**ETSO-C85a**
**Date : 24.10.03**

# European Aviation Safety Agency

## European Technical Standard Order

Subject: SURVIVOR LOCATOR LIGHTS

**1 - Applicability**
This ETSO gives the requirements which survivor locator lights that are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

**2 - Procedures**
2.1 - General
Applicable procedures are detailed in CS-ETSO Subpart A.
2.2 - Specific
None.

**3 - Technical Conditions**
3.1 - Basic
3.1.1 - Minimum Performance Standard
Standards set forth in Society of Automotive Engineers, Inc. (SAE), Aerospace Standard (AS) 4492, „Survivor Locator Lights," dated January 1995.
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-C88a
Date : 24.10.03

**European Aviation Safety Agency**

# European Technical Standard Order

**Subject:** AUTOMATIC PRESSURE ALTITUDE REPORTING CODE GENERATING EQUIPMENT

**1 - Applicability**

This ETSO gives the requirements which automatic pressure altitude reporting code generating 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 Society of Automotive Engineers, Inc ., (SAE) Aerospace Standard (AS) 8003 „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

3.2 - 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-C89**
**Date : 24.10.03**

# European Aviation Safety Agency

# European Technical Standard Order

**Subject:** OXYGEN REGULATORS, DEMAND

**1 - Applicability**

This ETSO gives the requirements which oxygen regulators, demand 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 „Oxygen Regulators, Demand".

3.1.2 - Environmental Standard

As specified in Federal Aviation Administration Standard „Oxygen Regulators, Demand".

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**

**Oxygen Regulators, Demand**

### 1. Purpose.

This standard contains minimum performance and quality control standards for the manufacture of demand oxygen system regulators.

### 2. Classification.

The term „demand regulator“ includes all of the following classes of regulators:

(a) Straight demand regulators designed to deliver oxygen only.

(b) Diluter demand regulators designed to deliver a mixture of oxygen and air, and oxygen only.

(c) Straight demand pressure breathing regulators (straight demand regulations designed to deliver undiluted oxygen under positive pressure).

(d) Diluter demand pressure breathing regulators (diluter demand regulators designed to deliver undiluted oxygen under positive pressure).

### 3. Design and Construction of Regulator.

To be eligible for approval under a TSO authorization, the regulator must possess the following design and construction characteristics:

3.1 Demand regulators designed to be mounted directly upon an oxygen mask or the crewmember's clothing or safety harness must include a flexible oxygen supply tube connecting the regulator inlet with the oxygen supply system.

3.2 Demand regulators must be constructed of materials that -

(a) Do not contaminate air or oxygen;

(b) Are not adversely affected by continuous contact with oxygen; and

(c) Are at least flame resistant.

3.3 (a) Demand regulators must be equipped with a 200 mesh screen, or equivalent filter, at the oxygen inlet port or at the oxygen inlet hose assembly.

(b) Diluter demand and diluter demand pressure regulators must be equipped with screening or not more than 100 mesh and not less than 30 mesh, or equivalent filter, at the air inlet port.

3.4 Diluter demand and diluter demand pressure breathing regulators must be provided with a means for manually selecting a delivery of undiluted oxygen. If the selection means is controlled by a rotating handle or lever, the travel must be limited to not more than 180 degrees from the „normal oxygen“ position to the „l00 percent oxygen“ position. The dilution position of the selection means must be designated „normal oxygen“ and the nondilution position must be designated „l00 percent oxygen.“ The selection means must be such that it will not assume a position between the „normal oxygen“ and „l00 percent oxygen“ positions.

3.5 Straight demand pressure breathing and diluter demand pressure breathing regulations must be designed to provide oxygen at a positive pressure of 11.0 ±3.0 inches $H_2O$ to determine mask peripheral leakage at altitudes below which positive pressures are hereinafter required. The means of obtaining this pressure must be by push, pull, or toggle control appropriately marked to indicate its purpose.

3.6 Diluter demand and diluter demand pressure breathing regulators must incorporate means to indicate when oxygen is and is not flowing from the regulator outlet. This requirement does not apply to mask mounted regulators.

### 4. Performance.

Two demand regulators of each class for which approval is sought must be shown to comply with the minimum performance standards set forth in paragraphs 4.1 through 4.10 in any position which the regulators can be mounted. Tests must be conducted at ambient atmospheric conditions of approximately 30 inches Hg and 70°F., except as otherwise specified. It is permissible to correct gas flow rates and pressures to STPD conditions by computation.

4.1 (a) Demand regulators must supply the following oxygen or oxygen-air flows at not more than the specified outlet pressures. These characteristics must be displayed at all altitudes, with the oxygen supply pressure at al1 values within the design inlet pressure range, and with the diluter valve open and closed.

| FLOW, LPM, ATPD: | MAXIMUM OUTLET SUCTION PRESSURE, INCHES OF WATER |
|---|---|
| 20 | 0.40 |
| 70 | .80 |
| 100 | 1.00 |

(b) Demand regulators must not flow more than 0.01 LPM, STPD, when the outlet suction pressure is reduced to 0 inches of $H_2O$ under the conditions specified in subparagraph (a) of this paragraph.

4.2 (a) Diluter demand and diluter demand pressure breathing regulators must supply the following percentages of cylinder oxygen, by volume, at the specified atmospheric pressures and corresponding altitudes. These oxygen percentages must be delivered at regulator outlet gas flows of 20, 70, and 100 LPM ATPD, with the oxygen supply pressure at all values within the design inlet pressure range.

| | | Minimum percent oxygen | |
|---|---|---|---|
| Pressure mm Hg | Altitude feet | Diluter demand | Diluter demand pressure breathing |
| 760 | 0 | 0 | 40 |
| 632.4 | 5,000 | 0 | 40 |
| 522.8 | 10,000 | 6 | 40 |
| 429.1 | 15,000 | 14 | 40 |
| 349.5 | 20,000 | 25 | 40 |
| 282.4 | 25,000 | 40 | 40 |
| 226.1 | 30,000 | 61 | 61 |
| 179.3 | 35,000 | 91 | 91 |
| 178.5 | 35,100 | 98 | 98 |
| 141.2 | 40,000 | 98 | 98 |
| 111.1 | 45,000 | Not applicable | 98 |

(b) Straight demand and straight demand pressure breathing regulators must supply not less than 98 percent oxygen, by volume, at all altitudes under the conditions specified in subparagraph (a) of this paragraph.

4.3 (a) Diluter demand pressure breathing regulators with the diluter valve open or closed, and straight demand pressure breathing regulators, must provide positive breathing pressure at a flow of 20 LPM, ATPD, in accordance with the following table:

| ALTITUDE 1,000 FEET | POSITIVE OUTLET PRESSURE-$H_2O$ |
|---|---|
| 30 | 0.0 +3.5 -0.0 |
| 40 | 2.5 ±2.5 |
| 42 | 6.0 ±1.5 |
| 44 | 10.0 ±1.0 |
| 45 | 12.0 ±1.0 |

(b) The positive pressure at 100 LPM, ATPD, must not increase by more than 0.8 inches $H_2O$ from the positive pressure at 20 LPN, ATPD.

(c) The positive pressure at 0.01 LPM, ATPD, must not decrease by more than 0.8 inches $H_2O$ from the positive pressure at 20 LPM, ATPD.

4.4 (a) The inward leakage of air through the regulator at sea level must not exceed 0.1 LPM, STPD, with a suction pressure of 1.0 inches $H_2O$ applied to the outlet port, the oxygen supply inlet port sealed, and the diluter valve closed.

(b) The outward leakage of air through the regulator at sea level must not exceed 0.1 LPM, STPD, with a positive pressure of 12 inches $H_2O$ applied to the outlet port, the oxygen supply inlet port sealed, and the diluter valve open and closed.

(c) The regulator outlet leakage must not exceed 0.01 LPM, STPD, with the regulator outlet port open and any oxygen supply pressure within the specified operating range applied at the regulator inlet port.

(d) The regulator overall leakage must not exceed 0.01 LPM, STPD, with the regulator outlet port sealed and the regulator inlet port pressurized to a value equal to the maximum specified oxygen supply pressure.

4.5 (a) Straight demand pressure breathing and diluter demand pressure breathing regulators must comply with paragraphs 4.1 through 4.4 after a negative pressure of 29 inches $H_2O$ and a positive pressure of 24 inches $H_2O$ are applied to the outlet port for a period of 2 minutes. The diluter valve and the regulator inlet port must be closed during these two pressure tests.

(b) Straight demand and diluter demand regulators must comply with paragraphs 4.1 through 4.4 after a negative pressure of 29 inches $H_2O$ and a positive pressure of 12 inches $H_2O$ are applied to the outlet port for a period of 2 minutes. The diluter valve and the regulator inlet port must be closed during these two pressure tests.

(c) Demand regulators must comply with paragraphs 4.1 through 4.4 after a positive pressure of 1.5 times the maximum oxygen supply pressure is applied to the inlet port, or to the inlet of the oxygen supply in the case of mask mounted regulators, for a period of 2 minutes. The positive pressure must be applied rapidly to simulate rapid opening of the supply valve. The diluter valve must be closed and the outlet port must be sealed during the test.

4.6 (a) Straight demand and diluter demand regulators must comply with paragraphs 4.1 through 4.4 after being subjected to a change in pressure from not less than 12.2 p.s.i.a. to not less than 2.7 p.s.i.a. in not more than one second.

(b) Straight demand pressure breathing and diluter demand pressure breathing regulators must comply with paragraphs 4.1 through 4.4 after beings subjected to a change in pressure from not less than 12.2 p.s.i.a. to not less than 2.1 p.s.i.a. in not more than one second.

4.7 Demand regulators must comply with paragraphs 4.1 through 4.4 under each condition specified in subparagraphs (a) through (d) of this paragraph with the maximum oxygen supply pressure applied to the regulator inlet:

(a) At a temperature of approximately 70° F. after being stored at a temperature of not less than 100° F. for 12 hours

(b) At a temperature of 70° F. after being stored at a temperature of not warmer than -67° F. for 2 hours.

(c) At a temperature of not less than 130° F.

(d) At a temperature of not more than 20° F.

4.8 Demand regulators must comply with paragraphs 4.1 through 4.4 after being subjected to the tests specified in sub-paragraphs (a) and (b) of this paragraph.

(a) The regulator must be vibrated along each mutually perpendicular axis for one hour (three hours total), at a frequency of 5 to 500 cps, and at a double amplitude of 0.036 inches or an acceleration of 2 „g," whichever occurs first. Mask mounted regulators need not be subjected to this vibration test.

(b) The regulator must be subjected to an endurance test of a total of 250,000 breathing cycles.

The peak breathing rate must be 30 LPM, STPD, for 200,000 cycles, and 70 LPM, STPD, for 50,000 cycles. The dilution valve must be open during one half of the 200,000 cycles and one half of the 50,000 cycles, and it must be closed during the remaining cycles. During the nonflow portion of the 30 LPM and 70 LPM breathing cycles, a back pressure of 0.5 and 1.0 inches $H_2O$, respectively, must be applied to the regulator outlet.

4.9 Demand regulators must be free of vibration, flutter, or chatter that will prevent compliance with paragraphs 4.1 through 4.3 when subjected to the following simulated flow conditions:

| Cycles | Peak flow per cycle LPM, STPD | Back pressure at 0 LPM, inches $H_2O$ | Diluter valve |
|---|---|---|---|
| 5,000 | 100 | 1.5 | Closed |
| 5,000 | 100 | 1.5 | Open |

4.10 Demand regulators, when subject to accelerations up to 3 „g“ in any position, must comply with paragraph 4.1(a) except that the specified suction pressures may be exceeded by not more than 0.6 inches $H_2O$.

### 5. Maximum Environmental (Cabin) Altitude.

The minimum pressure to which the regulator has been shown to comply under paragraph 4.6(a) or (b) of this standard determines the maximum environmental (cabin) altitude of the regulator, except that the maximum environmental (cabin) altitude must not exceed the value shown in the following table:

| CLASS | FEET |
|---|---|
| Straight or diluter-demand -------------------- | 40,000 |
| Pressure demand ------------------------------- | 45,000 |

### 6. Quality Control.

6.1 Each production regulator must be shown to comply with paragraphs 4.1 through 4.4.

6.2 One regulator selected at random from each lot must be shown to comply with paragraphs 4.1 through 4.10. The lot size may be selected by the applicant subject to the approval of the Federal Aviation Administration on the basis of evaluation of the quality control system of the applicant (see FAR, §37.5).

### 7. Abbreviations and Definitions.

| | |
|---|---|
| LPM | Liters per minute. |
| STPD. | Standard temperature and pressure, dry (0° C., 760 mm Hg., $PH_20=0$). |
| ATPD | Ambient temperature and pressure, dry (70° F.; ambient pressure; $PH_20=0$). |
| c.p.s. | Cycles per second. |
| p.s.i.a. | Pounds per square inch absolute. |
| g | Acceleration of gravity, 32 feet/second/second. |

ETSO-C90c
Date : 24.10.03

# European Aviation Safety Agency

# European Technical Standard Order

**Subject:** CARGO PALLETS, NETS AND CONTAINERS

**1 - Applicability**

This ETSO gives the requirements which cargo unit load 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 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, as amended and supplemented by this ETSO:

In lieu of NAS 3610, paragraph 3.5, paragraph 4 of this ETSO provides the marking 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, the following information shall be legibly and permanently marked on the major components:

- The identification of the article in the code system set out in paragraph 1.2.1 of NAS 3610, Revision 8.
- If the article is not omnidirectional, the words „FORWARD", „AFT", and „SIDE" must be conspicuously and appropriately placed.
- The burning rate determined for the article under NAS 3610, paragraph 3.7, Revision 8.

4.2 - Specific

None.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

**ETSO-C92c**
**Date : 24.10.03**

# European Aviation Safety Agency

# European Technical Standard Order

Subject: 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 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-C95**
**Date : 24.10.03**

**European**
**Aviation**
**Safety**
**Agency**

# European Technical Standard Order

**Subject:** 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) 8018 „Mach Meters“, dated October 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-C96a
Date : 24.10.03

**European Aviation Safety Agency**

# European Technical Standard Order

**Subject:** ANTICOLLISION LIGHT SYSTEMS

**1 - Applicability**

This ETSO gives the requirements which new models of anticollision light 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

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) 8017A „Minimum Performance Standard for Anticollision Light Systems“, dated January 30, 1986.

In addition to Chapter 3 General Standard of AS-8017A, all materials used except small parts (such as knobs, fasteners, seals, grommets and small electrical parts) that would not contribute significantly to the propagation of a fire, must be self-extinguishing when tested in accordance with applicable requirements of CS 25.869(a)(4) and Appx F at Change 14.

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-C97**
**Date : 24.10.03**

# European Aviation Safety Agency

# European Technical Standard Order

**Subject:** LITHIUM SULFUR DIOXIDE BATTERIES

**1 - Applicability**

This ETSO gives the requirements which lithium sulfur dioxide batteries 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 attached Federal Aviation Administration Standard „Lithium Sulfur Dioxide Batteries.

3.1.2 - Environmental Standard

As stated in the Federal Aviation Administration Standard.

3.1.3 – Computer Software

None

3.2 - Specific

None

**4 - Marking**

4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2; in addition to the markings required by this paragraph, each battery must be marked with the month and year of manufacture and the date on which it must be replaced. In addition, each cell and battery must be marked with the phrase: „$LiSO_2$ BATTERY CAUTION: PRESSURIZED CONTENTS; NEVER RECHARGE, SHORT CIRCUIT OR EXPOSE TO TEMPERATURES ABOVE 70°C".

4.2 - Specific

None.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

**FEDERAL AVIATION ADMINISTRATION STANDARD**
**LITHIUM SULFUR DIOXIDE BATTERIES**

**1.0 General.**

1.1 This standard applies to cells and batteries of a nonaguous $LiSO_2$ type. Batteries may consist of a single cell, cells connected in series or in parallel, or both, to obtain the necessary output for the intended application. Definitions for terms used in this standard are set forth in Appendix A of this standard.

**2.0 Minimum Performance Under Standard Conditions.**

2.1 *Cell Isolation.* Cells in a multi-cell battery or packs of more than one battery may not be connected in parallel unless provisions are made to prevent individual cells from being exposed to charging voltages greater than the cell's nominal open circuit voltage. When five or more cells are reconnected in series, each cell must be protected by a shunt diode.

2.2 *Cell connection.* All electrical connections between cells in a battery must be soldered, welded, or brazed in accordance with an approved process specification.

2.3 *Safety Relief*

2.3.1 *Safety Relief Mechanism.* Each cell used in the battery must incorporate a safety relief mechanism that will relieve internal pressure at a value and rate which will preclude venting violently, or explosion. The safety relief must operate at a temperature below 130°C in accordance with §T-l of Appendix B of this standard.

2.3.2 *Discharge Materials.* If a cell vents during any of the tests required by §§3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, and 3.10, the data requirements of §37.209 (d)(2) must be met.

2.4 *Encapsulation.* Encapsulation of the battery may not be used unless it is demonstrated, in accordance with §§T-2 and T-3 of Appendix B of this standard, that encapsulation does not inhibit the functioning of the safety release mechanism or cause the battery to overheat.

2.5 *Seal.* Each cell must be hermetically sealed. The seal must be tested in accordance with §T-4 of Appendix B of this standard. The difference in the weight of the cell before and after this test must be less than 50 milligrams.

2.6 *Current Limiting Protection.* The battery must have a current limiting device. This device must limit the current that can be drawn from the battery to a value lower than that which it was subjected to in §§3.8, 3.9, and 3.10 of this standard, and must be an integral part of the battery and not susceptible to shorting or any failure causing the device to be bypassed.

2.7 *Useful life.* The useful life of the battery may not exceed 4 years unless demonstrated. The useful life must be demonstrated at a minimum temperature of 40°C. When tested at periods in excess of 4 years, the battery must retain 80 percent of its ampere-hour capacity as demonstrated in accordance with §T-5 of Appendix B of this standard, and meet the requirements of §§2.9, 2.10, and all sections under §3.0 of this standard.

2.8 *Examination of Product.* When required, subsequent to a test required by §3.0 of this standard, each of the cells must be visually examined. Special emphasis must be placed on observing signs of leakage and overall appearance of the safety relief feature.

2.9 *Open Circuit Voltage.* Open circuit voltage of the battery must be measured and be within ±5 percent of its specified value, and the polarity must be correct.

2.10 *Capacity.* The variation in battery capacity may not vary more than ±10 percent when compared with the capacity as demonstrated in accordance with §T-6 of Appendix B of this standard.

**3.0 Minimum Performance Standards Under Environmental Conditions.**

3.1 *General.* Except as provided in §§3.6, 3.7, 3.8, 3.9, and 3.10 of this standard, the design of the battery must be such that subsequent to the application of the specified tests, no condition may exist that would be detrimental to the continued performance of the battery. The same battery must be used for the following tests and these tests must be performed in this order: §§3.2, 3.3, 3.4, 3.5, and 3.6.

3.2 *Shock Test.* The battery must be secured to a shock table by a mechanically secure device. The shock test machine must be capable of imparting to the battery a series of calibrated shock impulses. The shock impulse waveform must be a half sine pulse whose distortion at any point on the waveform may not be greater than 15 percent of the peak value of the shock pulse. For the purposes of this section, duration of the shock impulse is specified with reference to the zero points of the half sine wave, and shock forces are specified in terms of peak amplitude G values. The shock impulse must be measured using a calibrated accelerometer and associated instrumentation having a 3dB response over a range of at least 5 to 250 Hertz. The shock test must be conducted as follows:

(a) Mount the battery on the shock test machine in such a manner that it can be subjected to shock impulses in each direction successively along the three mutually orthogonal axes of the battery.

(b) Apply a l00G shock impulse of duration 23±2 milliseconds to the battery in a direction coincident with the first orthogonal axis.

(c) Reset the activation mechanism.

(d) Repeat the procedures specified in §§3-2(b) and (c) applying an impulse shock in the remaining 5 axial directions.

3.3 *Vibration Test.* The battery must be secured to a vibration table so that sinusoidal vibratory motion can be exerted parallel to one of the three major orthogonal axes of the battery. The battery must be affixed to the vibration table by the means specified by the equipment manufacturer for service installations. The vibration frequency must be varied at a rate not to exceed 1.0 octave per minute. The vibration must exhibit a constant total excursion of

2.5mm from 5 Hertz to the frequency at which an acceleration of 7G (zero-to-peak) is reached and from that frequency to 2,000 Hertz at a constant acceleration of 7G. Continue the vibration for a minimum of 1 hour. The tests described in this section must be repeated with the vibratory motion being applied along each of the other major axes of the cell.

3.4 *Temperature Cycle Test.* The battery must be subjected to a temperature not greater than -65°C for a period of 20 hours. The test chamber temperature must then be raised at a rate of 5° ± 2°C per minute to a temperature of at least +71°C, and this temperature maintained for a period of 4 hours. After the 4-hour period, the test chamber temperature must be returned, at a rate of 5° ± 2°C per minute, to a temperature not greater than -65°C, and this temperature must be maintained for 20 hours. The temperature cycle must be repeated 5 times. After completion of the temperature cycle, the battery must be returned to room temperature.

3.5 *Altitude Test.* The battery must be stored for 6 hours at an atmospheric pressure corresponding to an altitude of 15,000 meters at 24° ± 4°C. The pressure must then be increased to sea level pressure.

3.6 *Immersion Test – Salt Water.* After being immersed in salt water (3.5 ± 0.1 percent sodium chloride), with terminals insulated, for a period of at least 15 hours, the battery must be tested for leakage in accordance with §T-4 of Appendix B of this standard, and meet the requirements of §§2.8, 2.9, and 2.10 of this standard.

3.7 *High Temperature Battery Capacity Test.* After 30 days of storage at a temperature of 71° ± 2°C, the battery must be returned to room temperature and must be capable of delivering 90 percent of its rated capacity with no more than ± 10 percent variation in cell capacity. The test must be performed in accordance with §T-6 of Appendix B of this standard.

3.8 *Reverse Discharge Test.* The cell must not be fuse protected. The cell must be discharged in series with an external power supply at a current equal to that of the rating of the fuse used in the battery at a temperature of 24° ± 3°C. The discharge must be maintained for a time corresponding to the rated capacity of the battery that the cell will be used in or until the cell has vented. The cell condition must be monitored for 24 hours after termination of reverse discharge.

3.9 *Forced Discharge Test.* The battery must be operative and have the fuse removed for purposes of this test. The test must be conducted on (1) a battery that has not been discharged, and (2) a battery that has completed the high temperature battery capacity test of §3.7. A battery must be forced discharged at a current load equal to that of the rating of the fuse used in the battery at a temperature not greater than -20°C isothermally for a period corresponding to the rated capacity of the battery. The battery condition must be monitored for 24 hours after the rated capacity of the battery has been reached.

3.10 *Total discharge Test.* The battery must be operative and have the fuse removed for purposes of this test. The battery must be discharged at a temperature of 24° ± 3°C at a current level equal to that of the rating of the fuse used in the battery for a period corresponding to the rated capacity of the battery. Immediately thereafter, a direct short must be placed and left across the battery terminals. The battery condition must be monitored for 24 hours after the direct short has been applied.

## APPENDIX A

The following definitions of terms are applicable to the Lithium Sulfur Dioxide Batteries Standard.

**1.0 Definitions.** For purposes of this standard, the following definitions apply:

„Battery“ means an electrical energy source made up of one or more cells, arranged in electrical series or parallel or in a series-parallel combinations.

„Capacity“ means the total amount of electrical energy, measured in ampere hours, that a cell can generate.

„Cell“ means an individual electrochemical unit.

„Hermetic sealed cells“ means that each cell is sealed in such a manner that over the useful life of the cell there is no loss of gaseous or solid material from the cell.

„Venting“ means the controlled release of the electrolyte or any chemical reactant products, or both, from a cell.

