision 2020/011/R

The applicable standard is EUROCAE ED-112A, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, and shall be modified as per Table 1 below.

Table 1 — Modification of EUROCAE ED-112A for ADFR systems

Location	Initial ED-112A text	Amending text
3-1.1	This section details the additional requirements and exceptions that are specific to deployable recorders. The requirements specified in this section shall be met in addition to the requirements of Sections 1 and 2, together with Sections 4 and 5 as applicable, and the appropriate recorder specific parts. A deployable recorder is a recording medium housed in a crash-protected memory module that is automatically deployed (released) from the aircraft at the start of an accident sequence. Its characteristics have the objective of enabling it to land at low speeds clear of the main aircraft wreckage, or, in the event of an over-water accident, its flotation characteristics enable it to float on water. Since the recorder is no longer with the aircraft it should be equipped with a means to locate it. This type of recorder is attached to the exterior of the airframe, and under normal conditions, functions in the same manner as a fixed recorder. The Recorder Memory Unit, Beacon Transmitters, Antennas, Battery Pack and the survival packaging for these units are all an integral part of the Automatic Deployable Package. The deployable Package incorporates flight characteristics that enable it to deploy and rapidly establish a flight trajectory that clears the airframe.	This section details the additional requirements and exceptions that are specific to deployable recorders. The requirements specified in this section shall be met in addition to the requirements of Sections 1 and 2, together with the requirements of Sections 4 and 5 as applicable, and the appropriate recorder-specific parts. A deployable recorder is a recording medium housed in a crash-protected memory module that is automatically deployed (released) from the aircraft at the start of an accident sequence. Its characteristics have the objective of enabling it to land at low speeds clear of the main aircraft wreckage or, in the event of an over-water accident, its flotation characteristics enable it to float on water. An ELT is embedded in the deployable recorder to permit determination of the location of the point of the end of flight, and to locate the recorder. This type of recorder is attached to the exterior of the airframe, and under normal conditions, it functions in the same manner as a fixed recorder. The recorder memory unit, beacon transmitters, antennas, battery pack and the survival packaging for these units are all integral parts of the automatic deployable package. The deployable package incorporates flight characteristics that enable it to deploy and rapidly establish a flight trajectory that clears the airframe.
3-1.2		Ignore 3-1.2
3-1.3	This section defines the minimum specification to be met for Deployable Recorder Systems. It is applicable to any crash-protected recorder that is designed to be deployed, its ancillary equipment and its installation in civil aircraft.	This section defines the minimum specifications to be met for automatic deployable flight recorder systems. It is applicable to any crash-protected recorder that is designed to be deployed from a large aeroplane, and to its ancillary equipment.
3-1.4	3-1.4 APPLICATION Compliance with this section will ensure that deployable systems will perform their	Replace by the following paragraph: 3-1.4 DEFINITIONS The following definitions are provided for the terms that are used in Section 3.

	function under the conditions encountered in aircraft operations.	Activation depth The nominal depth of the hydrostatic sensor at which it triggers the deployment of the automatic deployable package (3-1.7.2, 3-3.2.10 as defined in this appendix). ADFR Automatic deployable flight recorder ADFR system The system composed of: the automatic deployable package; and the system components installed in the aircraft and that support the deployment (the deployment mechanism, sensors except those that detect the deformation of the aircraft, etc.) and the recording. Automatic deployable package The part of the system that is deployed, including the crash-protected memory module, the ELT (also named radio location beacon in ED-112A), its antenna and battery, contained in a floatable aerofoil. Deployment case A deployment condition as defined in Appendix 2 to this ETSO. Deployment time The time from a positive indication of a crash until the deployable recorder is released (ED-112A 3-1.7 f.). Immersion depth The maximum depth of immersion in salt water at which the automatic deployable package has been tested (3-3.2.8). Release point The point of the aircraft fuselage from which the automatic deployable package is released. Tested impact speed The speed used in the impact shock test in Section 3-3.2.1 as amended by this appendix, which is declared by the equipment manufacturer.
3-1.5.1	In addition to the safety requirements specified in paragraph 2-1.3.1, the following requirements shall apply to all deployable recorders: a. The exterior of the equipment shall have no sharp edges or projections that could damage inflatable survivable equipment or injure persons. b. The overall quantitative probability (per flight hour) of the failure event ‘non-commanded deployment’ shall be $< 10^{-7}$. This probability objective addresses such hardware and software components, which contribute directly to the deployment event.	In addition to the safety requirements specified in Section 2-1.3.1, the exterior of the automatic deployable package shall have no sharp edges or projections that could damage inflatable survivable equipment or injure persons.
3-1.5.2	In addition to the certification documents specified in paragraph 2-1.3.4, the following shall be provided. a. Instructions shall be provided for safely removing deployable recorders from the aircraft for maintenance purposes. b. The transmission frequency and modulation characteristics of the radio location beacon.	In addition to the certification documents specified in Section 2-1.3.4, the following shall be provided: The transmission frequency and modulation characteristics of the radio beacon. Installation instructions that contain: the tested impact speed (Impact shock test in Section 3-3.2.1); the deployment time as defined in 3-1.7.f; the distances required for the automatic deployable package to reduce its speed to the tested impact speed in the deployment cases as defined in Appendix 2 to this ETSO;