„Venting violently“ means the rapid uncontrolled discharge of either harmful gases or liquid, or both, from a cell accompanied by the generation of heat.

## APPENDIX B

The following test procedures give details for demonstrating that the requirements of the Lithium Sulfur Dioxide Batteries Standard are met.

**T-l Verification of safety relief mechanism (§2.3.1).**

*Equipment Required:*

Calibrated iron constantan thermocouple, accurate to within ± l° C.

Electric heating tape.

Recording potentiometer.

*Test Procedure:*

a. Attach a thermocouple to the surface of the metal cell case under test and attach the thermocouple to the recording potentiometer.

b. Wrap the circumference of the cell, not covering the ends, with the electric heating tape.

c. Increase the temperature of the cell at a linear rate of 10° ± 3°C per minute.

d. Continuously monitor the temperature of the cell case and record the temperature at which the cell(s) vent.

**T-2 Operation of safety relief in encapsulating material (§2.4).**

a. Expose the battery to environmental conditions which will cause the battery to vent (e.g., high temperature or direct short with the current limiting device inoperative).

b. The operation of the safety relief mechanisms and the encapsulation should be observed.

c. Determine that the encapsulation material does not cause the battery to vent in a manner different than that of the cell tested in §T-1.

**T-3 Heat transfer properties of the encapsulation material (§2.4).**

*Equipment Required:*

Two calibrated thermocouples accurate to ± 1° C.
Two recording potentiometers.

*Test Procedure:*

a. Attach a load to an encapsulated battery with the fuse removed which will draw a current equal to the ampere rating of the fuse used in the battery.

b. Attach a load to an identical battery without encapsulation and with the fuse removed which will draw a current equal to the ampere rating of the fuse used in the battery.

c. Continuously monitor the temperature of both batteries. The room ambient temperature should be 24° ± 3° C.

d. Continue the test until the ampere hour rating of the cell is reached.

**T-4 Hermetic Seal test (§2.5).**

*Equipment Required*

Temperature controlled oven.
Scale (accurate to 1 milligram).

*Test Procedure:*

a. Weigh each cell under test.

b. Place each cell in the temperature controlled oven.

c. Raise the temperature to 71°C.

d. Maintain this temperature for 30 days.

e. Lower the temperature to ambient.

f. Remove the cells and weigh each cell.

g. Compare the weight of each cell with the weight before the test.

**T-5 Useful life (§2.7).**

*Equipment Required:*

Temperature controlled oven.

*Test Procedure:*

a Place each battery in the temperature controlled oven, seals pointed down so that the seal is covered by the electrolyte.

b. Raise the temperature to at least 40°C.

c. Maintain this temperature for 4 years plus the additional time for which useful life is desired to be demonstrated.

d. Lower the temperature and remove each battery.

e. Measure the remaining capacity of the cell in accordance with §T-6 of this Appendix.

**T-6 Battery Capacity (§2.10).**

*Equipment Required:*

Resistive load.
Data recorder.
Digital printer.
Digital voltmeter.

*Test Procedure:*

a. Attach a resistive load to the battery under test which will initially draw a current equivalent to the value of the fuse used in the battery in which the cell under test is to be used.

b. Monitor the voltage time until the end-voltage of the battery reaches 0.5 volts.

c. Calculate the cell capacity using the timed averaged voltage method. The formula for this method is

$$\overline{V} = \frac{1}{tco} \sum_{i=1}^{n-1} \frac{(V_i + V_{i+1})}{2} \left(t_{i+1} - t_i\right)$$

$$AH = \overline{V} \, \frac{tco}{R_L}$$

where:

$V$ = Time averaged voltage
tco = Elapsed discharge time to cutoff in hours
$V_i$ = Voltage at time $t_i$
$V_{i+1}$ = Voltage at time $t_{i+1}$
$t_i$ = Time in hours at which $V_i$ was measured
$t_{i+1}$ = Time in hours at which $V_{i+1}$ was measured
AH = Discharged capacity
$R_L$ = Load resistance in ohms

**ETSO-C99**
**Date : 24.10.03**

# European Aviation Safety Agency

# European Technical Standard Order

**Subject:** PROTECTIVE BREATHING EQUIPMENT

**1 - Applicability**

This ETSO gives the requirements which protective breathing 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

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) 8031 „Personal Protective Devices for Toxic and Irritating Atmospheres, Air Transport Crew Members“, dated June 1980.

3.1.2 - Environmental Standard

As given in AS 8031, Section 8.

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

(1) Each component of equipment having multiple facial sizes must be marked to indicate its relative size and whether it will seal on beards e. g. „Beards will not seal“.

(2) Each smoke goggle/oxygen mask component, full-face mask and hood must be marked to indicate the average oxygen usage rate measured during contaminant leakage testing for each combination or full-face mask.

**5 - Availability of Referenced Document**

- See CS-ETSO Subpart A paragraph 3.
- FAA report N°FAA-AM-78-41 may be obtained from the National Technical Information Service (NTIS), Springfield, VA 22161 Catalogue N°ADA064678.

ETSO-C101
Date : 24.10.03

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** 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
Date : 24.10.03

# European Aviation Safety Agency

# European Technical Standard Order

**Subject:** 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-l72 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**
**Date : 24.10.03**

# European Aviation Safety Agency

# European Technical Standard Order

**Subject:** 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**
**Date : 24.10.03**

# European Aviation Safety Agency

# European Technical Standard Order

**Subject:** 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
Date : 24.10.03

# European Aviation Safety Agency

# European Technical Standard Order

**Subject:** 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 Standard

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 - plus or minus of theoretical value of correction or equivalent of plus or minus 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 plus or minus 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 - Computer Software

See 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-C109**
**Date : 24.10.03**

**European Aviation Safety Agency**

# European Technical Standard Order

**Subject:** 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

Date : 24.10.03

# European Aviation Safety Agency

# European Technical Standard Order

**Subject:** 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-C113**
**Date : 24.10.03**

**European Aviation Safety Agency**

# European Technical Standard Order

**Subject:** AIRBORNE MULTIPURPOSE ELECTRONIC DISPLAYS

**1 - Applicability**

This ETSO gives the requirements which airborne multipurpose electronic displays 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 8034 „Airborne Multipurpose Electronic Displays“, dated December 30, 1982 as amended by this ETSO in particular, add the following information to paragraph 4.3.3 of AS 8034:

„the following depicts acceptable display colours related to their functional meaning for electronic display systems:

(a) Display feature should be colour coded as follows:

| | |
|---|---|
| Warnings | Red |
| Flight envelope and system limits | Red |
| Cautions, abnormal sources | Amber/Yellow |
| Earth | Tan/Brown |
| Scales and associated figures | White, |
| Engaged modes | Green |
| Sky | Cyan/Blue |

(b) Precipitations and turbulence areas should be coded as follows:

| | | |
|---|---|---|
| Precipitation up to 4 millimeter per hour (mm/h) | | Green |
| " | 4 -12 mm/h | Amber/Yellow |
| " | 12 -50 mm/h | Red |
| " | above 50 mm/h | Magenta |
| Turbulence | | White or Magenta |

(c)Background colour (Grey or other shade) — Background colour may be used to enhancedisplay presentation

Colours must track brightness so that chrominance and relative chrominance separation are maintained as much as possible during day-night operations.“

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-C114**
**Date : 24.10.03**

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** 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 Dl17-73, 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.

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-l 981, Colorfastness to Water.

(iii) Federal Test Method Standard 191 Method 5906.

(iv) AATCC Chart for Measuring Transference of Color.

3.1.4 – 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.
- 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.

**ETSO-C115b**
**Date : 24.10.03**

# European
# Aviation
# Safety
# Agency

# European Technical Standard Order

Subject: AIRBORNE AREA NAVIGATION EQUIPMENT USING MULTI-SENSOR INPUTS

**1 - Applicability**

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

**2 - Procedures**

2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

2.2 - Specific

None.

**3 - Technical Conditions**

3.1 - General

3.1.1 - Minimum Performance Standard

Standards set forth in EUROCAE document ED-58 (June 1988) (RTCA DO-187 (1984)).

3.1.2 - Use of Global Positioning System Sensors

EUROCAE document ED-72A, „Minimum Operational Performance Standards for Airborne Supplemental Navigation Equipment Using Global Positioning System (GPS),“ dated April 1997, and ETSO-C129a, Airborne Supplemental Navigation Equipment Using Global Positioning System (GPS), provide standards for the use of GPS sensors. These standards provide additional and, in some cases, contradictory requirements to the requirements of this ETSO. Additional operational capabilities have been authorized for aircraft equipped with ETSO-C129a compliant equipment. If the ETSO applicant wishes to manufacture equipment that is eligible for these additional operational capabilities, then the applicant must certify that the GPS sensor is compliant with ETSO-C129a. In this case the following criteria shall apply:

(i) All additional standards contained in ETSO-C129a that apply to the appropriate class (B or C) of sensor being incorporated into the multi-sensor system must be complied with in addition to the requirements of this ETSO.

(ii) The performance requirements of ETSO-C129a take precedence over this ETSO when the GPS sensor is being used for navigation. It is acceptable to revert to the criteria of this ETSO when the GPS sensor is not installed or is otherwise not available. Reversion from ETSO-C129a requirements to ETSO-C115b requirements must be continuously in the pilot's primary field of view.

(iii) If any conflict is encountered between the two ETSOs, ETSO-C129a will always take precedence over ETSO-C115b.

(iv) The requirements of ETSO-C129a that are applicable to the multi-sensor system must be demonstrated as a part of demonstrating compliance with this ETSO. All testing which would require inputs from a GPS sensor must be conducted with a sensor that has been demonstrated to meet the criteria of ETSO-C129a for the class of sensor required by the multi-sensor system being evaluated. It is acceptable to simultaneously demonstrate compliance with ETSO-C129a for the sensor and ETSO-C115b for the multi-sensor system.

3.1.3 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1.

3.1.4 - 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-C116**
**Date : 24.10.03**

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** CREWMEMBER PROTECTIVE BREATHING EQUIPMENT

**1 - Applicability**

This ETSO gives the requirements that new models of crewmember protective breathing 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.

**3 - Technical Conditions**

3.1 - General

3.1.1 - Minimum Performance Standard

Standards set forth in the attached „Federal Aviation Administration Standard for Crewmember Protective Breathing Equipment".

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.

APPENDIX 1. FEDERAL AVIATION ADMINISTRATION STANDARD PROTECTIVE BREATHING EQUIPMENT DATED

1.0 Purpose. This appendix provides minimum standards for crewmembers protective breathing equipment.

2.0 Scope. These standards apply to protective breathing equipment that provides any crewmember with the ability to locate and combat a fire within the airplane cabin or any other accessible compartment at normal cabin altitudes (up to 8000 feet equivalent).

3.0 Minimum Performance Standards.

3.1 The PBE unit must contain a supply of breathable gas (allows the use of any breathable gas instead of requiring only oxygen and does allow the use of a chemical oxygen generator).

3.2 The unit shall adequately protect any adult, within the 5th percentile female (neck size circumference 11.1 inches) and 95th percentile male (neck size circumference 16.4 inches) body dimensions (including spectacle users). Any recommendations addressing long hair and/or beards shall be included in the instructions furnished with the manufactured units.

3.3 The unit shall have a means for any crewmember to determine the serviceability of the unit in its stowed condition.

3.4 Failure of the unit to operate or to cease operation shall be readily apparent to the user.

3.5 The supply of breathable gas shall meet the applicable SAE gas standard for purity.

3.6 The unit shall not result in a hazard when stored, in use, or during an inadvertent operation.

3.7 The stowed unit shall not be adversely affected by environmental extremes. The applicable sections of RTCA DO-160C shall be used to demonstrate unit compliance.

3.8 The unit shall have a stated reliability with an appropriate confidence level to establish any shelf life, operational limit and/or maintenance interval.

3.9 The unit shall wear comfortably in use leaving both hands free. It shall not be displaced during the normal tasks of locating and combating a fire (i.e., crawling, kneeling, running actions, etc.).

3.10 The unit shall provide adequate vision capability for its intended use, including the consideration of fogging and/or condensation.

3.11 The unit must allow intelligible two-way communication, including the use of airplane interphone and megaphone. The user must be able to communicate with a user or nonuser at a distance of at least four meters. A background noise of 65db and a user communication sound level of 85db or equivalent method is recommended.

3.12 The unit shall be capable of being easily donned and activated, after gaining access to the stowed unit within 15 seconds. It must be easy to doff.

4.0 Performance Requirements. The following shall apply to the approval of any crewmember PBE design to be identified and manufactured to this TSO:

4.1 The unit shall provide the required protection for the following work load profile, at an ambient temperature of 21°C for adults within the 5th percentile female (107 lbs) and 95th percentile male (220 lbs) body weight, at sea level and 8000 feet altitude:

0 to 05 minutes at 0.33 watts per lb. body weight.
5 to 07 minutes at 0.66 watts per lb. body weight.
7 to 12 minutes at 0.50 watts per lb. body weight.
12 to 14 minutes at 0.66 watts per lb. body weight.
14 to 15 minutes at 0.33 watts per lb. body weight.

NOTE: This test is to be performed in sequence.

4.2 The mean inspiratory values shall be within the following limits:

4.2.1 The carbon dioxide concentration level at mouth/nose shall not exceed 4 percent at sea level. The concentration may increase to 5 percent at sea level for a period not to exceed 2 minutes.

4.2.2 The carbon monoxide level shall not exceed 50 ppm, time weighted average.

4.2.3 The chloride level shall not exceed 1 ppm, time weighted average.

4.3 Upon donning, the unit shall be self purging by a sufficient supply of breathable gas to ensure one complete dead volume displacement within 20 seconds of initial operation.

4.4 The unit shall protect the user against toxic fumes and smoke. The eyes, nose, and mouth must be protected to 0.05 mean contaminant protection factor during the work profile stated as item 1 of this paragraph. Aerospace Standards (AS) 8031 and 8047 (Class 1) may be used as references, as applicable. AS 8031, states that the test contaminant must be n-pentane or similar gas having a molecular weight less than 100. The use of sulphur hexafluoride ($SF_6$) is an acceptable alternative. The use of aerosols such as sodium chloride (NaC1) or corn oil are not considered acceptable as an alternative for a challenge gas. Component sensitivity to particle size and the potential to precipitate on the unit surface are considerations that make aerosols unacceptable to measure a contaminant protection factor.

4.5 The internal temperature of the unit shall not exceed 40° wet bulb at an ambient temperature of 21°C.

4.6 The internal temperature of the unit shall not exceed 50°C wet bulb. for a 2 minute exposure, at an ambient temperature of 100°C.

4.7 Breathing inspiration/expiration resistance shall not exceed ± 3 1/2 inches of water from sea level to 8000 feet altitude, as measured at the mouth.

4.8 The unit shall operate at a mean positive pressure and shall incorporate relief valve(s) to prevent overpressure of the unit.

4.9 The unit shall be designed for peak breathing flows of 250 liters per minutes (LPM) and shall be capable of 80 liter-minute volume for a 30 second period at any time throughout its operation.

NOTE:

The test protocol to establish the combined performance requirement of the work load profile and contaminant levels shall be based upon the testing of 24 persons representative of the stated population range.

5.0 Construction Requirements. The following shall apply to the approval of any subject PBE design to be identified and manufactured to this TSO:

5.1 The unit and any stowage container/case shall be constructed of materials that are flame resistant that satisfy the requirements of FAR Section 25.853 and tested in accordance with Appendix F Part I (a) through (d) Vertical Test.

5.2 Any exposed portions of the unit and stowage case shall withstand and remain functional when exposed to a radiant heat flux of 1.0 BTU/ft$^2$ per second for 60 seconds. The unit shall also protect the head and neck of the user from dripping 200°C plastic materials and withstand a 1000°C flame for 5 seconds without material penetration while operational.

NOTE:

(1) The 1.0 BTU/ft$^2$ per second for 60 seconds criteria. A radiant heat source of sufficient size to expose the stowage case containing a PBE unit and any exposed portions of the unit in a manner to obtain the stated heat flux at the case surfaces, in a typical as installed arrangement, will be acceptable.

(2) Protection from dripping 200°C plastic material may be accomplished by a number of methods. One method is to ignite a polypropylene rod and allow the drops to impinge on the various external materials, seams, transparency, etc. The drop height should be adjusted so that the drop contact temperature is at least 200°C.

(3) The 5 second 1000°C test. This test is meant to protect a crewmember wearing the PBE from an unexpected flame lick. The two main concerns are failure of the unit that would injure the wearer and any leakage of the breathable atmosphere that could produce an explosion or hazard. The test rig shall expose the unit, while operating, to a 1000°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 will need to be adjusted to obtain the required temperature. In most cases the flame plume developed will not expose the complete unit. A segment may be passed through the flame plume to obtain the 5 seconds exposure period and then rotated to the next segment and passed through the flame plume, etc., until the complete unit has been tested. A visual (i.e., videotape) record to this test might be useful documentation, in addition to the measured parameters.

5.3 The size of the PBE unit when donned shall allow the wearer to pass through any access appropriate to the airplane type for which approval is requested, to investigate and/or combat an inflight fire. As a generic standard, the wearer must be able to pass through

460X460 $mm^2$ opening.

5.4 The material and fabrication of the unit shall cause the unit to be puncture/tear resistant. See ASTM references for suggested methods.

6.0 References. The following may be helpful in developing a PBE design and/or obtaining FAA approval of the basic design, they are not of themselves FAA requirements and may differ from the TSO requirements, which take precedence:

| | |
|---|---|
| SAE AS 8047 (Class 1) | Performance Standard for Cabin Crew Portable Protective Breathing Equipment for Use During Aircraft Emergencies. |
| SAE AS 8031 | Personal Protective Devices for Toxic and Irritating Atmospheres. Air Transport Crew Member. |
| SAE AS 8010 | Aviators Breathing Oxygen Purity Standard. |
| FAA-AM-78-41 | A Study of Workload and Oxygen Consumption for Airline Cabin Crew Member During a Simulated Inflight Smoke/Fire Emergency. |
| ASTM D1149 | Accelerate Ozone Cracking of Vulcanized Rubber. |
| ASTM D624 | Rubber Property-Tear Resistance. |
| ASTM D750 | Rubber Deterioration. |
| ASTM D228 | Abrasion Resistance. |
| ASTM D1922-67 | Standard Test Method for Propagation Tear Resistance of Plastic Film and Thin Sheeting by Pendulum Method. |
| ASTM D1004-86 | Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting. |
| ASTM D2582-67 | Standard Test Method for Puncture-Propagation Tear Resistance of Plastic Film and Thin Sheeting |

**ETSO-C117a**
**Date : 24.10.03**

# European Aviation Safety Agency

# European Technical Standard Order

Subject: AIRBORNE WINDSHEAR WARNING AND ESCAPE GUIDANCE SYSTEMS (REACTIVE TYPE) FOR TRANSPORT AEROPLANES

**1 - Applicability**

This ETSO gives the requirements that airborne windshear warning and escape guidance systems (reactive type) for transport aeroplanes which are 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 windshear conditions before the phenomenon is encountered nor to systems that use atmospheric and/or other data to predict the likelihood of a windshear alert.

**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

a. Purpose and Scope.

(1) Introduction. This ETSO prescribes the minimum performance standards for airborne windshear warning and escape guidance systems for transport category aeroplanes. This document defines performance, functions, and features for systems providing windshear warning and escape guidance commands based upon sensing the aeroplane's encounter of such phenomena. Airborne windshear warning and escape guidance systems that are to be identified with ETSO identification and that are manufactured on or after the date of this ETSO must meet the minimum performance standard specified herein.

(2) Scope. This ETSO applies only to windshear warning systems which identify windshear phenomenon by sensing the encounter of conditions exceeding the threshold values contained in this ETSO. In addition to windshear warning criteria, this ETSO provides criteria applicable to systems that provide optional windshear caution alert capability. Windshear escape guidance is provided to assist the pilot in obtaining the desired flight path during such an encounter.

(3) Applicable Documents. The following documents shall form a part of this ETSO to the extent specified herein. Should conflicting requirements exist, the contents of this ETSO shall be followed.

(i) EUROCAE/RTCA Document ED-14D/DO-160D, „Environmental Conditions and Test Procedures for Airborne Equipment" change 3, dated December 2002 respectively subsequent revisions, see CS-ETSO Subpart A § 2.

(ii) EUROCAE/RTCA Document ED-12B/DO-178B, „Software Considerations in Airborne Systems and Equipment Certification," dated December 1992 respectively subsequent revisions, see CS-ETSO Subpart A § 2.

(iii) Society of Automotive Engineers, Inc. (SAE) Aerospace Recommended Practice (ARP) 4102/11, „Airborne Windshear Systems," dated July 1988.

(4) Definitions of Terms.

(i) Airborne Windshear Warning System. A device or system which uses various sensor inputs to identify the presence of windshear once the phenomena is encountered and provides the pilot with timely warning. The system may include both windshear warning and windshear 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.

(ii) Airborne Windshear Warning and Escape Guidance System. A device or system which uses various sensor inputs to identify the presence of windshear once the phenomenon is encountered and provides the pilot with timely warning and adequate flight guidance to improve the probability of recovery from the windshear encounter. This system may include both windshear warning and windshear caution alerts.

(iii) Airborne Windshear Auto Recovery System. A device or system which integrates or couples autopilot and/or autothrottle systems of the aircraft with an airborne windshear flight guidance system.

(iv) Airborne Windshear Escape Guidance System. A system which provides the crew with flight guidance information to improve the recovery probability once encountering a windshear phenomenon.

(v) Failure. The inability of a system, subsystem, unit, or part to perform within previously specified limits.

(vi) False Warning or Caution. A warning or caution which occurs when the design windshear warning or caution threshold of the system is not exceeded.

(vii) 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 aircraft because of the duration of subsequent change of the windshear magnitude.

(viii) Recovery Procedure. A vertical flight path control technique used to maximize recovery potential from an inadvertent encounter with windshear.

(ix) Severe Windshear. A windshear of such intensity and duration which would exceed the performance capability of a particular aircraft type, and likely cause inadvertent loss of control or ground contact if the pilot did not have information available from an airborne windshear warning and escape guidance system which meets the criteria of this ETSO.

(x) Windshear Caution Alert. An alert triggered by increasing performance conditions which is set at a windshear level requiring immediate crew awareness and likely subsequent corrective action.

(xi) Windshear Warning Alert. An alert triggered by decreasing performance conditions which is set at a windshear level requiring immediate corrective action by the pilot.

b. General Standards. The following general requirements shall be met by all windshear warning and escape guidance systems:

(1) Airworthiness. Design and manufacture of the airborne equipment must provide for installation so as not to impair the airworthiness of the aircraft. Material shall be of a quality which experience and/or tests have demonstrated to be suitable and dependable for use in aircraft systems. Workmanship shall be consistent with high quality aircraft electromechanical and electronic component manufacturing practices.

(2) General Performance. The equipment must 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 materials used must be self-extinguishing. One means for showing compliance with this requirement is contained in CS 25.853 and Appendix F.

(4) Operation of Controls. Controls intended for use during flight shall be designed to minimize errors, and when operated in all 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 aircraft equipment must be designed such that normal or abnormal windshear warning and escape guidance equipment operation shall 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 aircraft for proper operation, it shall be identified in a manner that will ensure 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 equipment operation. 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 displays and controls shall be readable under all cockpit ambient light conditions ranging from total darkness to reflected sunlight and arranged to facilitate equipment usage. Limitations on equipment installations to ensure display readability should be included in the installation instructions.

(11) Effects of Test. The design of the equipment shall be such that the application of the specified test procedures shall not produce a condition detrimental to the performance of the equipment except as specifically allowed.

(12) Equipment Computational Response Time. The equipment shall employ suitable update rates for computation and display of detection and guidance information.

(13) Supplemental Heating or Cooling. If supplemental heating or cooling is required by system components to ensures 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 proper system operation.