		the activation depth at which the hydrostatic sensor triggers the deployment (3-1.7.2); the immersion depth that the automatic deployable package can withstand as tested in 3-3.2.8; other installation constraints ensuring that the automatic deployable package is released before the immersion can disable the system; the maximum ice thickness that can be permitted before de-icing action is necessary, as determined during the icing test in Table 2 of this ETSO; the recommended recorder orientation on the fuselage to ensure the performance of the deployment when installed; instructions for safely removing deployable recorders from the aircraft for maintenance purposes; the kinetic energy of the automatic deployable package once deployed from a fixed position; other installation constraints. The ADFR system installation manual shall state that the installer must verify that: the automatic deployable package is installed so that it may not be crushed or penetrated by aircraft parts when deployed and is located in an area limiting the exposure to fire before and after an accident; the hydrostatic sensor is installed in a fuselage section as close as possible as the one of the release mechanism; the installation is likely to result in an impact speed of the automatic deployable package that is less than the tested impact speed selected for the impact shock test of the crash-protected recording medium (Section 3-3.2.1) for the deployment cases listed in Appendix 2 to this ETSO – this may be achieved by comparing the distances determined in 3-1.5.2 b. 3. to the distances between the release point and the aircraft nose for case 1 and between the release point and the lowest part of the fuselage for case 2; the installation minimises the risk that the deployment of the automatic deployable package in normal flight conditions affects the capability of continued safe flight and landing.
3-1.6	Refer to ED-112A	Unchanged
3-1.6.1	A visual method to alert the cockpit crew when the deployable recorder is no longer captive to the aircraft shall be provided. The cockpit crew shall have an unobstructed view of the visual indicator when in the normal seated position. The brilliance of any indicator may be adjustable to levels suitable for data interpretation under all cockpit ambient light	The ADFR system shall provide a means to inform the flight crew that the recorder is no longer captive to the aircraft.

	conditions ranging from total darkness to reflected sunlight.	
3-1.7.a	Refer to ED-112A	Unchanged
3-1.7.b	Refer to ED-112A	Unchanged
3-1.7.c	Refer to ED-112A	Unchanged
3-1.7.d.	Refer to ED-112A	Ignore 3.1.7.d.
3-1.7.e.	Refer to ED-112A	Ignore 3.1.7.e.
3-1.7.f	Refer to ED-112A	Unchanged
3-1.7.g	Refer to ED-112A	Unchanged
3-1.7.h		h. There shall be no means for manual deployment.
3-1.7.i		i. when deployed on the ground from a static position, the point of impact of the automatic deployable package shall be within 20 metres of the deployment mechanism in any direction over a horizontal plane one metre below the release point.
3-1.7.	The design characteristics of a deployable recorder should result in the recorder landing clear of the aircraft wreckage. The unit shall incorporate flight characteristics that enable it to rapidly establish a flight trajectory that clears the airframe. The unit shall not be given sufficient initial momentum on deployment such that its release could endanger ground support personnel or the aircraft itself.	The design characteristics of a deployable recorder should result in the recorder landing clear of the aircraft wreckage. The automatic deployable package shall incorporate flight characteristics that enable it to rapidly establish a flight trajectory that clears the airframe. When the aircraft stands on the ground, the automatic deployable package shall not be given sufficient initial momentum on deployment such that its release could endanger ground support personnel or the aircraft itself. The automatic deployable package shall be shown to satisfy the deceleration requirements detailed in Appendix 2 to this ETSO.
3-1.7.1	Refer to ED-112A	Ignore 3-1.7.1
3-1.7.2	Sensor(s) shall be installed to activate deployment of the recorder at a depth of 3 m or more.	The ADFR system shall deploy the automatic deployable package when it detects an immersion by measuring the water pressure. A pressure equivalent to a water activation depth between 1.5 and 2.5 m is recommended for the switching threshold of a hydrostatic pressure switch. The system design shall be such that its progressive immersion does not affect the deployment of the automatic deployable package if installed as per the installation constraints. Automatic deployment shall take place up to 15 minutes after the loss of external electrical power. The installation manual shall contain the identification of all the component electronics, power sources, mechanisms and interconnecting cables, as well as any caution notes that are needed to ensure the activation and deployment of the ADFR system.
3-1.8.1	Refer to ED-112A	Unchanged

3-1.8.2	All deployable recorders shall be equipped with a Class 1 dual frequency 406 MHz and 121.5 MHz radio location beacon compliant with the requirements of ED-62A instead of the underwater locator beacon and its attachment as specified in paragraph 2-1.16.4. The radio locating device shall be attached to the deployable recorder such that the aerodynamic properties of the recorder are not adversely affected and the risk of damage to, or separation of, the locating device is minimised. In addition to meeting the endurance requirements specified by ED-62A, the 121.5MHz radio shall operate for an additional 102 hours for a total minimum operational duration of 150 hours. For the operational duration in exceedance of ED-62A (between 48 hours and 150 hours of operation), the minimum Equivalent Isotropic Radiated Power (EIRP) for the 121.5MHz radio shall be 5mW. <i>NOTE: Other required characteristics of the radio location beacon are outside the scope of this MOPS. Reference should be made to the applicable equipment standard.</i>	The automatic deployable package shall be equipped with an ELT that is approved in accordance with ETSO-C126c, type ELT(AD) Class 0 or 1 with capabilities C (crash resistance), H1 (121.5 MHz homing) and be of any generation (capability T.001 or T.018) instead of the underwater locator beacon and its attachment as specified in Section 2-1.16.4. The ELT shall radiate nominal power levels (as required per ETSO-C126c) for any orientation of the deployable package that is stable when laid on a flat horizontal surface. The radio locating device shall be attached to the deployable recorder such that the aerodynamic properties of the recorder are not adversely affected and the risk of damage to, or separation of, the locating device is minimised. In addition to meeting the endurance requirements specified by ED-62A, the 121.5MHz radio shall operate for an additional 102 hours for a total minimum operational duration of 150 hours. For the operational duration in exceedance of ED-62A (between 48 hours and 150 hours of operation), the minimum Equivalent Isotropic Radiated Power (EIRP) for the 121.5MHz radio shall be 5 mW.
3-1.8.3	Refer to ED-112A	Add the following text: If the automatic deployable package (ADP) is designed to be installed with one side exposed to the exterior of the aircraft and if its kinetic energy can reach 44 Joules within 0.5 metre from the release point when the aircraft is standing on the ground, that side of the ADP shall bear a conspicuous label. Note: This label is intended to provide a visual warning to maintenance and servicing crews, as well as to rescue or other personnel at the scene of an accident or incident in the event that the ADFR has not deployed.
3-1.8.4	Refer to ED-112A	Unchanged
3-2.1	CHAPTER 2-3 defines the environmental tests to be performed on the recorder system. Deployable recorders shall satisfy the functional requirements as detailed in Chapter 4 of the applicable function specific Part(s).	Table 2 of this ETSO defines the minimum environmental tests to be performed on the ADFR system. During each test, an unintended deployment of the ADFR shall be considered to indicate that the test has been failed. Unless Table 2 of this ETSO specifies that the deployment shall be performed during the tests, the successful deployment shall be verified after submission of the equipment to the test (this may be achieved by verifying the successful deployment only once after a group of