(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 must 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) Conduct of the system self-test feature must not adversely affect the performance of operation of other aircraft systems.

(iv) 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 ambiguous or erroneous guidance system mode annunciation.

(16) System Reliability.

(i) The probability of a false warning being generated within the windshear warning system or the windshear warning and escape guidance system shall be $1 \times 10^{-4}$ or less per flight hour.

(ii) The probability of an unannunciated failure of the windshear warning system or the windshear warning and escape guidance system shall be $1 \times 10^{-5}$ or less per flight hour (reserved).

c. Equipment Functional Requirements - Standard Conditions. The equipment shall meet the following functional requirements.

(1) Mode Annunciation. The windshear escape guidance display mode of operation shall be annunciated to the pilot upon escape guidance activation during a windshear encounter and upon reversion to a different flight guidance mode.

(2) Malfunction/Failure Indications. The equipment shall indicate:

(i) Inadequate or absence of primary power.

(ii) Equipment failures.

(iii) Inadequate or invalid warning or guidance displays or output signals.

(iv) Inadequate or invalid sensor signals or sources.

These malfunction/failure indications shall occur independently of any operator action. 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) Windshear Caution Alert. If the equipment includes a windshear caution alert:

(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 windshear condition no longer exists (not less than a minimum of 3 seconds) or a windshear warning alert occurs.

(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) Windshear Warning Alert.

(i) A windshear warning alert shall provide an annunciation of decreasing performance shear (downdraft, decreasing headwind, or increasing tailwind) with a magnitude equal or greater than 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 labeled „windshear“ dedicated for this purpose. The visual alert should remain at least until the threshold windshear condition no longer exists or a minimum of 3 seconds, whichever is greater. An aural alert shall be provided that annunciates „windshear“ for three aural cycles. The aural alert need not be repeated for subsequent windshear warning alerts within the same mode of operation.

(iii) Gust conditions shall not cause a nuisance warning alert. Turbulence shall not cause more than one nuisance warning alert per 250 hours (or 3,000 flight cycles based on 1 hour/flight) of system operation.

(5) Operating Altitude Range. The system shall be designed to function from at least 50 feet above ground level (AGL) to at least 1000 feet AGL.

(6) Windshear Escape Guidance. Flight guidance algorithms shall incorporate the following design considerations:

(i) At the point of system warning threshold, the available energy of the aeroplane must be properly managed through a representative number of windfield conditions. These conditions must take into account significant shear components in both the horizontal and vertical axes, individually and in combination.

(ii) The flight path guidance commands must be suitable to the dynamic response of aircraft of the type on which the system is intended for installation.

(iii) If the magnitude of the shear components are such as to overcome the performance capability of the aeroplane, guidance commands must be such that ground impact will occur in the absence of ability to produce additional lift, absence of excessive kinetic energy, and without putting the aircraft 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 flight path and pitch attitude should be limited to an angle-of-attack equivalent to onset of stall warning or maximum pitch command of 27º, whichever is less.

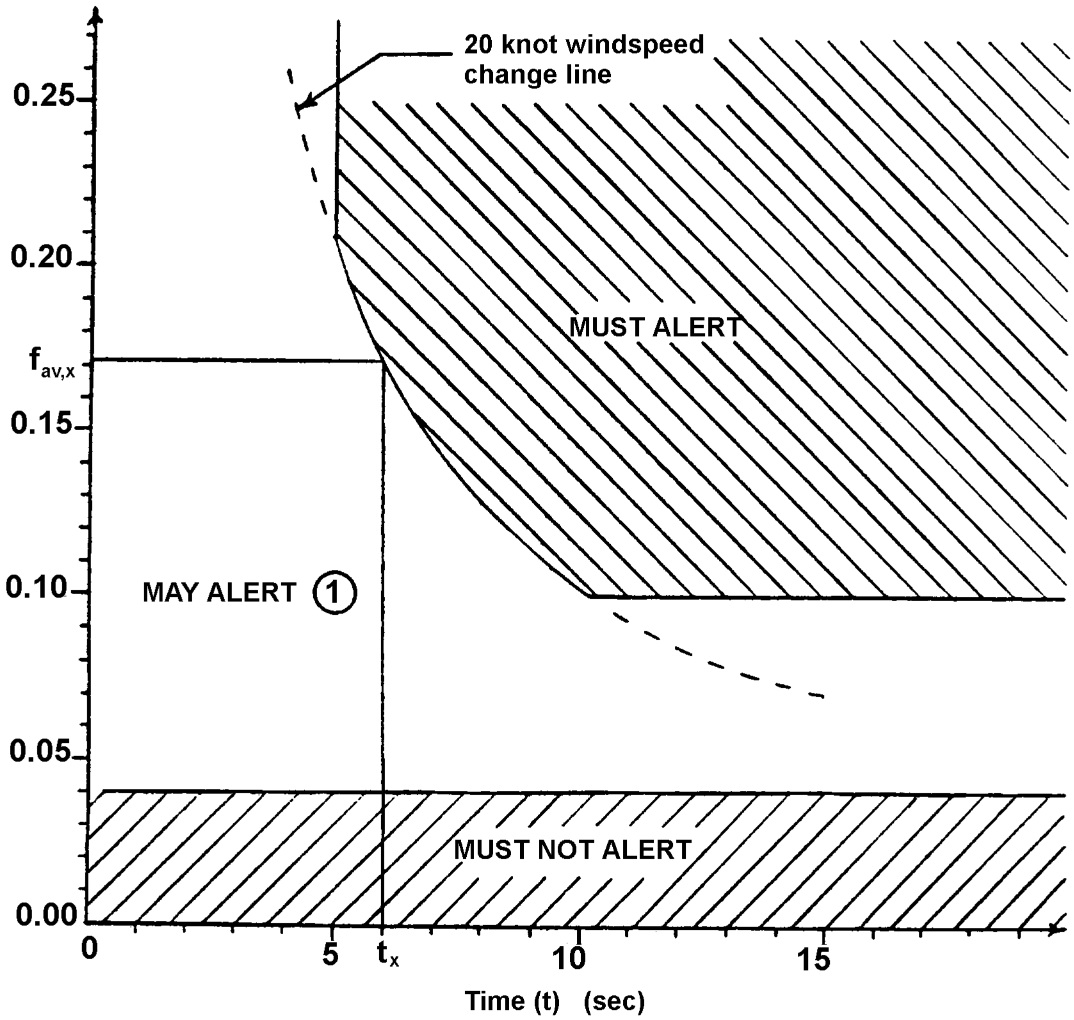
(vi) Flight guidance commands and any auto recovery mode (if included) may be automatically activated concurrent with or after the windshear warning alert occurs or may be manually selected. If manual selection is utilized, it shall only be via the takeoff-go around (TOGA) switch or equivalent means (i.e., a function of throttle position, other engine parameters, etc.).

(vii) Manual deselection of windshear flight guidance and any auto recovery mode (if included) shall be possible by means other than the TOGA switches.

(viii) Systems incorporating automatic reversion of flight guidance commands from windshear escape guidance to another flight guidance mode should provide a smooth transition between modes. Flight guidance commands shall not be removed from the flight guidance display until either manually deselected or until the aircraft, following exit of the warning conditions, has maintained a positive rate of climb and speed above 1.3 $V_{s1}$ 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 windspeed change, bounded as shown; applies to horizontal, vertical, and combination shear intensities)

$$= \frac{\int_{o}^{t_x} f(t)dt}{t_x} \quad \text{whereby } f(t) = \text{instantaneous shear intensity at time } t$$

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

d. Equipment Performance - Environmental Conditions. The environmental tests and performance requirements described in this subparagraph are intended to provide a laboratory means of determining the overall performance characteristics of the equipment under conditions representative of those that may be encountered in actual operations. Some of the environmental tests contained in this subparagraph need not be performed unless the manufacturer wishes to qualify the equipment for that particular environmental condition. These tests are identified by the phrase „When Required.“ If the manufacturer wishes to qualify the equipment to these additional environmental conditions, then these „When Required“ tests shall be performed.

Unless otherwise specified, the test procedures applicable to a determination of equipment performance under environmental test conditions are set forth in EUROCAE/RTCA Document ED-14D/DO-160D, „Environmental Conditions and Test Procedures for Airborne Equipment.“ Performance tests which must be made after subjection to test environments may be conducted after exposure to several environmental conditions.

(1) Temperature and Altitude Tests (ED-14D/DO-160D, Section 4.0). EUROCAE/RTCA Document ED-14D/DO-160D contains several temperature and altitude test procedures which are specified according to the category for which the equipment will be used. These categories are included in paragraph 4.2 of ED-14D/DO-160D. The following subparagraphs contain the applicable test conditions specified in Section 4.0 of ED-14D/DO-160D.

(i) Low Operating Temperature Test. The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 4.5.1, and the following requirements of this standard shall be met:

(a) Section 3.1.1(c)(1) - Mode Annunciation
(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(c) Section 3.1.1(c)(3) - Windshear Caution Alert
(d) Section 3.1.1(c)(4) - Windshear Warning Alert
(e) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(ii) High Short-Time Operating Temperature Test. The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 4.5.2, and the following requirements of this standard shall be met:

(a) Section 3.1.1(c)(1) - Mode Annunciation
(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(c) Section 3.1.1(c)(3) - Windshear Caution Alert
(d) Section 3.1.1(c)(4) - Windshear Warning Alert
(e) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(iii) High Operating Temperature Test. The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 4.5.3, and the following requirements of this standard shall be met:

(a) Section 3.1.1(c)(1) - Mode Annunciation
(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(c) Section 3.1.1(c)(3) - Windshear Caution Alert
(d) Section 3.1.1(c)(4) - Windshear Warning Alert
(e) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(iv) In-Flight Loss of Cooling Test (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 4.5.4, and the following requirements of this standard shall be met:

(a) Section 3.1.1(c)(1) - Mode Annunciation
(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(c) Section 3.1.1(c)(3) - Windshear Caution Alert
(d) Section 3.1.1(c)(4) - Windshear Warning Alert
(e) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(v) Altitude Test. The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 4.6.1, and the following requirements of this standard shall be met:

(a) Section 3.1.1(c)(1) - Mode Annunciation
(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(c) Section 3.1.1(c)(3) - Windshear Caution Alert
(d) Section 3.1.1(c)(4) - Windshear Warning Alert
(e) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(vi) Decompression Test (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 4.6.2, and the following requirements of this standard shall be met:

(a) Section 3.1.1(c)(1) - Mode Annunciation
(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(c) Section 3.1.1(c)(3) - Windshear Caution Alert
(d) Section 3.1.1(c)(4) - Windshear Warning Alert
(e) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(vii) Overpressure Test (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 4.6.3, and the following requirements of this standard shall be met:

(a) Section 3.1.1(c)(1) - Mode Annunciation
(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(c) Section 3.1.1(c)(3) - Windshear Caution Alert
(d) Section 3.1.1(c)(4) - Windshear Warning Alert
(e) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(2) Temperature Variation Test (ED-14D/DO-160D, Section 5.0). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 5.0, and the following requirements of this standard shall be met:

(i) Section 3.1.1(c)(1) - Mode Annunciation
(ii) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(iii) Section 3.1.1(c)(3) - Windshear Caution Alert
(iv) Section 3.1.1(c)(4) - Windshear Warning Alert
(v) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(3) Humidity Test (ED-14D/DO-160D, Section 6.0). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 6.0, and the following requirements of this standard shall be met:

(i) Section 3.1.1(c)(1) - Mode Annunciation
(ii) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(iii) Section 3.1.1(c)(3) - Windshear Caution Alert
(iv) Section 3.1.1(c)(4) - Windshear Warning Alert
(v) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(4) Shock tests (ED-14D/DO-160D, Section 7.0).

(i) Operational Shocks. The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 7.2, and the following requirements of this standard shall be met:

(a) Section 3.1.1(c)(1) - Mode Annunciation
(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(c) Section 3.1.1(c)(3) - Windshear Caution Alert
(d) Section 3.1.1(c)(4) - Windshear Warning Alert
(e) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(ii) Crash Safety Shocks. The application of the crash safety shock tests may result in damage to the equipment under test. Therefore, this test may be conducted after the other tests have been competed. In this case, paragraph 3.1.1 (b)(11), „Effects of Test," of this standard does not apply. The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 7.3, and shall meet the requirements specified therein.

(5) Vibration Test (ED-14D/DO-160D, Section 8.0). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 8.0, and the following requirements of this standard shall be met:

(i) Section 3.1.1(c)(1) - Mode Annunciation
(ii) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(iii) Section 3.1.1(c)(3) - Windshear Caution Alert
(iv) Section 3.1.1(c)(4) - Windshear Warning Alert

(v) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(6) Explosion Proofness Test (ED-14D/DO-160D, Section 9.0) (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D , Section 9.0. During these tests, the equipment shall not cause detonation of the explosive mixture within the test chamber.

(7) Waterproofness Tests (ED-14D/DO-160D , Section 10.0).

(i) Drip Proof Test (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 10.3.1, and the following requirements of this standard shall be met:

(a) Section 3.1.1(c)(1) - Mode Annunciation
(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(c) Section 3.1.1(c)(3) - Windshear Caution Alert
(d) Section 3.1.1(c)(4) - Windshear Warning Alert
(e) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(ii) Spray Proof Test (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 10.3.2, and the following requirements of this standard shall be met:

NOTE: This test shall be conducted with the spray directed perpendicular to the most vulnerable area(s) as determined by the equipment manufacturer.

(a) Section 3.1.1(c)(1) - Mode Annunciation
(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(c) Section 3.1.1(c)(3) - Windshear Caution Alert
(d) Section 3.1.1(c)(4) - Windshear Warning Alert
(e) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(iii) Continuous Stream Proof Test (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 10.3.3, and the following requirements of this standard shall be met:

(a) Section 3.1.1(c)(1) - Mode Annunciation
(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(c) Section 3.1.1(c)(3) - Windshear Caution Alert
(d) Section 3.1.1(c)(4) - Windshear Warning Alert
(e) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(8) Fluids Susceptibility Tests (ED-14D/DO-160D, Section 11.0).

(i) Spray Test (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 11.4.1, and the following requirements of this standard shall be met:

At the end of the 24-hour exposure period, the equipment shall operate at a level of performance that indicates that no significant failures of components or circuitry have occurred. Following the two-hour operational period at ambient temperature, after the 160-hour exposure period at elevated temperature, the following requirements of this standard shall be met:

(a) Section 3.1.1(c)(1) - Mode Annunciation
(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(c) Section 3.1.1(c)(3) - Windshear Caution Alert
(d) Section 3.1.1(c)(4) - Windshear Warning Alert
(e) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(ii) Immersion Test (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 11.4.2, and the following requirements of this standard shall be met:

At the end of the 24-hour immersion period specified in ED-14D/DO-160D, paragraph 11.4.2, the equipment shall operate at a level of performance that indicates that no significant failures of components or circuitry have occurred. Following the two-hour operational period at ambient temperature, after the 160-hour exposure period at elevated temperature, the following requirements of this standard shall be met:

(a) Section 3.1.1(c)(1) - Mode Annunciation
(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(c) Section 3.1.1(c)(3) - Windshear Caution Alert
(d) Section 3.1.1(c)(4) - Windshear Warning Alert
(e) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(9) Sand and Dust Test (ED-14D/DO-160D, Section 12.0) (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 12.0, and the following requirements of this standard shall be met:

(i) Section 3.1.1(c)(1) - Mode Annunciation
(ii) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(iii) Section 3.1.1(c)(3) - Windshear Caution Alert
(iv) Section 3.1.1(c)(4) - Windshear Warning Alert
(v) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(10) Fungus Resistance Test (ED-14D/DO-160D, Section 13.0) (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 13.0, and the following requirements of this standard shall be met:

(i) Section 3.1.1(c)(1) - Mode Annunciation
(ii) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(iii) Section 3.1.1(c)(3) - Windshear Caution Alert
(iv) Section 3.1.1(c)(4) - Windshear Warning Alert
(v) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(11) Salt Spray Test (ED-14D/DO-160D, Section 14.0) (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 14.0, and the following requirements of this standard shall be met:

(i) Section 3.1.1(c)(1) - Mode Annunciation
(ii) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(iii) Section 3.1.1(c)(3) - Windshear Caution Alert
(iv) Section 3.1.1(c)(4) - Windshear Warning Alert
(v) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(12) Magnetic Effect Test (ED-14D/DO-160D, Section 15.0). The equipment shall be subject to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 15.0, and the equipment shall meet the requirements of the appropriate instrument or equipment class specified therein.

(13) Power Input Tests (ED-14D/DO-160D, Section 16.0).

(i) Normal Operating Conditions. The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraphs 16.5.1 and 16.5.2, as appropriate, and the following requirements of this standard shall be met:

(a) Section 3.1.1(c)(1) - Mode Annunciation
(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(c) Section 3.1.1(c)(3) - Windshear Caution Alert
(d) Section 3.1.1(c)(4) - Windshear Warning Alert
(e) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(ii) Abnormal Operating Conditions. The application of the low voltage conditions (DC) (Category B equipment) test may result in damage to the equipment under test. Therefore, this test may be conducted after the other tests have been completed. Section 3.1.1(b)(11), „Effects of Test,“ does not apply. The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraphs 16.5.3 and 16.5.4, as appropriate, and the following requirements of this standard shall be met:

(a) Section 3.1.1(c)(1) - Mode Annunciation
(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(c) Section 3.1.1(c)(3) - Windshear Caution Alert
(d) Section 3.1.1(c)(4) - Windshear Warning Alert
(e) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(14) Voltage Spike Conducted Test (ED-14D/DO-160D, Section 17.0). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 17.0, and the following requirements of this standard shall be met:

(a) Section 3.1.1(c)(1) - Mode Annunciation
(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(c) Section 3.1.1(c)(3) - Windshear Caution Alert
(d) Section 3.1.1(c)(4) - Windshear Warning Alert
(e) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(15) Audio Frequency Conducted Susceptibility Test (ED-14D/DO-160D, Section 18.0). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 18.0, and the following requirements of this standard shall be met:

(i) Section 3.1.1(c)(1) - Mode Annunciation
(ii) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(iii) Section 3.1.1(c)(3) - Windshear Caution Alert
(iv) Section 3.1.1(c)(4) - Windshear Warning Alert
(v) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(16) Induced Signal Susceptibility Test (ED-14D/DO-160D, Section 19.0). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 19.0, and the following requirements of this standard shall be met:

(i) Section 3.1.1(c)(1) - Mode Annunciation
(ii) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(iii) Section 3.1.1(c)(3) - Windshear Caution Alert

(iv) Section 3.1.1(c)(4) - Windshear Warning Alert
(v) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(17) Radio Frequency Susceptibility Test (Radiated and Conducted) (ED-14D/DO-160D, Section 20.0). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 20.0, and the following requirements of this standard shall be met:

(i) Section 3.1.1(c)(1) - Mode Annunciation
(ii) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(iii) Section 3.1.1(c)(3) - Windshear Caution Alert
(iv) Section 3.1.1(c)(4) - Windshear Warning Alert
(v) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(18) Emission of Radio Frequency Energy Test (ED-14D/DO-160D, Section 21.0). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 21.0, and the requirements specified therein shall be met.

(19) Lightning Induced Transient Susceptibility (ED-14D/DO-160D, Section 22.0). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 22.0, and the requirements specified therein shall be met:

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

e. 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 tests shall be conducted with the power input voltage adjusted to design voltage ±2 percent. 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 designed for operation from an AC power source of essentially constant frequency (e.g., 400 Hz), the input frequency shall be adjusted to design frequency ±2 percent.

(b) In the case of equipment designed for operation from an AC power source of variable frequency (e.g., 300 to 1000 Hz), unless otherwise specified, test shall be conducted with the input frequency adjusted to within 5 percent of a selected frequency and within the range for which the equipment is designed.

(iii) Windfield Models. Unless otherwise specified, the windfield models used for tests shall be those specified in appendix 1 of this ETSO.

(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 conduct of the tests to prevent the introduction of errors resulting 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 tests shall be conducted under conditions of ambient room temperature, pressure, and humidity. However, the room temperature shall be not lower than 10° C.

(vii) Warm-up Period. Unless otherwise specified, all tests shall be conducted after the manufacturer's specified warm-up period.

(viii) Connected Loads. Unless otherwise specified, all 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 modes of operation that allow different combinations of sensor inputs to show that it meets both functional and accuracy criteria.

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

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

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

The test equipment signal sources shall provide the appropriate signal format for input to the specific system under test without contributing to the error values being measured. Tests need only be done once unless otherwise indicated.

The scenarios established for testing windshear warning and escape guidance systems represent realistic operating environments to properly evaluate such systems. The windfield models contained in appendix 1 of this ETSO should be used to evaluate the performance of the windshear warning and escape guidance system. The manufacturer may propose different windfield models provided it is shown that they represent conditions at least as severe as those contained in this ETSO.

(3) Test Setup. Simulator tests shall be used to demonstrate the performance capability of the windshear warning and escape guidance equipment. A suitable equipment interface shall be provided for recording relevant parameters necessary to evaluate the particular system under test. The aircraft simulator shall be capable of appropriate dynamic modeling of a representative aircraft and of the windfield and turbulence conditions contained in appendices 1 and 2 of this ETSO or other windfield/turbulence models found acceptable by the Administrator.

(4) Functional Performance (paragraphs (c)(1) through (c)(6)). Each of the functional capabilities identified in paragraphs (c)(1) through (c)(6) shall be demonstrated with the windshear warning and escape guidance equipment powered. These capabilities shall be evaluated either by inspection or in conjunction with the tests described in paragraphs (e)(5) through (e)(11).

(5) Mode Annunciation (paragraph (c)(1)). With the equipment operating, verify the windshear escape guidance display mode of operation is annunciated to the pilot upon escape guidance activation and upon reversion to a different flight guidance mode.

(6) Malfunction/Failure Indications (paragraph (c)(2)). Configure the equipment for simulation tests as defined in paragraph (e)(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) Windshear Caution Alert (paragraph (c)(3)). For equipment incorporating a windshear caution alert function, accomplish the following tests:

(i) Configure the equipment for simulation test as defined in paragraph (e)(3). Subject the equipment to acceleration waveform values meeting 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) (sec) | Result |
|---|---|---|
| 0.02 | 20 | no alert |
| 0.04 | 20 | no alert |
| 0.105 | 10 | alert within 10 sec |
| 1.049/t | t | alert within t sec (2) |
| 0.21 | 5 | alert within 5 sec |
| =0.270 | 5 | alert within 5 sec |

Notes: (1) The average shear intensity which must 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 percent 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. 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) t = 6, 7, 8, 9

The test conditions specified above shall be repeated 5 times. A different waveform for $f_{av,x}$ will be utilized for each of the 5 runs. An appropriate alert (or no alert) must be generated for each test condition.

Verify the system displays or provides an appropriate output for display of an amber caution annunciation dedicated for this purpose. Verify the visual caution display (or output) remains at least until the threshold windshear condition no longer exists or a minimum of 3 seconds (whichever is greater), or until a windshear warning occurs.

(ii) Subject the equipment to windspeeds defined by the Dryden turbulence model contained in appendix 2. The system shall be exposed to these conditions for a minimum of 50 hours (or 600 flight cycles) at each altitude specified in appendix 2 for a minimum total test duration of 250 hours (or 3,000 flight cycles based on 1 hour/flight cycle). No more than one nuisance caution shall be generated during this test.

(iii) Subject the equipment to windspeeds defined by the discrete gust rejection model contained in appendix 2. No alert shall be generated as a result of this test.

(8) Windshear Warning Alert (paragraph (c)(4)).