		tests has been performed on a single item of equipment). The ADFR system shall satisfy the functional requirements as detailed in Chapter 4 of the applicable function-specific part(s). The verification of deployment aspects may be performed using a dummy automatic deployable package.
3-3.1	Refer to ED-112A	Unchanged
3-3.2.1	The integrity of the crash-protected recording medium contents and the proper operation of the Radio Location Beacon are to be validated when subjected to the following impact shock test. a. Subject the deployable recorder package, to an impact shock applied to the most probable landing attitude in the most damage vulnerable direction. The shock shall be such a level as to simulate a landing velocity of 46.33 m/s (152 ft/s) onto a hard surface such as rock, concrete or steel. NOTE: The definitions of ‘landing attitude’ and ‘most damage-vulnerable direction’ should not be limited to the three primary axes of the recorder. b. The deployable recorder containing the protected memory module shall impact or be impacted by a hard surface (50 mm thick steel plate of dimensions greater than the overall dimensions of the recorder) at a minimum impact velocity of 46.33 m/s (152 ft/s). Figure 3-3.1 illustrates an acceptable impact shock test set-up for deployable recorders. Figure 3-3.2 illustrates an acceptable method and set-up for retrieval of the deployable after impact. The mass of the impact plate shall be greater than 10 times the mass of the deployable recorder and experience no yield when subjected to the impact. c. Apart from the test sequence specified in paragraph 3-1.8 a iii, electronic components external to the crash-protected memory may be removed and replaced with representative mass models prior to commencing the impact shock test. For test sequence iii, the radio location beacon shall be installed and the test carried out on the complete recorder.	The integrity of the contents of the crash-protected recording medium, the proper operation of the radio beacon and the seaworthiness of the automatic deployable package are to be validated when subjected to the following impact shock test. a. Subject the automatic deployable package to an impact shock that is applied to the most probable impact attitude in the most damage-vulnerable direction. The shock shall be at such a level as to simulate an impact speed of at least 46.33 m/s (152 ft/s) onto a hard surface such as a rock, concrete or steel. The equipment manufacturer may demonstrate a higher impact speed for the crash-protected recording medium (that may be specified by the organisation installing the ADFR) and declare it in the installation manual and the declaration of design and performance (DDP). In this case, the proper operation of the radio beacon and the seaworthiness of the automatic deployable package are still required to be demonstrated for the impact speed of 46.33 m/s. NOTE: The definitions of ‘impact attitude’ and ‘most damage-vulnerable direction’ should not be limited to the three primary axes of the recorder. b. The deployable recorder that contains the protected memory module shall impact or be impacted by a hard surface (a 50-mm-thick steel plate of dimensions greater than the overall dimensions of the recorder) at a minimum impact velocity of 46.33 m/s (or higher as declared by the manufacturer). Figure 3-3.1 illustrates an acceptable impact shock test set-up for the automatic deployable package. Figure 3-3.2 illustrates an acceptable method and set-up for the retrieval of the deployable after impact. The mass of the impact plate shall be greater than 10 times the mass of the deployable recorder and shall not yield when it is subjected to the impact. c. Apart from the test sequence specified in paragraph 3-1.8.a.iii, electronic components that are external to the crash-protected memory may be removed and replaced with representative mass models prior to commencing the impact shock test. For test sequence iii, the radio beacon shall be

		installed and the test carried out on the complete automatic deployable package.
3-3.2.2 (except note)	Refer to ED-112A	Unchanged
3-3.2.2 (note)	<i>NOTE: This test methodology is the same as the penetration test specified for Emergency Locator Transmitters (ELTs) in ED-62A.</i>	<i>NOTE: This test methodology is the same as that for the impact test specified for emergency locator transmitters (ELTs) in ED-62B Section 4.5.10. Per ETSO-C126c, the ELT(AD)s fitted to the ADFR are required to pass the ED-62B impact test described in Section 4.5.10.</i>
3-3.2.3	Refer to ED-112A	Add the following note to ED-112A Section 3-3.2.3: <i>NOTE: Per ETSO-C126c, the ELT(AD)s fitted to the ADFR are required to pass the static crush test, as described in ED-62B Section 4.5.12.</i>
3-3.2.4	Refer to ED-112A	Add the following note to ED-112A Section 3-3.2.4: <i>NOTE: Per ETSO-C126c, the ELT(AD)s fitted to the ADFR are required to pass the ED-62B Section 4.5.14 fire test.</i>
3-3.2.5	Refer to ED-112A	Add the following note to ED-112A Section 3-3.2.5: <i>NOTE: Per ETSO-C126c, the ELT(AD)s fitted to the ADFR are required to pass the ED-62B Section 4.5.14 fire test.</i>
3-3.2.6	Refer to ED-112A	Unchanged
3-3.2.7	Refer to ED-112A	Unchanged
3-3.2.8	The deployable recorder shall be buoyant and, when floating in fresh water or salt water, shall be self-righting and sufficiently stable to maintain the antenna substantially in its normal operating position and to transmit on its 406 MHz and 121.5 MHz frequencies. Transmission of the ELT frequencies shall be demonstrated by testing in fresh and then salt water and confirming the reception of the 406 MHz Alert frequency via COSPAS SARSAT Satellite, and the 121.5 MHz homing frequency via a SAR Homing receiver. This test shall be performed in water conditions that are representative of an open sea state 7 (equivalent to Beaufort Scale force 10).	The automatic deployable package shall be buoyant and, when floating in fresh water or salt water, shall be self-righting and sufficiently stable to maintain the antenna substantially in its normal operating position, and to transmit on its 406-MHz and 121.5-MHz frequencies. The automatic deployable package shall be immersed at the immersion depth for 5 minutes and shall then return to the surface when released. Transmission on the ELT frequencies shall then be demonstrated by conducting testing in fresh water and confirming the reception of the 406-MHz alert frequency via the COSPAS SARSAT Satellite. The 121.5-MHz homing transmission shall be tested in the conditions described in ED-62B Section 5.5.6.
3-3.2.9 a.	Unless it can be shown that the recording medium can withstand the conditions associated with deep sea immersion and that it is unlikely to be damaged as a consequence of collapse of any protective armour, immerse the recorder in sea water at a pressure of 60 MPa (equivalent to a depth of 6 000 m (20 000 feet) for a period of 30 days.	Ignore 3-3.2.9.a.
3-3.2.9 b.	Unless it can be shown that the recording medium and the identification required by paragraph 2-1.16.3 are resistant to the corrosive effects of sea water, immerse the	Unless it can be shown that the recording medium and the identification required by Section 2-1.16.3 are resistant to the corrosive effects of seawater, immerse the recorder in seawater at a depth of 3 m

	recorder in sea water at a depth of 3 m and nominal temperature of + 25°C for a period of 30 days.	and a nominal temperature of at least + 25.0 °C for a period of 90 days.
3-3.2.10		Add a section: Water immersion initiation test This test may be performed on an additional individual ADFR system that is not part of the test sequences defined in 3-1.8.1. The geometry of test set-up (orientation, relative position of the release mechanism and of the hydrostatic sensor) shall be the least favourable one permitted by the installation constraints with regard to the risk of being disabled by immersion. The ELT shall be activated and the system deprived of external power before the test for the duration defined in Section 3-1.7.2, as amended by this Appendix. Submerge it in fresh water at a speed of not less than 1 m per minute. Verify that the ADFR deploys when the hydrostatic pressure sensor is at a depth of between 1.5 and 2.5 m. Perform an aliveness test of the ELT as defined in EUROCAE ED-62B Section 4.3.1.

Table 2 — Environmental test for ADFR systems

Test	EUROCAE ED-14G/ RTCA DO-160G Section	Minimum category/Remarks
Temperature	4.0	Category to be defined by the manufacturer. Deployment shall be tested at the short-time low and short-time high operating temperatures.
Altitude	4.0	Category to be defined by the manufacturer.
Temperature Variations	5.0	A, S1 or S2
Humidity	6.0	C for the components and parts of the ADFR system that are exposed to the outside air, A for the rest of the system. Deployment shall be tested at the end of exposure period, without draining off any condensed moisture.
Operational Shock	7.0	Category to be defined by the manufacturer.
Crash Safety Shock	7.0	Category to be defined by the manufacturer.
Vibration	8.0	R, U or U2 and H or Z A deployment shall be performed during the test, at the most unfavourable vibration condition (e.g. the resonance frequency).
Explosion Proofness	9.0	As required.
Waterproofness	10.0	S for the components and parts of the ADFR system that are exposed to the outside air, Y for the rest of the system including for the water sensor.
Fluids Susceptibility	11.0	F, with at least fuel, hydraulic fluids, lubricating oils, de-icing fluids and fire extinguishants.
Sand and Dust	12.0	S
Fungus Resistance	13.0	F

Salt Spray	14.0	T
Magnetic Effect	15.0	Category to be defined by the manufacturer.
Power Input	16.0	Category to be defined by the manufacturer. A deployment shall be performed under the most unfavourable testing conditions. The unit under test may encompass only the installed components of the ADFR system.
Voltage Spike	17.0	Category to be defined by the manufacturer. The unit under test may encompass only the installed components of the ADFR system.
AF Conducted Susceptibility	18.0	Category to be defined by the manufacturer. A deployment shall be performed during the test under the most unfavourable testing conditions. The unit under test may encompass only the installed components of the ADFR system.
Induced Signal Susceptibility	19.0	Category to be defined by the manufacturer. A deployment shall be performed during the test under the most unfavourable testing condition. The unit under test may encompass only the installed components of the ADFR system.
RF Susceptibility	20.0	Category to be defined by the manufacturer. A deployment shall be performed during the test under the most unfavourable testing conditions.
RF Emission	21.0	Category to be defined by the manufacturer.
Lightning-Induced Transient Susceptibility	22.0	Category to be defined by the manufacturer.
Lightning Direct Effects	23.0	Category to be defined by the manufacturer. The recorder is required to successfully deploy after a direct impact. No unintended deployment shall occur, and no part shall detach.
Icing	24.0	The test shall be performed for Categories B and C. For Category B, 2 cycles are required. The deployment of the recorder shall be tested at the end of first cycle and at the end of the low-temperature phase for the second cycle. For Category C, the deployment shall be tested after the required ice thickness (as declared by the manufacturer) is met and the temperature is stabilised at its lowest value as required by the ED-14G/DO-160G test.
Electrostatic Discharge	25.0	A
Fire	26.0	C + ED-112A Sections 3-3.2.4 and 3-3.2.5.