(i) Configure the equipment for simulation tests as defined in paragraph (e)(3). Subject the equipment to acceleration waveform values meeting the following conditions (reference figure 2). The system shall generate an appropriate warning 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) (sec) | Result |
|---|---|---|
| 0.02 | 20 | no alert |
| 0.04 | 20 | no alert |
| 0.105 | 10 | alert within 10 sec |
| 1.049/t | t | alert within t sec (2) |
| 0.21 | 5 | alert within 5 sec |
| =0.270 | 5 | alert within 5 sec |

Notes: (1) The average shear intensity which must 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 percent 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. 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) t = 6, 7, 8, 9

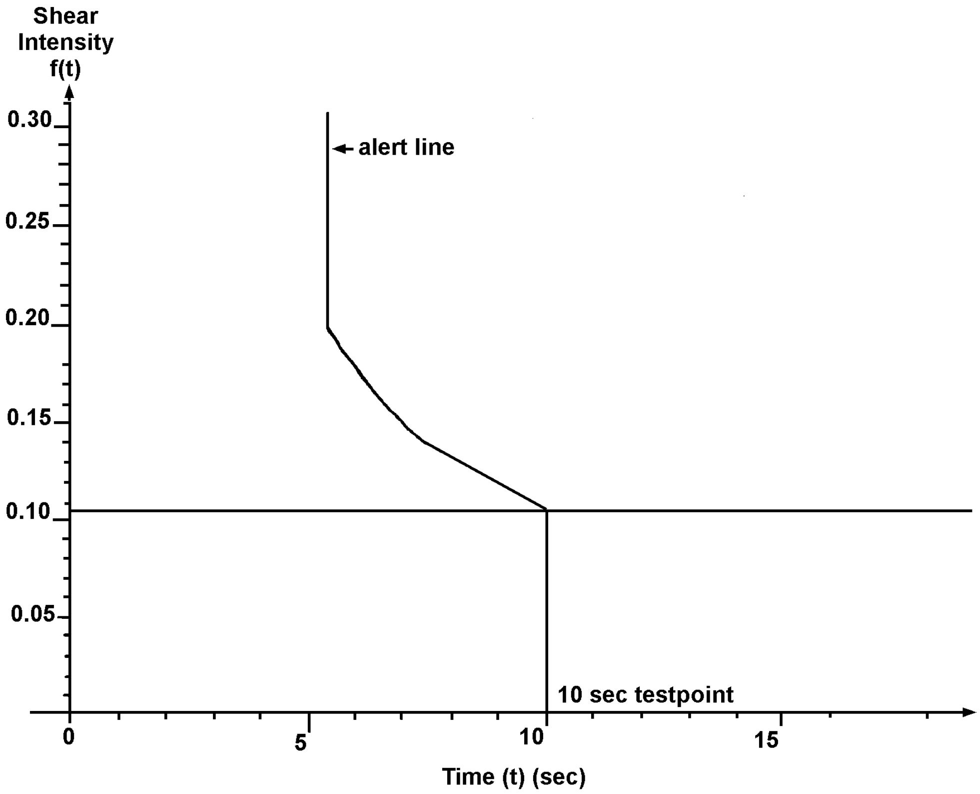
The test conditions specified above shall be repeated 5 times. A different waveform for $f_{av,x}$ will be utilized for each of the 5 runs. An appropriate alert (or no alert) must be generated for each test condition.

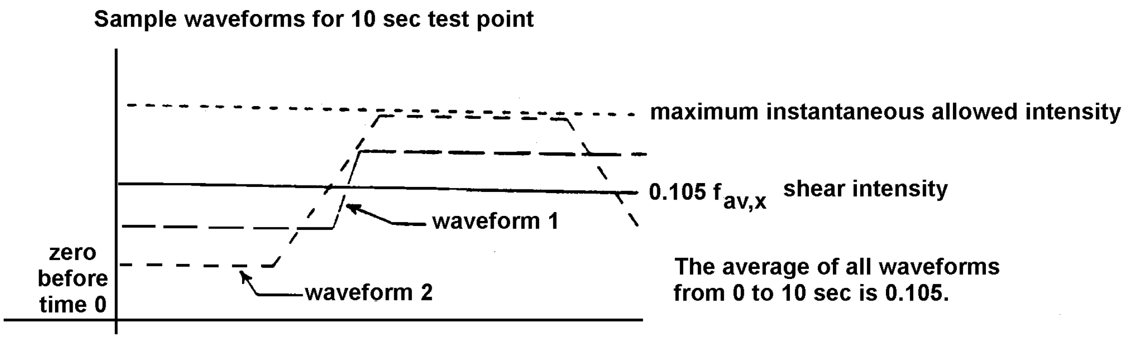
Verify the system displays or provides an appropriate output for display of a red warning annunciation labeled „windshear“ dedicated for this purpose. Verify the visual warning display (or output) remains until the threshold windshear condition no longer exists or a minimum of 3 seconds, whichever is greater. Verify an aural alert is provided that annunciates „windshear“ for three aural cycles.

(ii) Subject the equipment to windspeeds defined by the Dryden turbulence model contained in appendix 2. The system shall be exposed to these conditions for a minimum of 50 hours (or 600 flight cycles) at each altitude specified in appendix 2 for a minimum total test duration of 250 hours (or 3,000 flight cycles based on 1 hour/flight cycle). No more than one nuisance warning shall be generated during this test

FIGURE 2

WINDSHEAR ALERT TEST




(iii) Subject the equipment to windspeeds defined by the discrete gust rejection model contained in appendix 2. No alert shall be generated as a result of this test.

(9) Operating Altitude Range (paragraph (c)(5)). Configure the equipment for simulation tests as defined in paragraph (e)(3). Simulate a takeoff to an altitude of at least 1500 feet AGL. Verify the windshear warning and escape guidance system is operational from at least 50 feet AGL to at least 1000 feet AGL. Simulate an approach to landing from 1500 feet AGL to touchdown. Verify the windshear warning and escape guidance system is operational from at least 1000 feet AGL to at least 50 feet AGL.

(10) Windshear Escape Guidance (paragraph (c)(6)). Configure the equipment for simulation tests as defined in paragraph (e)(3). Subject the equipment to each of the windfield conditions contained in appendix 1 for each operating mode (takeoff, approach, landing, etc.) 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.

(i) Verify the flight path guidance commands manage the available energy of the aircraft to achieve the desired trajectory through the shear encounter. These tests shall be performed with vertical only, horizontal only, and combination vertical and horizontal shear conditions.

(a) For the takeoff case, verify the flight guidance commands produce a trajectory that provides a resultant flight path 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 onset of stall warning and then reducing pitch attitude to remain at the onset of stall warning until exiting the shear condition. Evidence of a significant decrement (considered over the entire spectrum of test cases) below the flight path provided by the fixed pitch method that results from use of the guidance commands provided by the system must be adequately substantiated.

(b) For the approach/landing case, verify the flight guidance commands produce a trajectory that provides a resultant flight path at least as good (when considered over the entire spectrum of test cases) as that obtained by establishing maximum available thrust and a 15° pitch attitude (at an approximate rate of 1.5° per second) until onset of stall warning and then reducing pitch attitude to remain at the onset of stall warning until exiting the shear condition. Evidence of a significant decrement (considered over the entire spectrum of test cases) below the flight path provided by the fixed pitch method that results from use of the guidance commands provided by the system must be adequately substantiated.

(c) For shear conditions exceeding the available performance capability of the aircraft, verify the flight guidance commands result in ground impact in the absence of ability to produce additional lift, absence of excessive kinetic energy, and without putting the aircraft into a stalled condition.

(ii) Verify the flight guidance command outputs are capable of display on associated flight displays. Interface specifications shall be verified and determined to be appropriate for the systems identified in the equipment installation instructions.

(iii) Verify that pitch attitude commands do not result in an angle-of-attack exceeding the onset of stall warning or a maximum pitch command of 27°, whichever is less.

(iv) For systems incorporating manual activation of recovery flight guidance commands, verify the system is activated only by the TOGA switches (or equivalent means). For systems providing automatic activation of recovery guidance, verify the system is activated concurrent with the windshear warning alert.

(v) Verify that windshear recovery guidance commands and any automatic recovery mode can be deselected by a means other than the TOGA switches.

(vi) For systems incorporating automatic reversion of flight guidance commands from windshear escape guidance to another flight guidance mode, verify that the transition between flight guidance modes provides smooth guidance information.

(vii) Verify flight guidance commands are not removed from the flight guidance display until either manually deselected or until the aircraft, following exit of the warning conditions, has maintained a positive rate of climb and speed above 1.3 $V_{s1}$ for at least 30 seconds.

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..In addition, the software for windshear warning and escape guidance functions must be verified and validated to at least Level C. An installation safety analysis for a particular aircraft installation should be accomplished to determine if software must be verified and validated to the more stringent Level B requirements.

**4 - Marking**

4.1 - General

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

4.2 - Specific

None.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

**APPENDIX 1**

This appendix contains data that defines the windfield models to be used in conducting the tests specified in paragraph (e)(10) of this TSO. This material was developed by the National Aeronautics And Space Administration (NASA), reference NASA Technical Memorandum 100632.

The downburst model parameters below provide the variables to be used to obtain the representative test conditions: (1)(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 TASS model.

(2) For the takeoff case, the downburst center is positioned at the point the aircraft lifts off the runway for all test cases.

(3) For the approach/landing case, the downburst center is positioned as stated. The test is begun with the aircraft at an initial altitude of 1500 feet on a 3° glideslope (touchdown point approximately 29000 feet away). Distance from starting point indicates where the center of the downburst shaft is located relative to the starting point. The number in parenthesis next to it indicates the relative distance of the microburst center from the touchdown point (not the end of the runway). A negative number indicates that the microburst center 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 aircraft 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 form the downburst center. 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 down draft radius, depth of outflow, and altitude of maximum outflow. In use, a microburst can be modeled 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 windshear environment has been recognized as a serious problem. Studies of aircraft trajectories through downbursts show that specific guidance strategies are needed for aircraft 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 use of numerical models impossible on any except very large capacity computers.

Bray [ref. 1] developed a method for analytic modeling of windshear conditions in flight simulators, and applied his method in modeling 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 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 takeoff were developed [ref. 2]. 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 [fig. 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. It was recognized 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 maneuvers and additional takeoff 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 center) (ft) |
| TASS | Terminal Area Simulation System |
| u | velocity in r-direction (or x-direction) (kts) |
| v | velocity in y-direction (kts) |
| w | velocity in z-direction (kts) |
| $w_{max}$ | magnitude of maximum vertical velocity (kts) |
| $u_{max}$ | magnitude of maximum horizontal velocity (kts) |
| x | horizontal (runway) distance, aeroplane to downburst center (ft) |
| y | horizontal (side) distance, aeroplane to downburst center (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) |
| $\lambda$ | scaling factor ($s^{-1}$) |

DEVELOPMENT OF VELOCITY EQUATIONS

Beginning with the full set of Euler and mass continuity equations, some simplifying assumptions about the down burst flow conditions were made. Effects of viscosity were parameterized 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

$$\nabla \cdot v = 0. \tag{1}$$

Written out in full, equation 2 is

$$\frac{\partial u}{\partial r} + \frac{\partial w}{\partial z} + \frac{u}{r} = 0\,. \tag{2}$$

This equation is satisfied by solutions of the form

$$w = g\left(r^2\right)q(z) \tag{3a}$$

$$u = \frac{f\left(r^2\right)}{r}\,p(z) \tag{3b}$$

provided that

$$f'\left(r^2\right) = \frac{\lambda}{2}\,g\left(r^2\right) \tag{4a}$$

$$q'(z) = -\lambda p(z). \tag{4b}$$

Note that $f'\left(r^2\right) = \dfrac{\partial f\left(r^2\right)}{\partial r^2}$. 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 weather model TASS (Terminal Area Simulation System) [ref. 3,4]. The TASS model is based on data from the Joint Airport Weather Studies (JAWS) [ref. 5], and provides a three-dimensional velocity field, frozen in time, for given locations of an aeroplane within the shear [ref. 6]. 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. 7]. Specific points of interest are the maximum horizontal velocity (located 100 - 200 meters 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.

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 decay exponentially at increasing radius.

A pair of shaping functions that gave velocity profiles matching 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:

$$f\left(r^2\right) = \frac{\lambda R^2}{2}\left[1 - e^{-(r/R)^2}\right]$$

$$q(z) = -\lambda\left\{\varepsilon\left(e^{-z/\varepsilon} - 1\right) - z*\left(e^{-z/z*} - 1\right)\right\}.$$

Figures 4 and 5 show plots of these shaping functions.

Combining the functions as in equation 3, the horizontal and vertical velocities are expressed as

$$u = \frac{\lambda R^2}{2r}\left[1 - e^{-(r/R)^2}\right]\left(e^{-z/z*} - e^{-z/\varepsilon}\right) \qquad (5)$$

$$w = -\lambda e^{-(r/R)^2}\left[\varepsilon\left(e^{-z/\varepsilon} - 1\right) - z*\left(e^{-z/z*} - 1\right)\right]. \qquad (6)$$

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“ behavior, 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 where 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

$$\frac{z_m}{z*} = \frac{1}{(z*/\varepsilon) - 1} 1n\left(z*/\varepsilon\right).$$

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 $w_{max} = \lambda z* \left(e^{-(z_h/z*)} - 0.92\right)$.

A ratio of maximum outflow and downflow velocities can be formed

$$\frac{u_m}{w_m} = \frac{0.2357R}{z* \left(e^{-(z_h/z*)} - 0.92\right).}$$

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 resulting in:

$$\lambda = \frac{w_m}{z* \left(e^{-(z_h/z*)} - 0.92\right)} = \frac{u_m}{0.2357R.}$$

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 the Appendix.

## DISCUSSION AND RESULTS

Vertical and horizontal velocity profiles for u and w are shown in figures 6 and 7. Four profiles are shown for each component. The horizontal wind profiles in figure 6 were taken at the radios 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 nondimensionalized 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.

Different shears can be modeled by specifying four parameters, and the location of downburst center relative to the aeroplane flying through it. The four parameters are: 1) a characteristic horizontal dimension; 2) maximum wind velocity; 3) altitude of maximum outflow; and 4) depth of outflow. The characteristic horizontal dimension specified is the radius of the downdraft column, noting that this is about 89 percent of the radius of peak outflow. The maximum wind velocity can be either horizontal or vertical.

## CONCLUDING REMARKS

The analytic micorburst 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 downflow and outflow (in the radial direction) are also characterized 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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APPENDIX

Define intermediate variables to simplify written equations:

$e_r = e^{-(r/R)^2}$

$e_e = e^{-(h/\varepsilon)}$

$e_z = e^{-(h/z^*)}$

$e_d = e_z - e_e$

$e_c = z^*(1 - e_z) - \varepsilon(1 - e_e)$

Horizontal and Vertical Velocities

$$W_X = \frac{\lambda R^2}{2r^2}(1 - e_r)e_d x_{ad}$$

$$W_y = \frac{\lambda R^2}{2r^2}(1 - e_r)e_d y_{ad}$$

$$W_h = -\lambda e_r e_c$$

Partial Derivatives

$$\frac{\partial w_x}{\partial x} = \frac{\lambda R^2 e_d}{2r^2}\left[e_r\left(\frac{2x_{ad}{}^2}{R^2} + \frac{2x_{ad}{}^2}{r^2} - 1\right) - \frac{2x_{ad}{}^2}{r^2} + 1\right]$$

$$\frac{\partial w_x}{\partial y} = \frac{\lambda R^2 x_{ad} y_{ad} e_d}{r^2}\left[e_r\left(\frac{1}{R^2} + \frac{1}{r^2}\right) - \frac{1}{r^2}\right]$$

$$\frac{\partial w_x}{\partial h} = \frac{\lambda R^2 x_{ad}}{2r^2}\left(1 - e_r\right)\left[\frac{e_e}{\varepsilon} - \frac{e_z}{z^*}\right]$$

$$\frac{\partial w_y}{\partial x} = \frac{\lambda R^2 x_{ad} y_{ad} e_d}{r^2}\left[e_r\left(\frac{1}{R^2} + \frac{1}{r^2}\right) - \frac{1}{r^2}\right]$$

$$\frac{\partial w_y}{\partial y} = \frac{\lambda R^2 e_d}{2r^2}\left[e_r\left(\frac{2y_{ad}{}^2}{R^2} + \frac{2y_{ad}{}^2}{r^2} - 1\right) - \frac{2y_{ad}{}^2}{r^2} + 1\right]$$

$$\frac{\partial w_y}{\partial h} = \frac{\lambda R^2 y_{ad}}{2r^2}\left(1 - e_r\right)\left[\frac{e_e}{\varepsilon} - \frac{e_z}{z^*}\right]$$

$$\frac{\partial w_h}{\partial x} = \frac{2\lambda x_{ad} e_r e_c}{R^2}$$

$$\frac{\partial w_h}{\partial y} = \frac{2\lambda y_{ad} e_r e_c}{R^2}$$

$$\frac{\partial w_h}{\partial h} = -\lambda e_r e_d$$

Other Relationships

From TASS $\quad \frac{z_m}{z*} = 0.22 \quad \frac{z*}{\varepsilon} = 12.5$

Maximums $\quad w_{x\ max} = 0.2357\lambda R$

$w_{y\ max} = w_{x\ max}$

$w_{h\ max} = \lambda z*(e^{-(z_h/z*)} - 0.92)$ .

( $\lambda$ is determined from the above relationships)

$$\frac{w_{x_{max}}}{w_{h_{max}}} = \frac{0.2357R}{z*\left(e^{-z_h/z*} - 0.92\right)}$$

Variable List

$z*$ = altitude where $w_x$ is half the value of $w_{x\ max}$ (ft)
$\varepsilon$ = characteristic height of boundary layer effects (ft)
$z_h$ = depth of outflow (ft)
$z_m$ = altitude of maximum outflow (ft)
$\lambda$ = 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

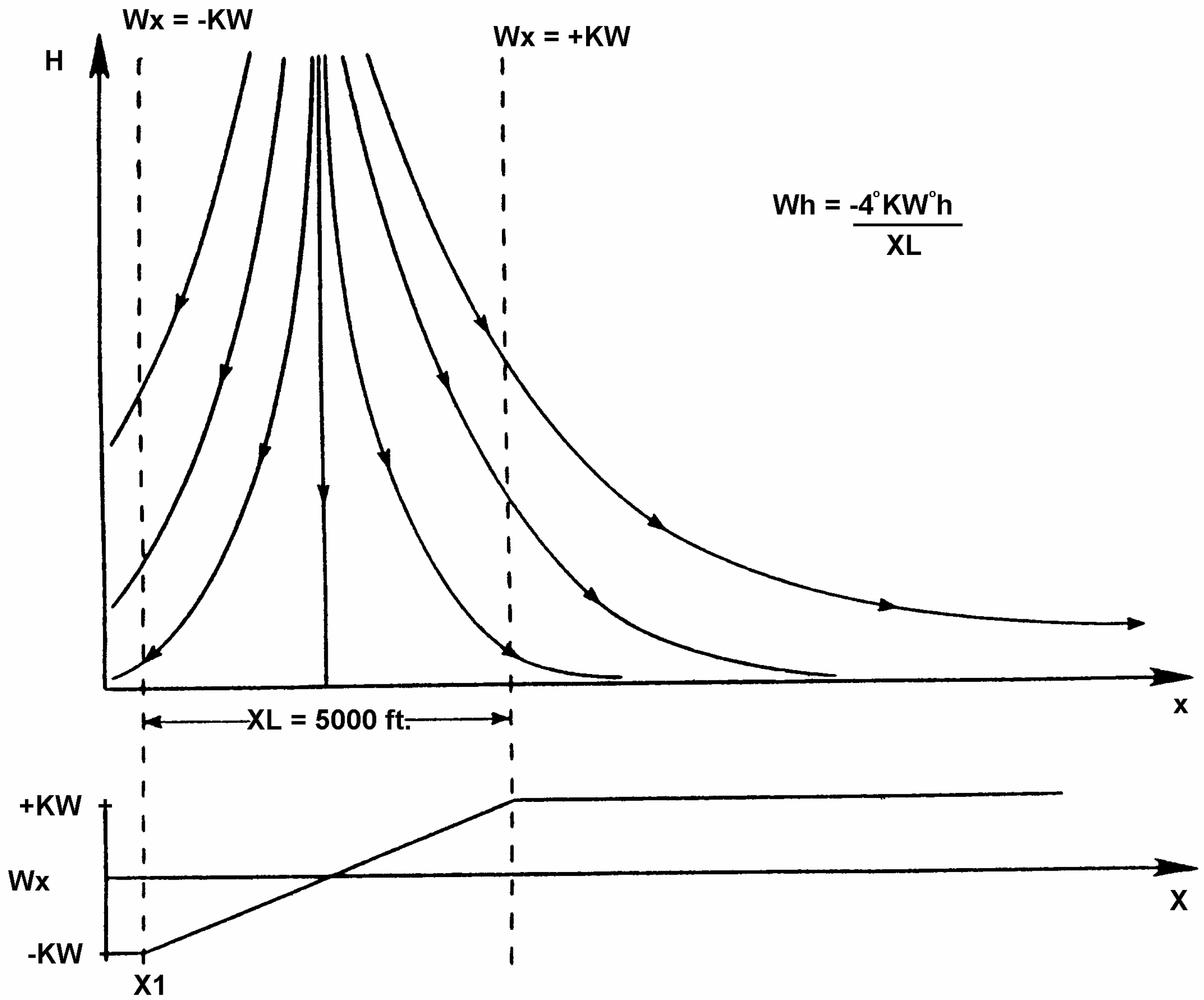



Figure 1 Wind Model Used In Guidance Studies

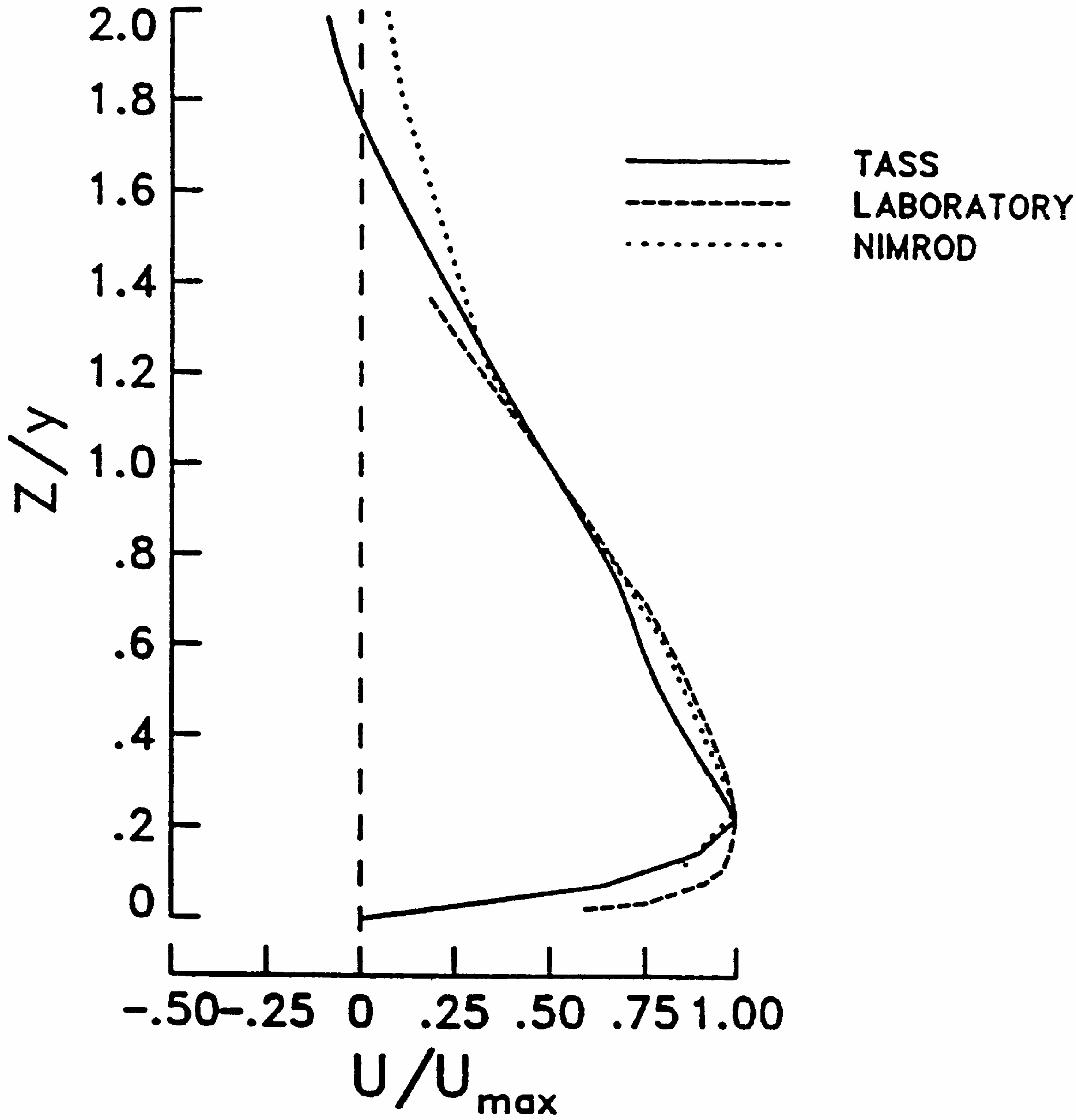



Figure 2 Vertical Profile of Microburst Outflow (Nondimensional)