[Amdt ETSO/16]

APPENDIX 2 TO ETSO-2C517 – DISTANCES REQUIRED FOR THE DECELERATION OF THE AUTOMATIC DEPLOYABLE PACKAGE

ED Decision 2020/011/R

This Appendix defines the minimum acceptable performance for the deceleration of the automatic deployable package. The objective is to ensure that the collision of the automatic deployable package with the ground will not damage the crash-protected recording medium in two cases that are typical of an accident trajectory. For those cases, the applicant will perform the following tasks:

1. consider the tested impact speed used in the impact shock test (Section 3-3.2.1) V_{impact} ;
2. determine the distance D_{captive} that is required for the automatic deployable package to be released;
3. determine the distance D_{released} that the automatic deployable package needs to decelerate to the tested impact speed once released; and
4. compare the total distance $D_{\text{Decelerate}}$ (distance needed for the deployable package to be released and decelerated by drag forces so that its speed is less than the tested impact speed) with a maximum value D_{max} defined in Table 3.

Note: The applicant may increase the tested impact speed V_{impact} to reduce $D_{\text{Decelerate}}$.

The initial release position, attitude and speed of the automatic deployable package are determined by the platform attitude and speed vector as defined in Table 3 and Figure 1 below and by the orientation of the ADFR relative to the platform. They shall account for any initial speed increment or accelerations that may be provided by the deployment mechanism.

If the ADFR manufacturer does not limit the installation of the ADFR to only one deployment direction relative to the platform (e.g. deployment in the direction of axis z or direction of y axis), the deployment direction resulting in the highest impact speed shall be considered, or cases shall be added to cover the permitted direction domain.

The impact surface is the plane defined by the following conditions:

- its normal vector $\vec{n}$ is specified in table 3 of this ETSO; and
- the component of the automatic deployable package speed along this normal vector $\vec{n}$ is equal to the speed value V_{impact} used for the impact shock test of the crash-protected recording medium (Section 3-3.2.1).

The distance D_{captive} is the distance covered by the platform from the positive indication of a crash until the deployable package is released (3-1.7 f.).

The distance D_{released} is the distance between the initial release position and the impact surface.

The distance $D_{\text{Decelerate}}$ is equal to $D_{\text{Decelerate}} = D_{\text{captive}} + D_{\text{released}}$.

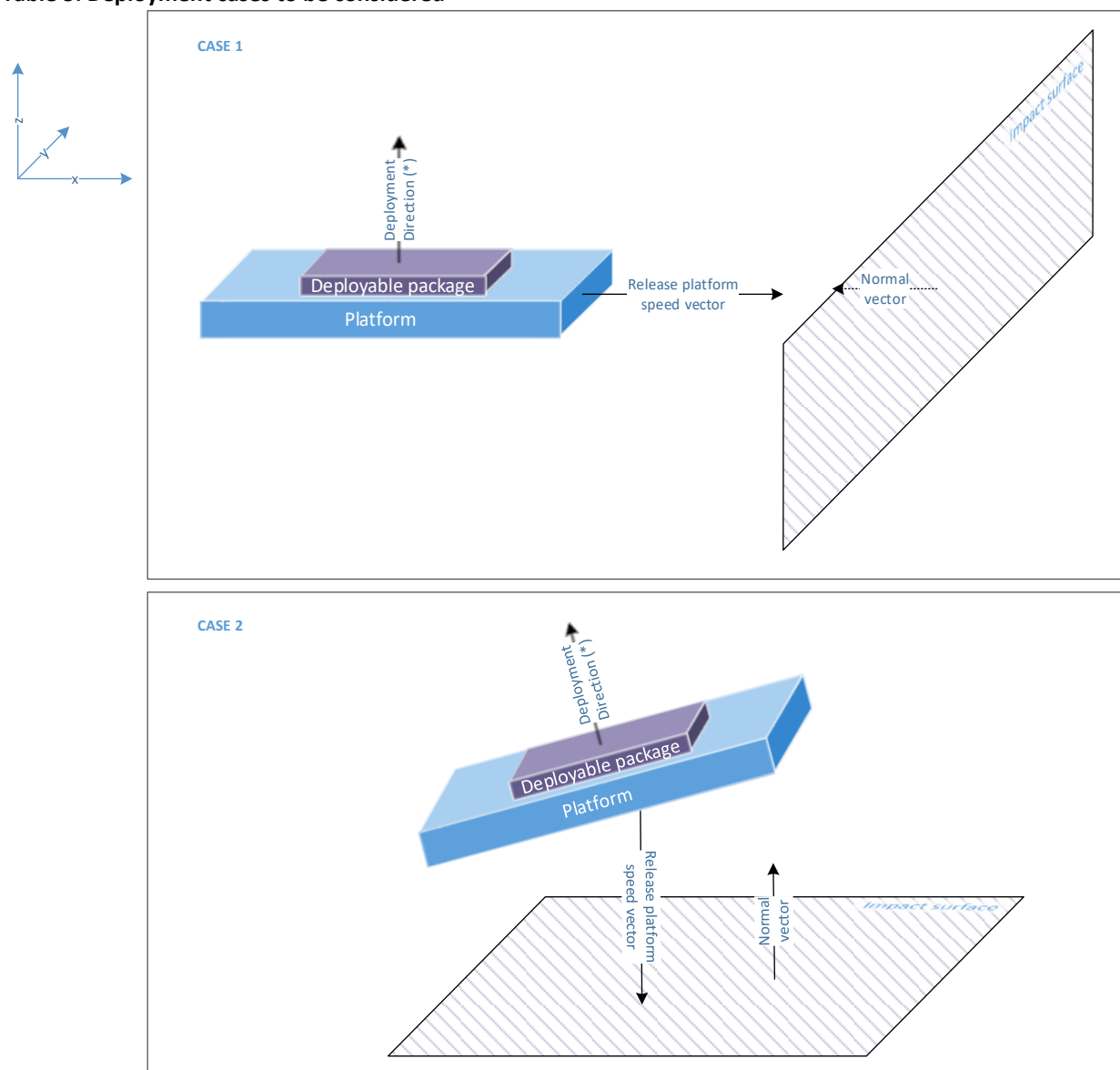
Deceleration requirements

For each deployment case specified in Table 3 of this ETSO, the distance $D_{\text{Decelerate}}$ shall be less than the maximum distance D_{max} .

Note: This condition is used to determine whether recorded data is likely to be retained by the crash-protected recording medium after a collision with terrain, when the ADFR system is installed on a large aeroplane.

Deployment case	Release platform attitude			Release platform speed vector			Impact surface - Normal vector $\vec{n}$			Maximum distance to reduce the speed component along the normal vector to the tested impact speed value ($D_{\max}$)
	Pitch	Roll	Yaw	Vx	Vy	Vz	x	y	z	
	°			m/s						m
Case 1	0	0	0	150	0	0	-1	0	0	70
Case 2	15	0	0	0	0	-50	0	0	1	20

Table 3: Deployment cases to be considered



(*) Different deployment directions relative to the platform may have to be considered depending on the installation constraints. The figure above represents a case where the deployable package is deployed upwards when installed in the aircraft.