VERTICAL PROFILES OF VERTICAL VELOCITY
FOR 30 JUN 82 CASE:
SENSITIVITY TO RADIUS OF PRECIPITATION SHAFT

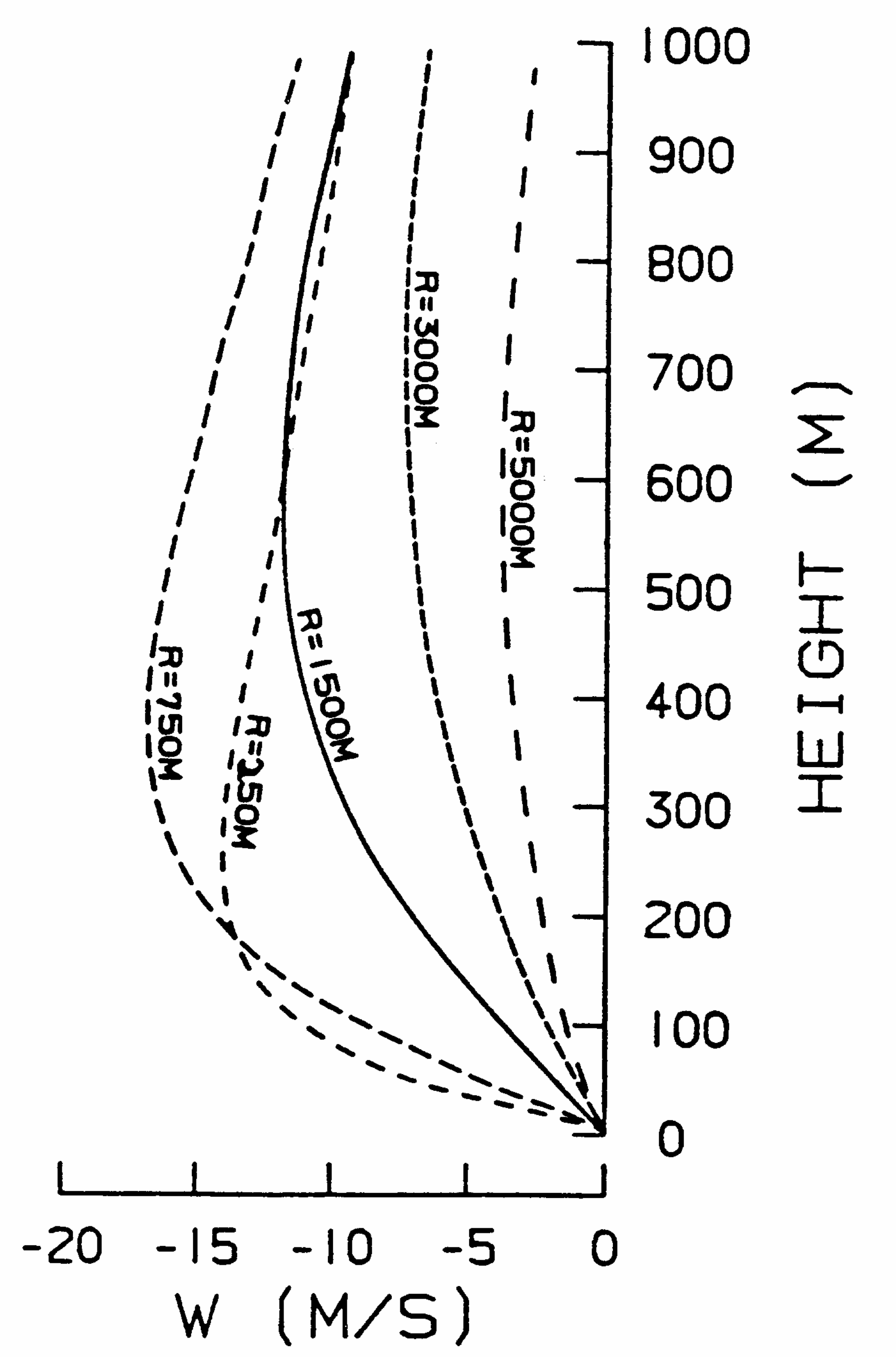



Figure 3 Vertical Profile of Microburst Downflow

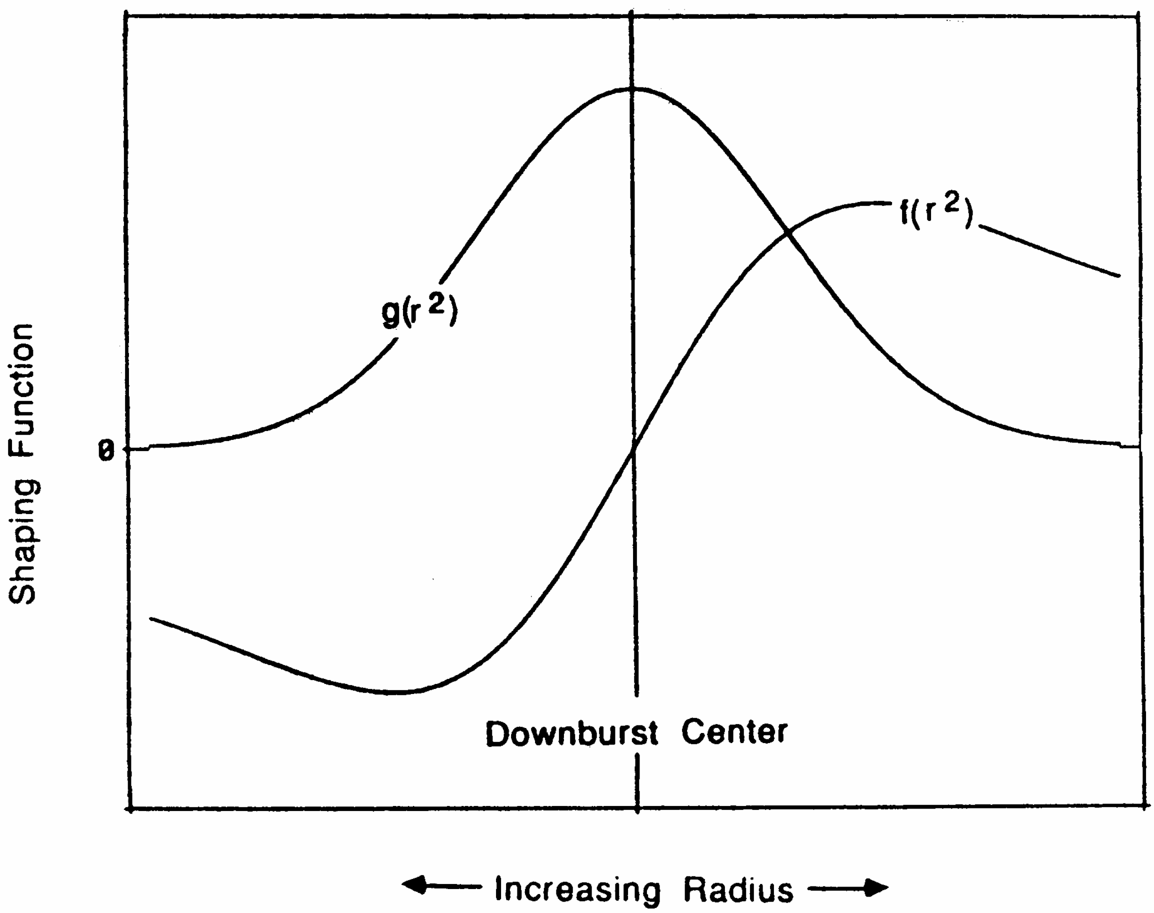



Figure 4 Characteristic Variation of Horizontal Shaping Functions

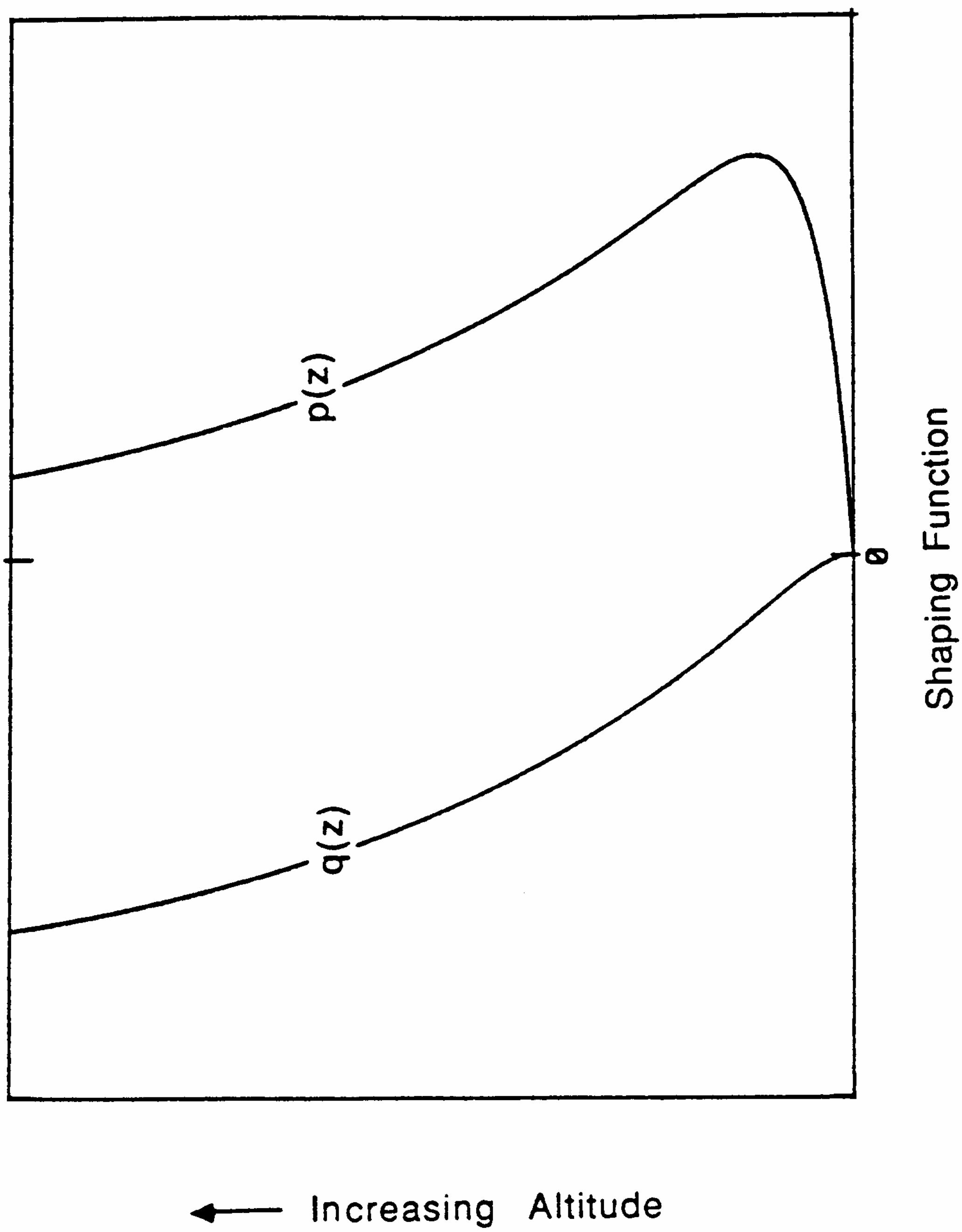



Figure 5 Characteristic Variation of Vertical Shaping Functions

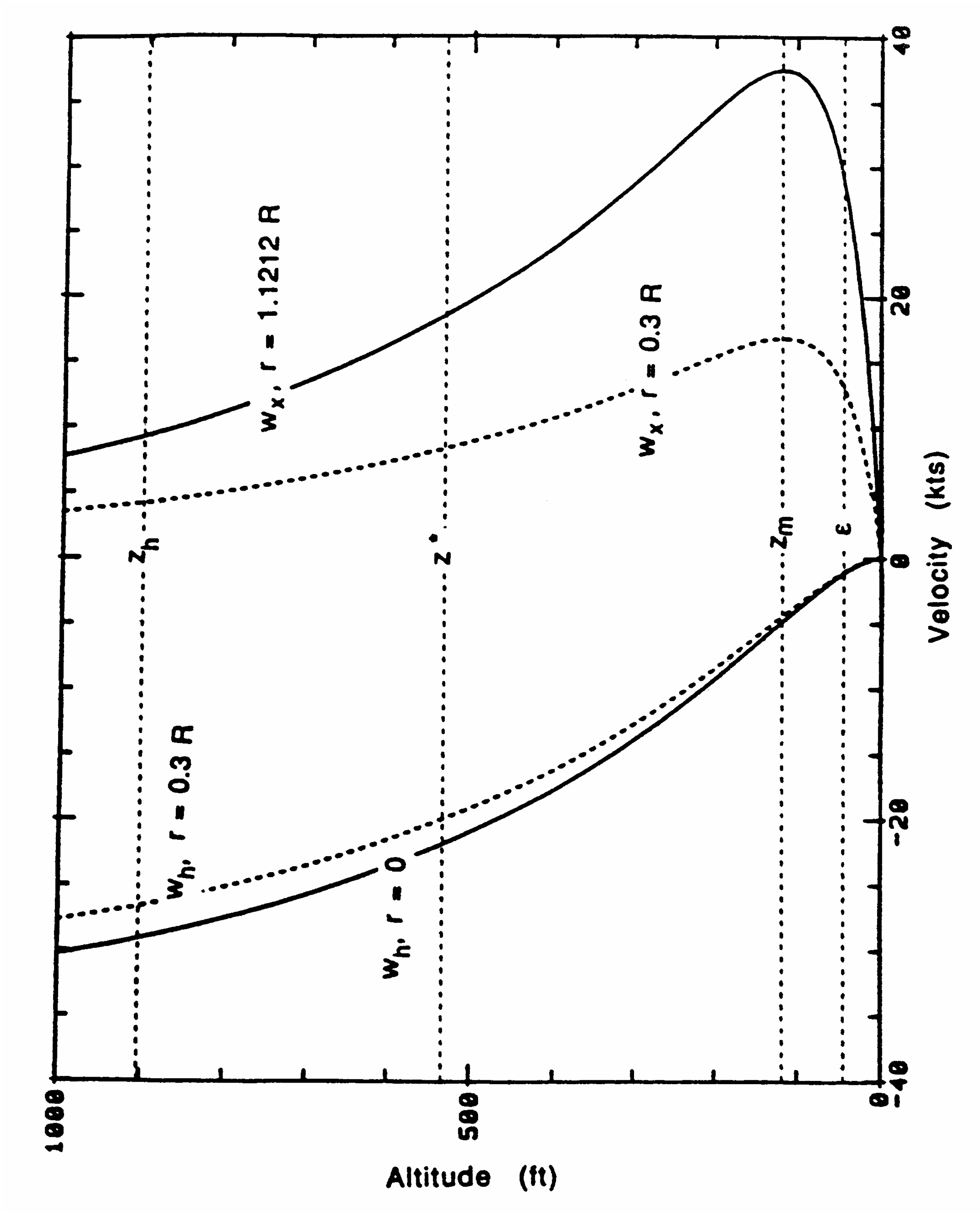



Figure 6 Vertical Velocity Profiles For Analytical Model

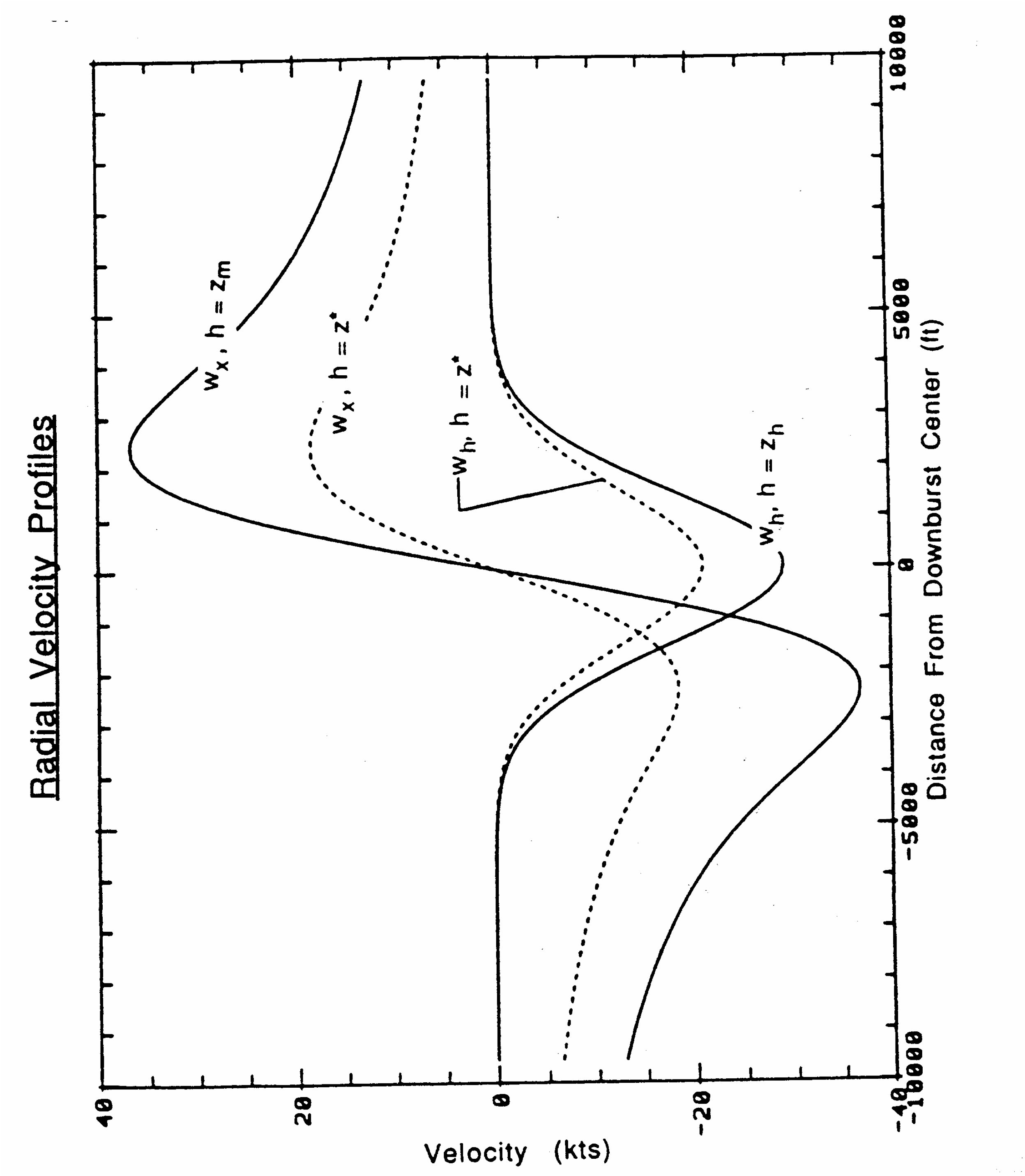



Figure 7 Radial Velocity Profiles For Analytical Model

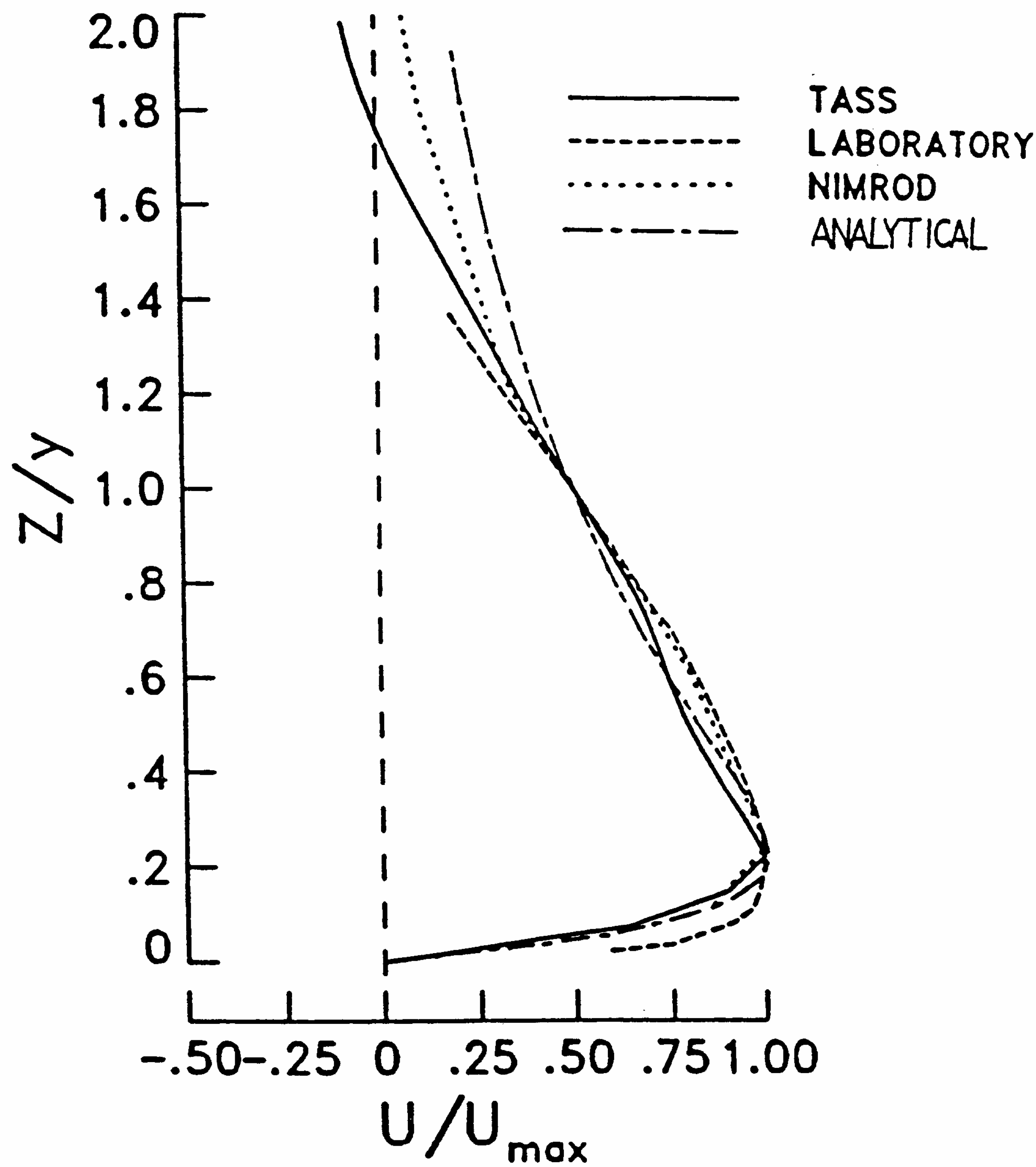



Figure 8 Comparison of Wind Model Vertical Profiles

**APPENDIX 2**

This appendix contains data that defines the Dryden turbulence model and discrete gust model to be used in conduction the tests specified in paragraphs (e)(7)(ii), (e)(7)(iii), (e)(8)(ii), and (e)(8)(iii) of this TSO.

Dryden Turbulence Model

Fu(S) = SIGMAu * SQRT (TAUu/PI) * 1/(1+TAUu*S)

$$Fv(S) = SIGMAv * SQRT\ (TAUv/PI2) * \frac{(1 + SQRT3*TAUv*S)}{(1 + TAUv*S)*(1 + TAUv*S)}$$

$$Fw(S) = SIGMAw * SQRT\ (TAUw/PI2) * \frac{(1 + SQRT3*TAUw*S)}{(1 + TAUw*S)*(1 + TAUw*S)}$$

where:

SIGMAu, SIGMAv, SIGMAw are the RMS intensities;
TAUu = Lu/VA;
TAUv = Lv/VA;
TAUw = Lw/VA;
Lu, Lv, Lw are the turbulence scale lengths;
VA 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 SIGMAu, SIGMAv, SIGMAw, Lu, Lv, and Lw 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 | RMS Intensities (ft/sec) | | | Scale Lengths (feet) | | |
|---|---|---|---|---|---|---|
| (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 must 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 OMEGAt)] shall be used. The following table lists the values of A and OMEGA to be used (simulates an approximate15 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 |

**APPENDIX 3**

**SHEAR INTENSITY**

$$f(t) = \frac{\dot{w}_x}{g} - \frac{w_h}{V}$$

where

$\dot{w}_x$ = Horizontal component of the wind rate of change expressed in g units (1.91 kts/sec = 0.1 g) (positive for increasing headwind).

$W_h$ = Vertical component of the wind vector w (ft/sec) (positive for downdraft).

V = True airspeed (ft/sec).

g = Gravitational acceleration (ft/sec$^2$).

## APPENDIX 4

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 degree 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-degree of freedom mathematical model which simulates the motion of an aircraft 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 aircraft dynamics during a windshear encounter are accurately modeled. This model has been used by several investigators to study the behavior of an aircraft during windshear encounters.

(Copies of that listing may be may be purchased from the Superintendent of Documents, Government Printing Office, Washington, DC  20402-9325, USA.)

**European Aviation Safety Agency**

# European Technical Standard Order

**Subject:** TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS)AIRBORNE EQUIPMENT, TCAS I.

**1 - Applicability**

This ETSO gives the requirements which new models of active traffic alert and collision avoidance system airborne equipment 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-197 Section 2, dated March 20, 1987, as amended and supplemented by 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-C119b**
**Date : 24.10.03**

# European Aviation Safety Agency

# European Technical Standard Order

Subject: TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS) AIRBORNE EQUIPMENT, TCAS II

**1 - Applicability**

This ETSO gives the requirements that new models of traffic alert and collision avoidance system airborne equipment 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-185A dated 16 December 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-C121**
**Date : 24.10.03**

**European Aviation Safety Agency**

# European Technical Standard Order

**Subject:** UNDERWATER LOCATING DEVICES (ACOUSTIC) (SELF-POWERED)

**1 - Applicability**

This ETSO gives the requirements that new models of underwater locating devices (acoustic)(self-powered) 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 SAEdocument AS 8045 dated May 16, 1988, Sections 4 through 7, as amended and supplemented by this ETSO:

3.1.2 - Environmental Standards

(i) See CS-ETSO Subpart A paragraph 2.1 and in addition

(ii) Salt Water Immersion American Society Testing Materials (ASTM)Document D. 1141-75 „Standard Specification for Substitute Ocean Water“, dated 1980.

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 major equipment components:

Each separate component of equipment that is manufactured under this ETSO (antenna, receiver, sensors, display panels, etc.) must be legibly and permanently marked with at least the name of the manufacturer, the ETSO number and part number.

4.2 - Specific

None

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

**ETSO-C123a**
**Date : 24.10.03**

**European**
**Aviation**
**Safety**
**Agency**

# European Technical Standard Order

Subject: COCKPIT VOICE RECORDER SYSTEMS

**1 - Applicability**

This ETSO gives the requirements that new models of cockpit voice recorder systems 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-56A chapter 2, 3, 4, 5, and 6, dated October 1993, with amendment 1 dated 25 November 1997, as amended and supplemented by 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-C124a**
**Date : 24.10.03**

**European**
**Aviation**
**Safety**
**Agency**

# European Technical Standard Order

Subject: FLIGHT DATA RECORDER SYSTEMS

**1 - Applicability**

This ETSO gives the requirements that new models of flight data recorder systems 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-55 dated May 1990 with amendment 1 dated 23 September 1998, as amended and supplemented by 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-C127a**
**Date : 24.10.03**

**European Aviation Safety Agency**

# European Technical Standard Order

Subject: ROTORCRAFT, TRANSPORT AEROPLANE, AND NORMAL AND UTILITY AEROPLANE SEATING SYSTEMS

**1 - Applicability**

This ETSO prescribes the minimum performance standards (MPS) that rotorcraft, transport aeroplane, and normal and utility aeroplane seating systems of the following designated types that are manufactured on or after the date of this ETSO, must meet in order to be identified with the applicable ETSO marking.

Type A - Transport Aeroplane
Type B - Rotorcraft
Type C1 - Normal & Utility Aeroplane - Crew Seats
Type C2 - Normal & Utility Aeroplane - Passenger Seats

**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 8049A, „Performance Standards for Seats in Civil Rotorcraft and Transport Airplanes“, dated September, 1997, as amended by Appendix 1 of this ETSO.

Additions :

Additional information on the dynamic testing of seating systems is contained in Advisory Circular (AC) 20-137, „Dynamic Evaluation of Seat Restraint Systems & Occupant Restraint for Rotorcraft (Normal & Transport)“, AC 23.562-1, „Dynamic Testing of Part 23 Airplane Restraint/Systems and Occupant Protection“, and AC 25.562-1A, „Dynamic Evaluation of Seat Restraint Systems & Occupant Protection on Transport Airplanes“. Compliance with these AC’s is not necessary to receive a ETSO authorization under this ETSO. However, the applicant for a seat installation approval should be aware that any seating system may be required to meet the criteria contained in these AC’s in order to qualify for installation in an aircraft.

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 applicable seat type : „Type A-“, „Type B-“, „Type C1-“, or „Type C2-“ followed by the appropriate seat facing direction designation : „FF“-forward; „RF“-rearward; or „SF“-sideward,

(ii) for Type A passenger seating systems, the approved seat pitch necessary to maintain clearance to assure an effective emergency evacuation, as defined in AC 25.562-1A, Appendix 2. Use appropriate statement as follows : „See installation limitations in component maintenance manual (CMM) or drawing number (insert number)“ or „Minimum or Allowable range (if applicable) seat pitch (insert number/range).“,

(iii) 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,

(iv) for Type A and Type B transport passenger, flight attendant, and observer seating systems, each seat cushion required for qualification of the seating system must be marked with „Complies with CS 25.853(c), or CS 29.853(b), as applicable“ when tested in accordance with the requirements of Section 3.4.2 of SAE AS 8049A, as revised by subparagraph 2.2.3 of Appendix 1 of this ETSO.

4.2 - Specific

None.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

## APPENDIX 1. TRANSPORT AEROPLANE, AND NORMAL AND UTILITY AEROPLANE SEATING SYSTEMS

1. Purpose. This appendix prescribes the MPS for seating systems, as modified by the FAA for reference in this TSO.

2. Requirements. The standards applicable to this TSO are set forth in the industry standard specified in paragraph 3 of this TSO. SAE AS 8049A, „Performance Standards for Seats in Civil Rotorcraft and Transport Airplanes," dated September 1997, which is the applicable standard is modified as follows:

2.1 Exceptions.

2.1.1 The information contained in Section 1. SCOPE: and Section 2. REFERENCES: of SAE AS 8049A is duplicative and shall be disregarded.

2.1.2 Compliance with Section 3.1 Guidance: of SAE AS 8049A is not required, except for Subsections 3.1.4, 3.1.8, 3.1.11, 3.1.14 (passenger seats only), 3.1.15 and 3.1.17 through 3.1.20.

2.1.3 Compliance with the dynamic test procedures and documentation of Subsection 5.3.1 Dynamic Impact Test Parameters: through Subsection 5.3.9.2 Impact Pulse Shape: of SAE AS 8049A may be demonstrated by equivalent procedures such as those described in either AC 23.562-1 or 25.562-1A. The simplified procedures for head injury criteria (HIC) outlined in policy letter TAD-96-002 dated February 16, 1996 also may be used in lieu of the selection of test conditions described in Subsection 5.3.6.2 of SAE AS 8049A. The use of any equivalent procedures must be established by the applicant and accepted in advance by the Manager, Aircraft Certification Office (ACO), Federal Aviation Administration (FAA), having geographic purview of the applicant's facility (See subparagraph 2.2.1 of this Appendix).

2.1.4 Compliance with the dynamic impact test pass/fail criteria of Subsections 5.4.3, 5.4.4, and 5.4.9 of SAE AS 8049A for permanent deformation limits, HIC, and femur loads, respectively, is not required. However, the data must be reported, as required by subparagraph 5.a(12) of this TSO.

2.1.5 Disregard the marking requirements specified in Section 6. MARKINGS: of SAE AS 8049A. Marking of the article shall be in accordance with paragraph 4 of this TSO.

2.2 Additions.

2.2.1 As applicable, at least 30 days prior to conducting any required TSO testing and prior to submitting an application for TSO authorization per 14 CFR 21.605(a), the applicant shall submit, to the FAA ACO manager, a proposed plan for demonstrating compliance with the requirements of this TSO for the following:

2.2.1.1 Any procedures that the applicant has identified in consideration of the design guidance in the SAE AS 8049A Subsections identified in subparagraph 2.1.2 of this Appendix; and

2.2.1.2 Those equivalent procedures the applicant has proposed to use to demonstrate compliance with dynamic test requirements of subparagraph 2.1.3 of this Appendix.

2.2.2 Under Section 3.2 Requirements: of SAE AS 8049A, add a new Subsection 3.2.15 to read as follows: Except for rearward facing seats, the pelvic restraint system shall be designed such that the vertical angle subtended by the projection of the pelvic restraint centerline and the seat reference point (SRP) water line shall not be greater than 55 degrees. The SRP water line is a line/plane passing through the SRP parallel to the horizon. The pelvic restraint centerline is formed by a line from the pelvic restraint anchorage to a point located 9.75 inches forward of the SRP and 7.00 inches 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 of SAE AS 8049A).

2.2.3 Replace Subsection 3.4.2 of SAE AS 8049A with the following: Type A-Transport Airplane and Type B-Transport Rotorcraft passenger, flight attendant, and observer seat cushion systems shall be tested and shall meet the fire protection provisions of Appendix F, Part II of 14 CFR Part 25, as required in 14 CFR 25.853(c) effective February 2, 1995 and 14 CFR 29.853(b) effective October 26, 1984 respectively, or the equivalent shall be demonstrated by analysis (similarity) to provide equivalent protection. Type B- Normal Rotorcraft upholstery shall be self extinguishing when tested to meet the fire protection provisions of 14 CFR 27.853(b) effective February 4, 1980. Type C1- and C2- Normal & Utility Airplane seat cushions shall be self extinguishing when tested to meet the fire protection provisions of paragraph (c) of Appendix F of 14 CFR Part 23, as required in 14 CFR 23.853(d)(3)(ii) effective February 9, 1995.

2.2.4 The following two items shall be included in Subsection 5.3.10.3 Test Data: of SAE AS 8049A: o. Post test retrieval of life preserver; and p. Evaluation of seat egress (See adjustable features in Subsection 3.2.6 and baggage stowed under seat in Subsection 3.2.7 of SAE AS 8049A. These two items will be part of the data submittal required by subparagraph 5.a(12)(iv) of this TSO.

2.2.5 Under APPENDIX A PROCEDURES FOR EVALUATING PULSE SHAPES, revise Subsection A.6 STEP 5 (REFERENCE FIGURE 5A): of SAE AS 8049A to read: Construct a line parallel to the ideal (minimum regulatory requirement) pulse and offset by 2 g in magnitude less than the ideal during the time interval between $T_1$ and $T_3$. Likewise construct a line parallel to the ideal pulse and offset by 2 g in magnitude less than the ideal (minimum regulatory requirement) pulse on the trailing side of the pulse from:

$$T_3 < t < T_1 + 1.33(T_3 - T_1)$$

If the magnitude of the acquired pulse is 2 g less than the ideal pulse shape at any point along the acquired pulse shape during the period $T_1 < t < T_1 + 1.33(T_3 - T_1)$, the pulse is unacceptable.

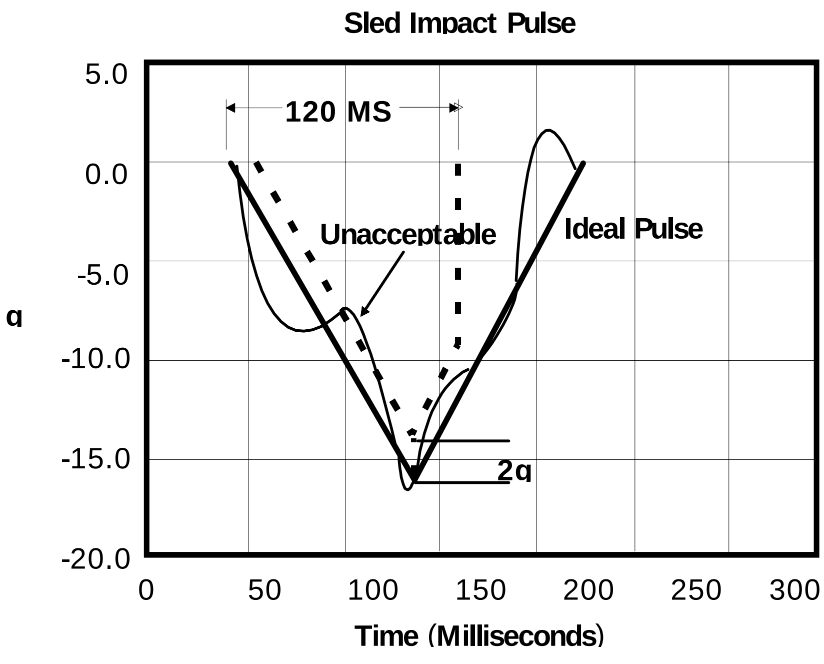



FIGURE 5A

## APPENDIX 2. TEST CONDITIONS

SAE AS 8049A incorporates, as a reference, the following test standards for which a more recent version of these standards may be substituted, if approved by the FAA ACO manager having geographical purview over the manufacturer’s facilities.

1. SAE J211- Instrumentation for Impact Tests.

2. Code of Federal Regulations, Title 49, Part 572, Anthropomorphic Test Dummies.

**ETSO-C129a**
**Date : 24.10.03**

**European Aviation Safety Agency**

# European Technical Standard Order

Subject: AIRBORNE SUPPLEMENTAL NAVIGATION EQUIPMENT USING GLOBAL POSITIONING SYSTEM (GPS)

**1 - Applicability.**

This ETSO gives the requirements that the subject article which 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

Airborne supplemental area navigation equipment using GPS that are to be so identified and that are manufactured on or after the date of this ETSO must meet the minimum performance standard of EUROCAE Document No.ED-72A.

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-C135
Date: 24.10.03

# European Aviation Safety Agency

# European Technical Standard Order

**Subject:** TRANSPORT AEROPLANE WHEELS AND WHEEL AND BRAKE ASSEMBLIES

**1 - Applicability**

This ETSO prescribes the minimum performance standard that transport category aeroplane wheels, and wheel and brake assemblies must meet to be identified with the applicable ETSO marking. Articles that are to be so identified on or after the date of this ETSO, must meet the requirements of Appendix 1 of this ETSO titled, "Minimum Performance Specification for Transport Aeroplane Wheels, Brakes, and Wheel and Brake Assemblies". 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 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

Appendix 1 to this ETSO.

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.

**APPENDIX 1: MINIMUM PERFORMANCE SPECIFICATION FOR TRANSPORT AEROPLANE WHEELS, BRAKES, AND WHEEL AND BRAKE ASSEMBLIES**

## 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 transport aeroplane.

1.2 APPLICATION.

Compliance with this minimum specification by manufacturers, installers, and users 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 manufacturer.

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 highest pressure at which full retraction of the piston(s) is assured.

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 ETSO.

1.4.7 D - Distance Averaged Deceleration.

D = ( (Initial brakes-on speed)$^2$- (Final brakes-on speed)$^2$)/(2 (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.

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.

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.

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).

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.

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.

1.4.15 L - Wheel Rated Radial Limit Load.

L is the wheel rated maximum radial limit load (paragraph 3.2.1).

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).

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).

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).

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).

1.4.27 WRP - Wheel Rated Inflation Pressure.

WRP is the wheel rated inflation pressure (wheel unloaded).

## CHAPTER 2
## GENERAL DESIGN SPECIFICATION.

### 2.1 AIRWORTHINESS.

As specified in CS 25.1529, the continued airworthiness of the aeroplane on which the equipment is to be installed must be considered. See paragraph 4 of this ETSO, titled "Data to be Furnished with Manufactured Articles."

### 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.

### 2.3 DESIGN.

Unless shown to be unnecessary by test or analysis, the equipment must comply with the following:

#### 2.3.1 Wheel Bearing Lubricant Retainers.

Wheel bearing lubricant retainers must retain the lubricant under all operating conditions, prevent the lubricant from reaching braking surfaces, and prevent foreign matter from entering the bearings.

#### 2.3.2 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, alternatively, 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 must define all relevant test parameter values.

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, 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 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 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 were 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, as determined under 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 ·005 inches (·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. There must be no interference in any critical areas between the wheel and brake assembly, or between the most critical deflected tyre and brake (with fittings) up to limit load conditions, taking into account the axle flexibility. Lack of interference can be established by analyses and/or tests.

3.2.1.3 Ultimate Load.

Apply to the wheel used in the yield test in paragraph 3.2.1.2, 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, as determined under 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). 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.

Liquid pressure must not exceed the pressure that would develop if gas inflation were used and the tyre were deflected to its maximum extent. 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, as determined under 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 ·005 inches (·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. There must be no interference in any critical areas between the wheel and brake assembly, or between the most critical deflected tyre and brake (with fittings) up to limit load conditions, taking into account the axle flexibility. Lack of interference can be established by analyses and/or tests.

3.2.2.3 Combined Ultimate Load.

Apply to the wheel, used in the yield test of paragraph 3.2.2.2, radial and side loads not less than 2 times for castings and 1·5 times for forgings, the respective ground limit loads as determined under JAR 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). 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 0·15xS side load applied in the outboard direction | 100 (161) |
| Wheel Rated Static Load, S, plus a 0·15xS 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 $0{\cdot}5V_R^2$ 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 (JAR 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.

3.3.1.2 For tests detailed in paragraphs 3.3.2, 3.3.3, and 3.3.4, the test energies $KE_{DL}$, $KE_{RT}$, and $KE_{SS}$ and brake application speeds $V_{DL}$, $V_{RT}$, and $V_{SS}$ are as defined by the aeroplane manufacturer.

3.3.1.3 For tests detailed in paragraphs 3.3.2, 3.3.3, and 3.3.4, 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, 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. 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. 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, defined by the aeroplane manufacturer, but not less than 10 ft/s$^2$ (3·05 m/s$^2$). (See 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, defined by the aeroplane manufacturer, but not less than 6 ft/s$^2$ (1·83 m/s$^2$). (See 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 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, 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, the brake pressure must be adjusted to the Brake Rated Maximum Parking Pressure, $BRPP_{MAX}$, and maintained for at least 3 minutes (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 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 defined by the aeroplane manufacturer. This test is not required if the testing required in paragraph 3.3.3 is more severe or the condition is shown to be extremely improbable 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 airline’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 BRWL (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, 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 is illustrated in Figure 3-2.

3.3.5 Structural Torque Test.

The Wheel/Brake Rated Structural Torque, $ST_R$, is equal to the torque demonstrated in the test defined in 3.3.5.1.

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, 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, 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. 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.

3.4 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) and release to a pressure not exceeding the Brake Rated Retraction Pressure, BRPRET. 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 meet the leakage requirements of paragraph 3.4.5 at the completion of 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.

The brake actuation system must comply with the dynamic leakage limits in paragraph 3.4.5.2 for 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), 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 1 000 cycles, followed by 25 cycles of $BROP_{MAX}$ 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 $KE_{DL}$ stops and release to a pressure not exceeding $BRP_{RET}$, for 25 cycles, followed by 5 cycles of $BROP_{MAX}$ 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 manufacturer 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, BRPMAX,
Brake Rated Retraction Pressure, BRPRET,
Wheel/Brake Rated Structural Torque, STR,
Rated Design Landing Deceleration, DDL,
Rated Accelerate-Stop Deceleration, DRT,
Rated Most Severe Landing Stop Deceleration, DSS (if applicable),
Brake Rated Tyre Size,TSBR,
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.