Figure 1: Deployment cases to be considered

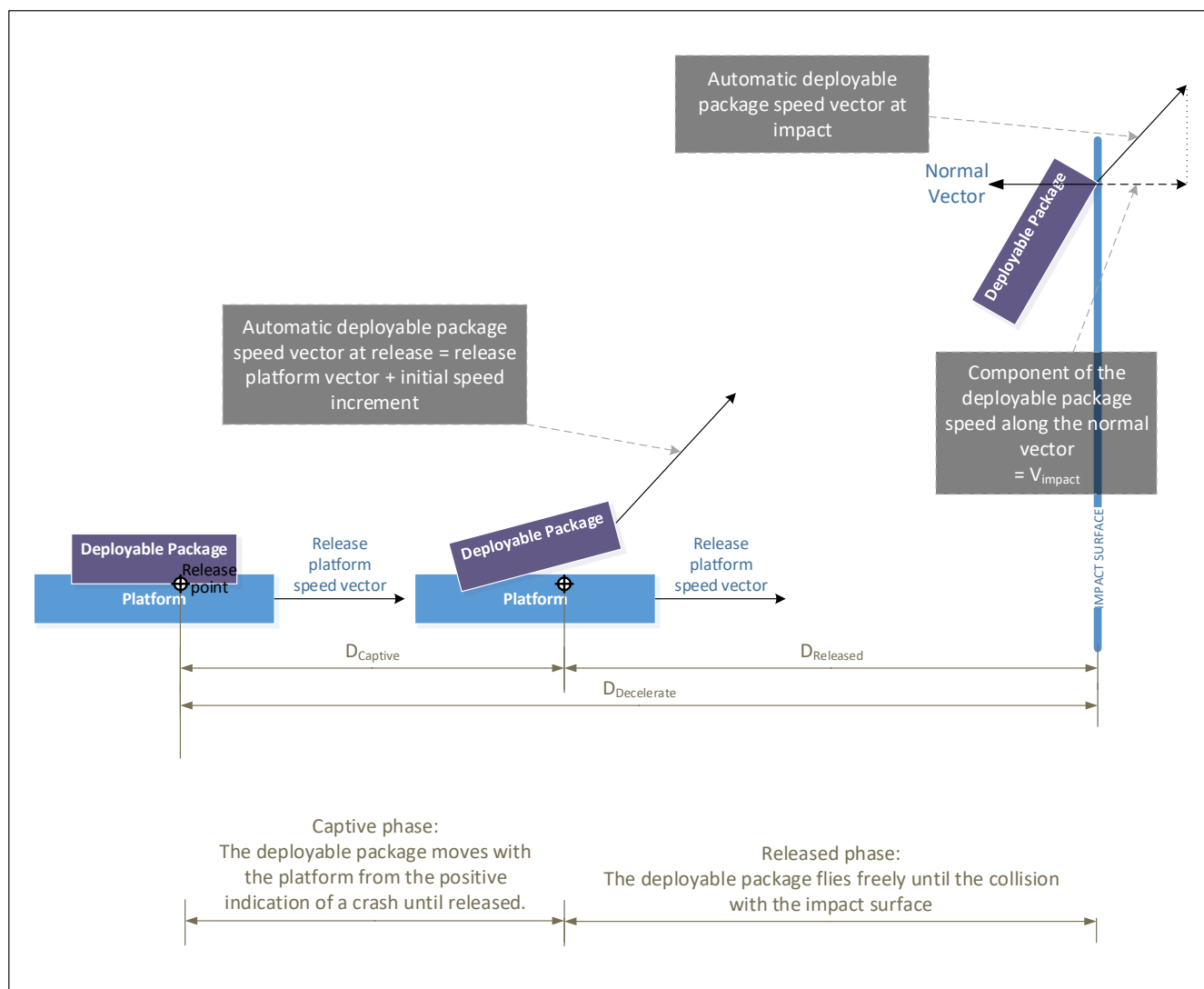


Figure 2: Sequence of the automatic deployable package release

[Amdt ETSO/16]

ETSO-2C518

ED Decision 2020/011/R

RUNWAY OVERRUN AWARENESS AND ALERTING SYSTEMS**1 Applicability**

This ETSO provides the requirements which runway overrun awareness and alerting systems that are designed and 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**

The 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**

The applicable standards are those provided in EUROCAE ED-250, Minimum Operational Performance Standards for a Runway Overrun Awareness and Alerting System, dated December 2017.

3.1.2 Environmental Standard

See CS-ETSO, [Subpart A](#), paragraph 2.1.

3.1.3 Software

See CS-ETSO, [Subpart A](#), paragraph 2.2.

3.1.4 Airborne Electronic Hardware

See CS-ETSO, [Subpart A](#), paragraph 2.3.

3.2 Specific**3.2.1 Failure Condition Classification**

See CS-ETSO, [Subpart A](#), paragraph 2.4.

4 Marking**4.1 General**

See CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

None.

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/16]

ETSO-2C519

ED Decision 2020/011/R

EMERGENCY BREATHING SYSTEMS (EBSs)**1 Applicability**

This ETSO provides the requirements which emergency breathing systems (EBSs) category A, for operations to or from helidecks that are located in hostile sea areas, that are designed and manufactured on or after the date of this ETSO, must meet in order to be identified with the applicable ETSO marking.

EBS category A means EBSs that are capable of being successfully deployed underwater.

2 Procedures**2.1 General**

The 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**

The applicable standards are those provided in AeroSpace and Defence Industries Association of Europe — Standardization (ASD-STAN) document EN4856:2018, dated December 2018.

3.1.2 Environmental Standard

See CS-ETSO, [Subpart A](#), paragraph 2.1.

3.1.3 Software

None.

3.1.4 Airborne Electronic Hardware

None.

3.2 Specific**3.2.1 Failure Condition Classification**

None.

4 Marking**4.1 General**

See CS-ETSO, [Subpart A](#), paragraph 1.2.

4.2 Specific

The specific marking requirements are detailed in ASD-STAN document EN4856:2018.

5 Availability of Referenced Documents

See CS-ETSO, [Subpart A](#), paragraph 3.

[Amdt ETSO/16]