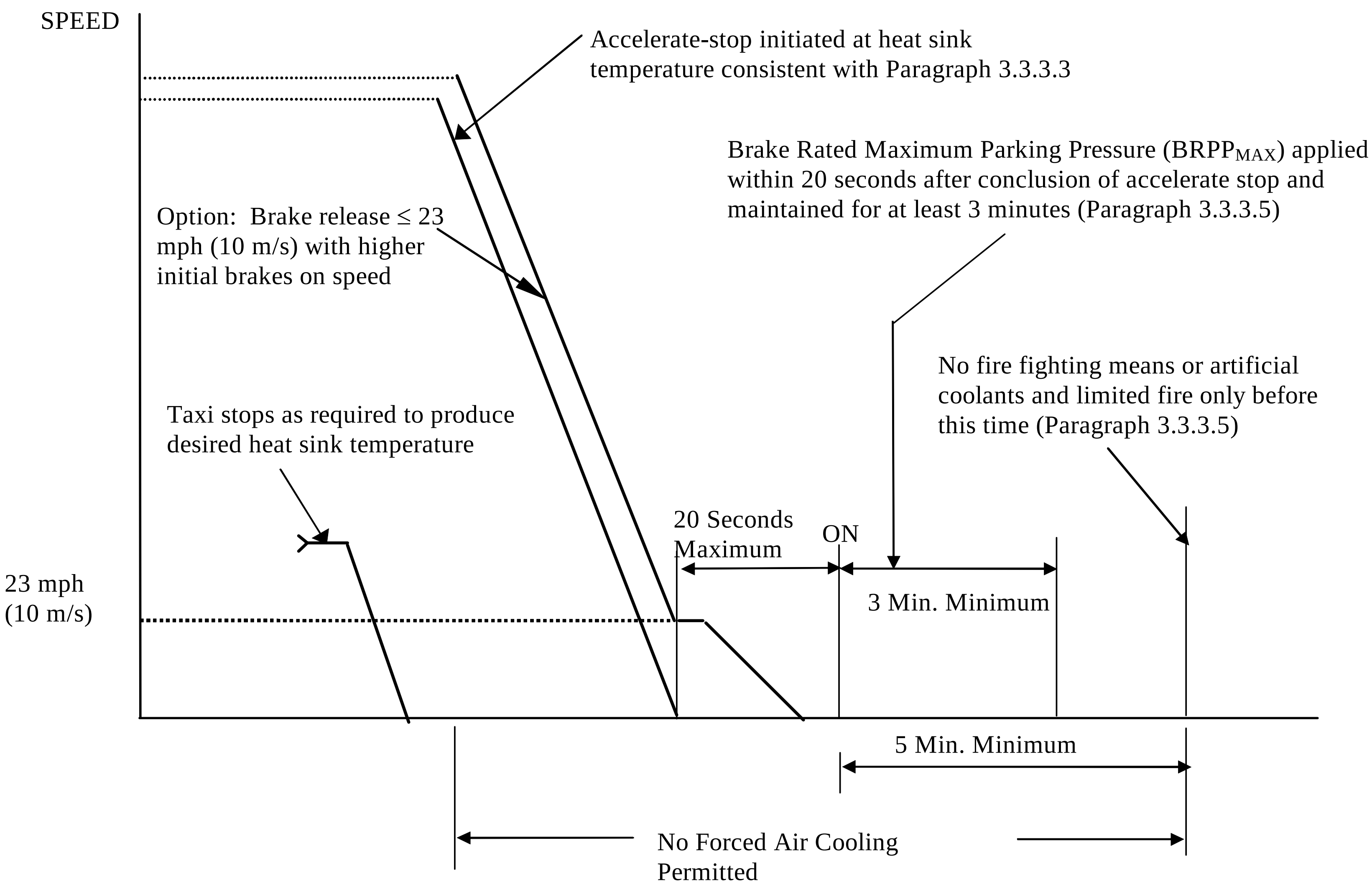



**Figure 3-1. Taxi, Accelerate-Stop, Park Test Sequence**

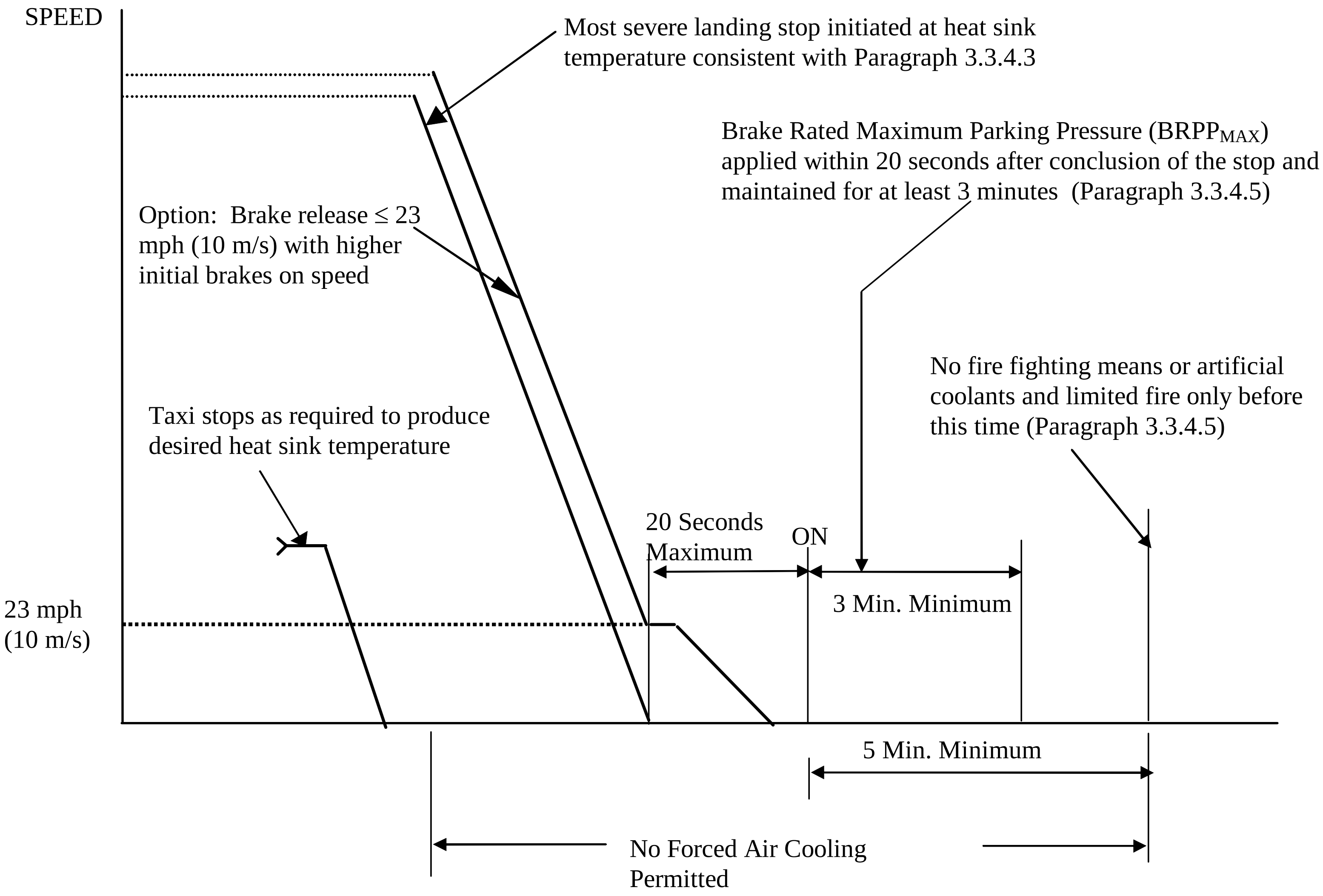



**Figure 3-2. Most Severe Landing-Stop, Park Test Sequence**

**ETSO-C141**
**Date : 24.10.03**

**European Aviation Safety Agency**

# European Technical Standard Order

Subject: 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-C144**
**Date : 24.10.03**

# European Aviation Safety Agency

## European Technical Standard Order

Subject: AIRBORNE GLOBAL POSITIONING SYSTEM ANTENNA

**1 - Applicability**

This ETSO gives the requirements that new models of airborne global positioning system 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 Section 2 of RTCA/DO-228, “Minimum Operational Performance Standards for Airborne Global Navigation Satellite System Antenna”.

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.

**ETSO-C145**
**Date : 24.10.03**

**European Aviation Safety Agency**

# European Technical Standard Order

Subject: AIRBORNE NAVIGATION SENSORS USING THE GLOBAL POSITIONING SYSTEM (GPS) AUGMENTED BY THE WIDE AREA AUGMENTATION SYSTEM (WAAS)

**1 - Applicability**

This ETSO gives the requirements that new models of airborne navigation sensors using the Global Positioning System (GPS) augmented by the Wide Area Augmentation System (WAAS) that are manufactured on or after the date of this ETSO must meet in order to be identified with 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. These deviations will be used by the pilot or autopilot to guide the aircraft. These standards do not address integration issues with other avionics, such as the potential for the sensor to inadvertently command an autopilot hardover. These standards also do not address the use of position information for other applications such as automatic dependent surveillance.

**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

Airborne navigation sensors using GPS augmented by WAAS that are to be so identified must meet the minimum performance standards for Class Beta equipment set forth in Section 2 of RTCA/DO-229A, “Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Equipment”, dated June 8, 1998, as amended and supplemented by this ETSO. Class Beta equipment is defined in Section 1 of RTCA/DO-229A.

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 - Failure Condition Classification.

Failure of the function defined in paragraph 1 of this ETSO has been determined to be :

- a major failure condition for loss of function and malfunction of en route, terminal, or nonprecision approach position data ;
- a major failure condition for loss of function of precision approach position data ;
- and a hazardous failure condition for the malfunction of precision approach position data.

The applicant must develop the system to at least the design assurance level commensurate with this hazard classification.

3.3. - Functional qualifications.
The required performance shall be demonstrated under the test conditions specified in RTCA/DO-229A, Section 2.5. The use of test procedures other than those specified in Sections 2.5.2 through 2.5.9 of RTCA/DO-229A constitutes a deviation to this ETSO.

**4 - Marking**

4.1 - General

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

4.2 - Specific

In addition, the following requirements apply to all separate components of equipment that are manufactured under this ETSO :

- The operational equipment class as defined in Section 1 of RTCA/DO-229A (e.g., Class 2),
- When applicable, identification that the article is an incomplete system or that the article accomplishes additional functions beyond that described in paragraph 1 of this ETSO.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

**ETSO-C146**
**Date : 24.10.03**

**European Aviation Safety Agency**

# European Technical Standard Order

Subject: STAND-ALONE AIRBORNE NAVIGATION EQUIPMENT USING THE GLOBAL POSITIONING SYSTEM (GPS) AUGMENTED BY THE WIDE AREA AUGMENTATION SYSTEM (WAAS)

**1 - Applicability**

This ETSO gives the requirements that new models of stand-alone airborne navigation equipment using the Global Positioning System (GPS) augmented by the Wide Area Augmentation System (WAAS) that are manufactured on or after the date of this ETSO must meet in order to be identified with 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. These deviations will be used by the pilot or autopilot to guide the aircraft. These standards do not address integration issues with other avionics, such as the potential for the sensor to inadvertently command an autopilot hardover. These standards also do not address the use of position information for other applications such as automatic dependent surveillance.

**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

Airborne navigation sensors using GPS augmented by WAAS that are to be so identified must meet the minimum performance standards for Class Gamma or Class Delta equipment set forth in Section 2 of RTCA/DO-229B, “Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Equipment”, dated October 5, 1999, as amended and supplemented by this ETSO. Class Gamma and Class Delta equipment are defined in Section 1.4 of RTCA/DO-229B.

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 - Failure Condition Classification.

Failure of the function defined in paragraph 1 of this ETSO has been determined to be:

- a major failure condition for loss of function and malfunction of en route, terminal, or nonprecision approach position data ;
- a major failure condition for loss of function of precision approach position data ;
- and a hazardous failure condition for the malfunction of precision approach position data.

The applicant must develop the system to at least the design assurance level commensurate with this hazard classification.

3.3. - Functional qualifications.
The required performance shall be demonstrated under the test conditions specified in RTCA/DO-229B, Section 2.5. The use of test procedures other than those specified in Sections 2.5.2 through 2.5.9 of RTCA/DO-229B constitutes a deviation to this ETSO.

**4 - Marking**
4.1 - General

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

4.2 - Specific

In addition, the following requirements apply to all separate components of equipment that are manufactured under this ETSO :

- The operational equipment class as defined in Section 1.4.2 of RTCA/DO-229B (e.g., Class 2). A marking of Class 4 indicates compliance to Delta-4 requirements. The functional equipment class defined in Section 1.4.1. of RTCA/DO-229B (e.g. Gamma, Delta) is not required to be marked.
- When applicable, identification that the article is an incomplete system or that the article accomplishes additional functions beyond that described in paragraph 1 of this ETSO.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

**ETSO-C147**
**Date : 24.10.03**

**European Aviation Safety Agency**

# European Technical Standard Order

Subject: 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 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, with the exceptions listed in 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.

3.2 - Specific

None

**4 - Marking**

4.1 - General

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

4.2 - Specific

The equipment class, as defined in paragraph 1, shall be marked.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

**APPENDIX 1. 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.**

**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 <u>Intruder Aircraft</u> eliminate the last line: "Scenario C and D ≥ -78 dBm.

under <u>Test Description</u> 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 ±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 chose 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 by 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 chose 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 | Upper Limit for $\sum_{k=1}^{K} P(k)$ | |
|---|---|---|
| | 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 Σ 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 chose 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 <u>directional</u> 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:

The interface between Active TAS and the pilot shall be based on the FAA Advisory Circular entitled "Airworthiness Approval of Traffic Alert and Collision Avoidance Systems (Active TCAS I)". It shall however 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. 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 Advisory Circular entitled "Airworthiness Approval of Traffic and Collision Avoidance Systems (Active TCAS I)" 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 afixed gear aircraft with 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-<X>O’Clock”, spoken once, (where <X> 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.

**European Aviation Safety Agency**

# European Technical Standard Order

Subject: TERRAIN AWARENESS AND WARNING SYSTEM (TAWS)

**1 - Applicability**

This ETSO gives the requirements which Terrain awareness and Warning System (TAWS) 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 this paragraph and appendices 1-3.

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. In addition:

Software implementing the functions defined in this ETSO must be developed to Level C as defined in ED-12B/DO-178B. Monitoring software required by appendix 1 of this ETSO must be developed to Level C. Software in the TAWS other than the software implementing the function and monitoring requirements defined in the ETSO, such as maintenance software, should be developed to Level C also unless the applicant can demonstrate that the ETSO functional software and monitoring software is protected from failure of the other software by means such as developed to the highest level commensurate with its functionality and its most severe failure condition categories as determined by a system safety assessment.

3.2 - Specific

3.2.1 - Failure Condition Classification. A minimum level of reliability and integrity must be built into the TAWS computer for warning functions. Therefore, the presentation of misleading information (MI), as defined in paragraph 2.8 of appendix 1, on the terrain display, or the unannunciated loss of the terrain warning functions as a result of TAWS Computer failure should be shown to be improbable (i.e. $<10^{-5}$ per flight hour). A false terrain warning as a result of a TAWS computer failure should also be shown to be improbable (i.e. $<10^{-5}$ per flight hour). False sensor inputs (erroneous altitude, terrain data, airport data, etc) to the TAWS computer need not be considered for compliance to these failure condition classifications.

3.2.2 - Functional Qualifications. The required performance shall be demonstrated under the test conditions specified in appendixes 1and 3.

3.2.3 - Fire Protection. All material used shall be self-extinguishing 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.

**4 - Marking**

4.1 - General

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

4.2 - Specific

None.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

APPENDIX 1. FEDERAL AVIATION ADMINISTRATION MINIMUM PERFORMANCE STANDARD (MPS) FOR A TERRAIN AWARENESS AND WARNING SYSTEM, AS AMENDED BY JAA

1.0 Introduction.

1.1 Purpose. This standard provides the MPS for a Terrain Awareness and Warning System (TAWS).

1.2 Scope. This appendix sets forth the standard for two Classes of TAWS equipment, Class A and Class B.

1.3 System Function and Overview. The system shall provide the flight crew with sufficient information and alerting to detect a potentially hazardous terrain situation that would permit the flight crew to take effective action to prevent a controlled flight into terrain (CFIT) event. The basic TAWS functions for all ETSO approved systems include the following :

a. A Forward Looking Terrain Avoidance (FLTA) function. The FLTA function looks ahead of the aeroplane along and below the aeroplane's lateral and vertical flight path and provides suitable alerts if a potential CFIT threat exists.

b. A Premature Descent Alert (PDA) function. The PDA function of the TAWS uses the aeroplane's current position and flight path information as determined from a suitable navigation source and airport database to determine if the aeroplane is hazardously below the normal (typically 3 degree) approach path for the nearest runway as defined by the alerting algorithm.

c. An appropriate visual and aural discrete signal for both caution and warning alerts.

d. Class A TAWS equipment must provide terrain information to be presented on a display system.

e. Class A TAWS equipment must provide indications of imminent contact with the ground for the following conditions as further defined in DO-161A, Minimum Performance Standards - Airborne Ground Proximity Warning Equipment, dated May 27, 1976, and Section 3.3 of this appendix. Deviations from DO-161A are acceptable providing the nuisance alert rate is minimized while an equivalent level of safety for the following conditions is provided.

(1) Excessive Rates of Descent
(2) Excessive Closure Rate to Terrain.
(3) Negative Climb Rate or Altitude Loss After Take-off
(4) Flight Into Terrain When Not in Landing Configuration
(5) Excessive Downward Deviation From an ILS Glideslope.
(6) Voice callout „Five Hundred“ when the aeroplane descends to 500 feet above the terrain or nearest runway elevation.

NOTE: Class A equipment will be entitled to a ETSO-C92c authorization approval for the purpose of complying with the mandatory GPWS requirements in CS-OPS 1.665 , until such time that those rules are superseded by TAWS rules.

f. Class B equipment must provide indications of imminent contact with the ground during the following aeroplane operations as defined in Section 3.4 of this appendix.

(1) Excessive Rates of Descent
(2) Negative Climb Rate or Altitude Loss After Takeoff
(3) A voice callout „Five Hundred“ when the aeroplane descends to 500 feet above the nearest runway elevation.

1.4 Added Features. If the manufacturer elects to add features to the TAWS equipment, those features shall at least meet the same qualification testing and software verification and validation requirements as provided under this ETSO. Additional information such as „human-made“ obstacles may be added as long as they do not adversely alter the terrain functions.

1.5 Other Technologies. Although this ETSO envisions a TAWS based on the use of an onboard terrain and airport data base, other technologies such as the use of radar are not excluded. Other concepts and technologies may be approved under this ETSO using IR 21A.610, Approval for Deviation.

2.0 Definitions.

2.1 Alert. A visual, aural, or tactile stimulus presented to attract attention and convey information regarding system status or condition.

2.2 Aural Alert. A discrete sound, tone, or verbal statement used to annunciate a condition, situation, or event.

2.3 Caution Alert. An alert requiring immediate crew awareness. Subsequent corrective action will normally be necessary.

2.4 Controlled Flight Into Terrain (CFIT). An accident or incident in which an aeroplane, under the full control of the pilot, is flown into terrain, obstacles, or water.

2.5 Failure. The inability of the equipment or any sub-part of that equipment to perform within previously specified limits.

2.6 False Alert. An inappropriate alert that occurs as a result of a failure within the TAWS or when the design alerting thresholds of the TAWS are not exceeded.

2.7 Hazard. A hazard is a state or set of conditions that together with other conditions in the environment could lead to an accident.

2.8 Misleading Information (MI). An incorrect depiction of the terrain threat relative to the aeroplane during an alert condition (excluding source data).

2.9 Nuisance Alert. An inappropriate alert, occurring during normal safe procedures, that occurs as a result of a design performance limitation of TAWS.

2.10 Search Volume. A volume of airspace around the aeroplane's current and projected path that is used to define a TAWS alert condition.

2.11 Visual Alert. The use of projected or displayed information to present a condition, situation, or event.

2.12 Warning Alert. An alert for a detected terrain threat that requires immediate crew action.

3.0 Required TAWS Functions.

3.1 Class A and Class B Requirements for Forward Looking Terrain Avoidance (FLTA). The majority of CFIT accidents have occurred because the flight crews did not have adequate situational information regarding the terrain in the vicinity of the aeroplane and its projected flight path. Class A and Class B Equipment will be required to look ahead of the aeroplane, within their design search volume and provide timely alerts in the event terrain is predicted to penetrate the search volume. The FLTA function should be available during all airborne phases of flight including turning flight. The search volume consists of a computed look ahead distance, a lateral distance on both sides of the aeroplane's flight path, and a specified look down distance based upon the aeroplane's vertical flight path. This search volume should vary as a function of phase of flight, distance from runway, and the required obstacle clearance (ROC) in order to perform its intended function and to minimize nuisance alerts. The lateral search volume should expand as necessary to accommodate turning flight. The TAWS search volumes should consider the accuracy of the TAWS navigation source. The TAWS lateral search area should be less than the protected area defined by the United States Standard for Terminal Instrument Procedures (TERPS), FAA Handbook 8260.3B and ICAO PANOPS 8168, volume 2 to prevent nuisance alerts.

3.1.1 Reduced Required Terrain Clearance (RTC). Class A and Class B equipment shall provide suitable alerts when the aeroplane is currently above the terrain in the aeroplane's projected flight path but the projected amount of terrain clearance is considered unsafe for the particular phase of flight. The required obstacle (terrain) clearance (ROC) as specified in TERPS and the Aeronautical Information Manual (AIM) have been used to define the minimum requirements for obstacle/terrain clearance (RTC) appropriate to the FLTA function. These requirements are specified in Table 3.1. The FLTA function must be tested to verify the alerting algorithms meet the test conditions specified in Appendix 3, Tables A, B, C, D, E, and F.

TABLE 3.1

TAWS REQUIRED TERRAIN CLEARANCE (RTC) BY PHASE OF FLIGHT

| Phase of Flight | TERPS (ROC) | TAWS (RTC) Level Flight | TAWS (RTC) Descending |
|---|---|---|---|
| Enroute | 1000 Feet | 700 Feet | 500 Feet |
| Terminal (Intermediate Segment) | 500 Feet | 350 Feet | 300 Feet |
| Approach | 250 Feet | 150 Feet | 100 Feet |
| Departure (See Note 1) | 48 Feet/NM | 100 Feet | 100 Feet |

NOTE 1: During the Departure Phase of Flight, the FLTA function of Class A and B equipment must alert if the aeroplane is projected to be within 100 feet vertically of terrain. However, Class A and Class B equipment should not alert if the aeroplane is projected to be more than 400 feet above the terrain.

NOTE 2: As an alternate to the stepped down reduction from the terminal to approach phase in Table 3.1, a linear reduction of the RTC as the aircraft comes closer to the nearest runway is allowed, providing the requirements of Table 3.1 are met.

NOTE 3: During the visual segment of a normal instrument approach (typically about 1 NM from the runway threshold), the RTC should be defined/reduced to minimize nuisance alerts. Below a certain altitude or distance from the runway threshold, logic may be incorporated to inhibit the FLTA function. Typical operations below Minimum Descent Altitude (MDA), Decision Height (DH), or the Visual Descent Point (VDP) should not generate nuisance alerts.

NOTE 4: The specified RTC values are reduced slightly for descending flight conditions to accommodate the dynamic conditions and pilot response times.

3.1.2 Imminent Terrain Impact. Class A and Class B equipment shall provide suitable alerts when the aeroplane is currently below the elevation of a terrain cell along the aeroplane's lateral projected flight path and, based upon the vertical projected flight path, the equipment predicts that the terrain clearance will be less than the value given in the RTC column of Table 3.1. See appendix 3 for test conditions that must be conducted (Table G).

3.1.3 FLTA Turning Flight. Class A and Class B equipment shall provide suitable alerts for the functions specified in 3.1.1 and 3.1.2 above when the aeroplane is in turning flight.

3.2 Class A and Class B Equipment Safety Agency for Detection and Alerting for Premature Descents Along the Final Approach Segment. Class A and Class B equipment shall provide a suitable alert when it determines that the aeroplane is significantly below the normal approach flight path to a runway. Approximately one third of all CFIT accidents occur during the final approach phase of flight, when the aeroplane is properly configured for landing and descending at a normal rate. For a variety of reasons which include poor visibility, night time operations, loss of situational awareness, operating below minimums without adequate visual references and deviations from the published approach procedures, many aeroplanes have crashed into the ground short of the runway. A means to detect and alert the flight crew to this condition is an essential safety requirement of this ETSO. There are numerous ways to accomplish the overall objectives of this requirement. Alerting criteria may be based upon height above runway elevation and distance to the runway. It may be based upon height above terrain and distance to runway or other suitable means. This ETSO will not define the surfaces for which alerting is required. It will specify some general requirements for alerting and some cases when alerting is inappropriate. See appendix 3 Table H for test requirements.

a. The PDA function should be available for all types of instrument approaches. This includes both straight-in approaches and circling approaches. This includes approaches that are not aligned within 30 degrees of the runway heading.

b. The TAWS equipment should not generate PDA alerts for normal VFR operations in the airport area. Aeroplanes routinely operate at traffic pattern altitudes of 800 feet above field/runway elevation for traffic pattern operations within 5NM of the airport.

c. Aeroplanes routinely operate in VFR conditions at 1000 feet AGL within 10-15 NM of the nearest airport and these operations should not generate alerts.

d. Aeroplanes routinely operate in the visual segment of a circling approach within 2 NM of the airport/runway of intended landing with 300 feet of obstacle clearance. Operations at circling minimums should not cause PDA alerts or FLTA alerts.

3.3 Class A Requirements for GPWS Alerting. In addition to the TAWS Forward Looking Terrain Avoidance and PDA functions, the equipment shall provide the GPWS functions listed below in accordance with ETSO-C92c. Some GPWS alerting thresholds may be adjusted or modified to be more compatible with the FLTA alerting functions and to minimize GPWS nuisance alerts. However, it is essential to retain the independent protective features provided by both the GPWS and FLTA functions. In each case, all the following situations must be covered. The failure of the ETSO C92c equipment functions, except for power supply failure, input sensor failure, or failure of other common portions of the equipment, shall not cause a loss of the FLTA, PDA, or Terrain Display.

The functions described in ETSO-C92c and the referenced document DO-161A include :

(1) Excessive Rates of Descent
(2) Excessive Closure Rate to Terrain
(3) Negative Climb Rate or Altitude Loss After Take-Off
(4) Flight Into Terrain When Not in Landing Configuration
(5) Excessive Downward Deviation From an ILS Glideslope

a. Flap Alerting Inhibition. A separate guarded control may be provided to inhibit GPWS alerts based on flaps being other than the landing configuration.

b. Speed. Airspeed or groundspeed shall be included in the logic that determines basic GPWS alerting time for „Excessive Closure Rate to Terrain“ and „Flight Into Terrain When Not in Landing Configuration“ to allow maximum time for the flight crew to react and take corrective action.

c. Voice Callouts. Voice callouts of altitude above the terrain shall be provided during non precision approaches per ETSO-C92c but are recommended for all approaches. These advisories are normally, but are not limited to 500 feet above the terrain or the height above the nearest runway threshold elevation.

d. Barometric Altitude Rate. Class A and Class B equipment may compute Barometric Altitude Rate using an Instantaneous Vertical Speed Indicator (IVSI) or an inertial smoothed vertical speed indicator. An alternative 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 revisions) and/or altimeter altitude (accuracy specified in ETSO-2C87 (Low range radio altimeters) - for air carrier aircraft, or later revisions) to meet the warning requirements described in RTCA Document No. DO-161A. In addition, ETSO-C106 for Air Data Computers may be used as an alternative means of compliance with this provision.

e. Sweep Tones „Whoop-Whoop“. If a two tone sweep is used to comply with RTCA Document No. DO-161A, paragraph 2.3, the complete cycle of two tone sweeps plus annunciation may be extended from „1.4“ to „2“ seconds.

> NOTE: Class A equipment will be entitled to a ETSO-C92c authorization approval for the purpose of complying with the mandatory GPWS requirements in CS-OPS 1.665 until such time that those rules are superseded by TAWS rules.

3.4 Class B Requirements for GPWS Alerting

a. Class B equipment must provide alerts for excessive descent rates. The alerting envelope of DO-161A has been modified to accommodate a larger envelope for both caution and warning alerts. Height above Terrain may be determined by using the Terrain Data Base elevation and subtracting it from QNH barometric altitude (or equivalent). In addition, since the envelopes are not limited by a radio altitude measurement to a maximum of 2500 feet AGL, the envelopes are expanded to include higher vertical speeds. The equipment shall meet either the requirements set forth in appendix 3, Section 7.0 or that specified in DO-161A.

b. Class B equipment must provide alerts for „Negative Climb Rate After Takeoff or Missed Approach“ or „Altitude Loss After Takeoff“ as specified in DO-161A. The alerting is identical to the alerting envelope in DO-161A except that Height above Terrain is based upon Height above Runway threshold elevation instead of radio altitude.

c. Class B equipment must provide a voice callout „Five Hundred“ during descents for landing. This feature is primarily intended to provide situational awareness to the flight crew when the aeroplane is being operated properly per normal procedures. During a normal approach, it is useful to provide the flight crew with a 500 foot voice callout referenced to the runway threshold elevation for the runway of intended landing. This feature also has an important CFIT protection function. In the event the aeroplane is operated unintentionally close to terrain when not in the airport area or the area for which PDA protection is provided, a 500 foot voice callout referenced to Height above Terrain will alert the flight crew to a hazardous condition.
The equipment shall meet the requirements specified in appendix 3, Section 9.0.

NOTE 1: Class B equipment will not require a radio altimeter. Height above Terrain may be determined by subtracting the elevation of the current position terrain cell from the current barometric altitude (or equivalent).

NOTE 2: Class B equipment should compute the voice callout for five hundred feet based upon barometric height above runway elevation. The nearest runway elevation may be used for this purpose.

3.5 Class A Equipment Requirements for a Terrain Display. Class A equipment shall be designed to interface with a Terrain Display, either color or monochromatic. Class A equipment for TAWS shall be capable of providing the following terrain related information to a display system.

a. The terrain shall be depicted relative to the aeroplane's position such that the pilot may estimate the relative bearing to the terrain of interest.

b. The terrain shall be depicted relative to the aeroplane's position such that the pilot may estimate the distance to the terrain of interest.

c. The terrain depicted shall be oriented to either the heading or track of the aeroplane. In addition, a North-up orientation may be added as a selectable format.

d. Variations in terrain elevation depicted relative to the aeroplane's elevation (above and below) shall be visually distinct. Terrain that is more than 2000 feet below the aeroplane's elevation need not be depicted.

e. Terrain that generates alerts shall be displayed in a manner to distinguish it from non-hazardous terrain, consistent with the caution and warning alert level.

3.6 Class B Equipment Requirements for a Terrain Display. Operators required to install Class B equipment are not required to include a Terrain Display. However, Class B TAWS equipment shall be capable of driving a terrain display function in the event the installer wants to include the terrain display function.

NOTE: This ETSO does not include requirements for the display system/hardware.

4.0 Aural and Visual Alerts.

4.1 The TAWS is required to provide aural alerts and visual alerts for each of the functions described in Section 3.0 of this appendix.

4.2 The required aural and visual alerts must initiate from the TAWS system simultaneously, except when suppression of aural alerts are necessary to protect pilots from nuisance aural alerting.

4.3 Each aural alert shall identify the reason for the alert such as „too low terrain“ and „Glideslope,“ or other acceptable annunciation.

4.4 The system shall remove the visual and aural alert once the situation has been resolved.

4.5 The system shall be capable of accepting and processing aeroplane performance related data or aeroplane dynamic data and providing the capability to update aural and visual alerts at least once per second.

4.6 The aural and visual outputs as defined in Table 4-1 shall be compatible with the standard cockpit displays and auditory systems.

4.7 The aural and visual alerts should be selectable to accommodate operational commonality among fleets of aeroplanes.

4.8 The visual display of alerting information shall be immediately and continuously displayed until the situation is no longer valid.

4.9 As a minimum the TAWS shall be capable of providing aural alert messages described in Table 4 -1. In addition to this minimum set, other voice alerts may be provided.

TABLE 4 – 1

| STANDARD SET OF VISUAL AND AURAL ALERTS | | |
|---|---|---|
| **Alert Condition** | **Caution** | **Warning** |
| Reduced Required Terrain Clearance<br><br>Class A & Class B | **Visual Alert**<br>Amber text message that is obvious, concise, and must be consistent with the Aural message.<br><br>**Aural Alert**<br>Minimum Selectable Voice Alerts:<br>„Caution, Terrain; Caution, Terrain“ **and**<br>„Terrain Ahead; Terrain Ahead“ | **Visual Alert**<br>Red text message that is obvious, concise and must be consistent with the Aural message.<br>**Aural Alert**<br>Minimum Selectable Voice Alerts:<br>„Terrain, Terrain; Pull-Up, Pull- up“ **and**„Terrain Ahead, Pull- up; Terrain Ahead, Pull-Up“ |
| Imminent Impact with Terrain<br><br>Class A & Class B | **Visual Alert**<br>Amber text message that is obvious, concise, and must be consistent with the Aural message.<br><br>**Aural Alert**<br>Minimum Selectable Voice Alerts:<br>„Caution, Terrain; Caution, Terrain“ **and**<br>„Terrain Ahead; Terrain Ahead“ | **Visual Alert**<br>Red text message that is obvious, concise and must be consistent with the Aural message.<br>**Aural Alert**<br>Minimum Selectable Voice Alerts:<br>„Terrain, Terrain; Pull-Up, Pull- up“<br>**and**<br>„Terrain Ahead, Pull- up; Terrain Ahead, Pull-Up“ |
| Premature Descent Alert (PDA)<br><br>Class A & Class B | **Visual Alert**<br>Amber text message that is obvious, concise and must be consistent with the Aural message.<br><br>**Aural Alert**<br>„Too Low Terrain“ | **Visual Alert**<br>None Required<br><br>**Aural Alert**<br>None Required |
| Ground Proximity Envelope 1, 2 or 3 Excessive Descent Rate<br><br>Class A & Class B | **Visual Alert**<br>Amber text message that is obvious, concise, and must be consistent with the Aural message.<br><br>**Aural Alert**<br>„Sink Rate“ | **Visual Alert**<br>Red text message that is obvious, concise and must be consistent with the Aural message.<br>**Aural Alert**<br>„Pull-Up“ |
| Ground Proximity Excessive Closure Rate (Flaps not in Landing Configuration)<br>Class A | **Visual Alert**<br>Amber text message that is obvious, concise, and must be consistent with the Aural message.<br><br>**Aural Alert**<br>„Terrain-Terrain“ | **Visual Alert**<br>Red text message that is obvious, concise, and must be consistent with the Aural message.<br>**Aural Alert**<br>„Pull-Up“ |
| Ground Proximity Excessive Closure Rate (Landing Configuration)<br>Class A | **Visual Alert**<br>Amber text message that is obvious, concise, and must be consistent with the Aural message.<br><br>**Aural Alert**<br>„Terrain-Terrain“ | **Visual Alert**<br>None Required.<br><br>**Aural Alert**<br>„Pull-Up“ – for gear up<br>None Required – for gear down |

TABLE 4 – 1 (Continued)

| STANDARD SET OF VISUAL AND AURAL ALERTS | | |
|---|---|---|
| **Alert Condition** | **Caution** | **Warning** |
| Ground Proximity<br><br>Altitude Loss after Take-off<br><br>Class A & Class B | **Visual Alert**<br>Amber text message that is obvious, concise, and must be consistent with the Aural message.<br><br>**Aural Alert**<br>„Don't Sink“ and „Too Low-Terrain“ | **Visual Alert**<br>None Required.<br><br>**Aural Alert**<br>None Required. |
| Ground Proximity Envelope 1 (Not in Landing Configuration) Class A | **Visual Alert**<br>Amber text message that is obvious, concise, and must be consistent with the Aural message.<br><br>**Aural Alert**<br>„Too Low Terrain“ and „Too Low Gear“ | **Visual Alert**<br>None Required.<br><br>**Aural Alert**<br>None Required. |
| Ground Proximity Envelope 2 Insufficient Terrain Clearance (Landing and Go-around configuration) Class A | **Visual Alert**<br>Amber text message that is obvious, concise, and must be consistent with the Aural message.<br><br>**Aural Alert**<br>„Too Low Terrain“ and „Too Low Flaps“ | **Visual Alert**<br>None Required.<br><br>**Aural Alert**<br>None Required |
| Ground Proximity Envelope 3 Insufficient Terrain Clearance (Take-off configuration) Class A | **Visual Alert**<br>Amber text message that is obvious, concise, and must be consistent with the Aural message.<br><br>**Aural Alert**<br>„Too Low Terrain“ | **Visual Alert**<br>None Required.<br><br>**Aural Alert**<br>None Required |
| Ground Proximity Excessive Glide Slope Deviation Class A | **Visual Alert**<br>Amber text message that is obvious, concise, and must be consistent with the Aural message.<br><br>**Aural Alert**<br>„Glide Slope“ | **Visual Alert**<br>None Required.<br><br>**Aural Alert**<br>None Required |
| Ground Proximity Voice Call Out (See Note 1)<br><br>Class A & Class B | **Visual Alert**<br>None Required<br><br>**Aural Alert**<br>„Five Hundred“ | **Visual Alert**<br>None Required.<br><br>**Aural Alert**<br>None Required |

NOTE 1: The aural alert for Ground Proximity Voice Call Out is considered advisory.

NOTE 2: Visual alerts may be put on the terrain situational awareness display, if this fits with the overall human factors alerting scheme for the flight deck.

This does not eliminate the visual alert color requirements, even in the case of a monochromatic display. Typically in such a scenario adjacent colored annunciator lamps meet the alerting color requirements.

4.10 Prioritization

a. Class A Equipment. Class A Equipment shall have an interactive capability with other external alerting systems so an alerting priority can be automatically executed for the purpose of not causing confusion or chaos on the flight deck during multiply alerts from different alerting systems. Typical alerting systems that may be interactive with TAWS include Predictive Windshear (PWS), Reactive Windshear (RWS), and possibly in the future Airborne Collision Avoidance System (ACAS). Table 4 – 2 includes an alert prioritization scheme. If the PWS, RWS and/or ACAS functions are provided within the TAWS, Table 4 - 2 also applies. The Agency will consider alert prioritization schemes other than the one included in Table 4 – 2.

b. Class B Equipment. Class B Equipment does not require prioritization with external systems such as ACAS, RWS, PWS. If prioritization with those functions is provided, the prioritization scheme shall be in accordance with the Table 4 - 2. The Agency will consider alert prioritization schemes other than the one included in Table 4 – 2.

c. Class B Equipment. Class B equipment shall establish an internal priority alerting system (scheme) for each of the functions. The priority scheme shall ensure that more critical alerts override the presentation of any alert of lesser priority. Table 4 – 3 is the internal priority scheme of the system. Class B equipment need only consider the TAWS functions required for Class B equipment.

Table 4 - 2

| ALERT PRIORITIZATION SCHEME | | | |
|---|---|---|---|
| Priority | Description | Alert Level [b] | Comments |
| 1 | Reactive Windshear Warning | W | |
| 2 | Sink Rate Pull-Up Warning | W | continuous |
| 3 | Excessive Closure Pull-Up Warning | W | continuous |
| 4 | RTC Terrain Warning | W | |
| 5 | $V_1$ Callout | I | |
| 6 | Engine Fail Callout | W | |
| 7 | FLTA Pull-Up warning | W | continuous |
| 8 | PWS Warning | W | |
| 9 | RTC Terrain Caution | C | continuous |
| 10 | Minimums | I | |
| 11 | FLTA Caution | C | 7 s period |
| 12 | Too Low Terrain | C | |
| 13 | PDA („Too Low Terrain“)Caution | C | |
| 14 | Altitude Callouts | I | |
| 15 | Too Low Gear | C | |
| 16 | Too Low Flaps | C | |
| 17 | Sink Rate | C | |
| 18 | Don't Sink | C | |
| 19 | Glideslope | C | 3 s period |
| 20 | PWS Caution | C | |
| 21 | Approaching Minimums | I | |
| 22 | Bank Angle | C | |
| 23 | Reactive Windshear Caution | C | |
| Mode 6 [a] | ACAS RA ("*Climb*", "*Descend*", etc.) | W | Continuous |
| Mode 6 [a] | ACAS TA ("*Traffic, Traffic*") | C | Continuous |

NOTE 1: These alerts can occur simultaneously with TAWS voice callout alerts.
NOTE 2: W = Warning, C = Caution, A = Advisory, I = Informational

**Table 4 – 3**

| TAWS INTERNAL ALERT PRIORITIZATION SCHEME | |
|---|---|
| **Priority** | **Description** |
| 1. | Sink Rate Pull-Up Warning |
| 2. | Terrain Awareness Pull-Up warning |
| 3. | Terrain Awareness Caution |
| 4. | PDA ("*Too Low Terrain*") Caution |
| 5. | Altitude Callouts „500“ |
| 6. | Sink Rate |
| 7. | Don't Sink (Mode 3) |

4.11 During ILS or other localizer-based approach operations, TAWS should not cause an alert for a terrain/obstacle located outside the TERPS protected airspace. Special design considerations may be necessary to address this issue.

NOTE 1: Non-GPS RNAV/FMC Systems that are used for the TAWS aeroplane horizontal aeroplane information may be „Localizer Updated“ to remove cross track errors. In addition, the alerting envelope may be modified to account for the higher accuracy and closer obstacles associated with ILS conditions.

NOTE 2: GPS-based Systems that are used for the TAWS aeroplane horizontal aeroplane position information should be able to meet the minimum criteria found in Appendix 1, Section 5.0.

NOTE 3: The level off initiation height of 20 percent of the vertical speed was chosen (as a minimum standard for nuisance alarm-free operations) because it is similar to typical autopilot or flight director level off (altitude capture) algorithms whereas the technique of using 10 percent of the existing vertical speed as a level off initiation point is usually considered as a minimum appropriate only to manual operations of smaller general aviation aeroplanes. With high rates of descent, experienced pilots often use a manual technique of reducing the vertical speed by one half when reaching 1000 feet above/below the level off altitude. This technique will significantly reduce the likelihood of nuisance alerts. In the event that use of the 20 percent of vertical speed as a minimum standard for nuisance free operations is shown not to be compatible with the installed autopilot or flight director level off (altitude capture) algorithms, consideration should be given to setting the alert logic closer to the 10 percent vertical speed criteria to minimize nuisance alerts.

5.0 Aeroplane Horizontal Position Determination for Source Data.

5.1 Class A equipment. Class A equipment that uses the on-board aeroplane navigation system for horizontal position information for the TAWS and that meets ETSO-C115b or follow AC90-45A for approved RNAV systems, ETSO-C129a for GPS, TSO-C145 for WAAS, or that follow the recommendations in AC 20-130a or AC-138 are considered acceptable. See note below.

5.2 Class B equipment. Class B equipment will be required to interface with an approved GPS for horizontal position information as specified in 5.1. See note below.

NOTE: Experience with these systems to date and analysis support that, as position accuracy decreases, a larger area must be considered for alerts in order for the system to perform its intended function. As the area of consideration is expanded and position accuracy is decreased the system tends to become more prone to nuisance alerts. In order to keep the system nuisance free, the TAWS must be inhibited or its operation degraded to accommodate certain types of operations. Therefore designers should be aware that at the present time only systems that use position information which provides GPS accuracy will be considered to meet this ETSO except for aircraft operated under CS-OPS-1. Operations under CS-OPS-1 provide factors that compensate for the decreased accuracy. These factors include type of operation, route structure analysis, flight crew training, route proving requirements, continued surveillance, and extensive operations into a limited number of airports.

5.3 Internal GPS Navigator Function. Class A and Class B equipment that use a GPS internal to the TAWS for horizontal position information and are capable of detecting a positional error that exceeds the appropriate alarm limit for the existing phase of flight in accordance with ETSO-C129a/ ED-72A, or equivalent are considered acceptable. When this alarm limit is activated, the GPS computed position is considered unsuitable for the TAWS function, and an indication should be provided to the flight crew that the TAWS functions that require GPS for operation are no longer available.

6.0 Class A and Class B Requirements for a Terrain and Airport Database.

6.1 Minimum Geographical Considerations As a minimum, terrain and airport information shall be provided for the expected areas of operation, airports and routes to be flown.

6.2 Development and Methodology. The manufacturer shall present the development and methodology used to validate and verify the terrain and airport information. RTCA DO-200A/EUROCAE ED 76, Standards for Processing Aeronautical Data, should be used as a guideline.

6.3 Resolution. Terrain and airport information shall be of the accuracy and resolution suitable for the system to perform its intended function. Terrain data should be gridded at 30 arc seconds with 100 foot resolution within 30 nautical miles of all airports with runway lengths of 3500 feet or greater and whenever necessary (particularly in mountainous environments) 15 arc seconds with 100 foot resolution (or even 6 arc seconds) within 6 nautical miles of the closest runway. It is acceptable to have terrain data gridded in larger segments over oceanic and remote areas around the world.

> Note : Class B equipment may require information relative to airports with runways less than 3500 feet whether public or private. Small airplane owners and operators probably will be the largest market for Class B equipment. Such operators frequently use airports of less than 3500 feet. Those TAWS manufacturers who desire to sell to this market must be willing to customize their terrain databases to include selected airports used by their customers.

6.4 Updates and Continued Airworthiness. The system shall be capable of accepting updated terrain and airport information.

7.0 <u>Class A and Class B Failure Indication</u>. Class A and Class B equipment shall include a failure monitor function that provides reliable indications of equipment condition during operation. It shall monitor the equipment itself, input power, input signals, and aural and visual outputs. A means shall be provided to inform the flight crew whenever the system has failed or can no longer perform the intended function.

8.0 <u>Class A and Class B Requirements for Self-Test</u>. Class A and Class B equipment shall have a self-test function to verify system operation and integrity. It shall monitor the equipment itself, input power, input signals, and aural and visual outputs. Failure of the system to successfully pass the self-test shall be annunciated.

> NOTE: Flight crew verification of the aural and visual outputs during a self-test is an acceptable method for monitoring aural and visual outputs.

9.0 <u>Class A Equipment Requirements for a Terrain Awareness Inhibit for the FLTA function, the Premature Descent Alert function and Terrain Display</u>.

9.1 Manual Inhibit. Class A equipment shall have the capability, via a control switch to the flight crew, to inhibit only the FLTA function, the Premature Descent Alert function, and Terrain Display. This is required in the event of a navigational system failure or other failures that would adversely affect FLTA, the Premature Descent Alert function or the Terrain Display. The basic TAWS required functions shall remain active when the inhibit function is utilized.

9.2 Automatic Inhibit. The capability of automatically inhibiting Class A functions within TAWS equipment is acceptable utilizing the conditions described in paragraph 7.0. If auto inhibit capability is provided, the „inhibit status“ must be annunciated to the flight crew.

<u>10.0 Phase of Flight Definitions</u>. The TAWS equipment search volumes and alerting thresholds should vary as necessary to be compatible with TERPS and other operational considerations. For that reason, a set of definitions is offered for Enroute, Terminal, Approach and Departure Phases of Flight. Other definitions for enroute, terminal and approach may be used by TAWS provided they are compatible with TERPS and standard instrument approach procedures and will comply with the test criteria specified in Appendix 3.

10.1 Enroute Phase. The Enroute Phase exists anytime the aeroplane is more than 15 NM from the nearest airport or whenever the conditions for Terminal, Approach and Departure Phases are not met.

10.2 Terminal Phase. The Terminal Phase exists when the aeroplane is 15 NM or less from the nearest runway while the range to the nearest runway threshold is decreasing and the aeroplane is at or below (lower than) a straight line drawn between the two points specified in Table 10-1 relative to the nearest runway.

TABLE 10-1

HEIGHT ABOVE RUNWAY VERSUS DISTANCE TO RUNWAY

| Distance to Runway | Height above Runway |
|---|---|
| 15 NM | 3500 Feet |
| 5 NM | 1900 Feet |

10.3 Approach Phase. Distance to nearest runway threshold is equal to, or less than 5 NM; and height above the nearest runway threshold location and elevation is equal to, or less than 1900 feet; and distance to the nearest runway threshold is decreasing.

10.4 Departure Phase. The Departure Phase should be defined by some reliable parameter that initially determines that the aeroplane is on the ground upon initial power-up. If, for example, the equipment can determine that the aeroplane is „on the ground“ by using some logic such as ground speed less than 35 knots and altitude within +/- 75 feet of field elevation or nearest runway elevation and „airborne“ by using some logic such as ground speed greater than 50 knots and altitude 100 feet greater than field elevation, then the equipment can reliably determine that it is in the „Departure Phase.“ Other parameters to consider are climb state, and distance from departure runway. Once the aeroplane reaches 1500 feet above the departure runway, the Departure Phase is ended.

11.0 <u>Class A and Class B Summary Requirements.</u>
(Reserved )

TABLE 11-1

(RESERVED)

## APPENDIX 2. STANDARDS APPLICABLE TO ENVIRONMENTAL TEST PROCEDURES

**RESERVED FOR MODIFICATIONS OF OR ADDITIONAL REQUIREMENTS BEYOND THE TEST PROCEDURES CONTAINED IN EUROCAE/RTCA DOCUMENT ED-14D/DO-160D.**

# APPENDIX 3. TEST CONDITIONS

1.0 Forward looking Terrain Avoidance - Reduced Required Terrain Clearance (RRTC) Test Conditions. This condition exists, when the aeroplane is currently above the terrain but the combination of current altitude, height above terrain, and projected flight path indicates that there is a significant reduction in the Required Terrain Clearance (RTC).

1.1 Phase of Flight Definitions. For the following test conditions, refer to appendix 1, paragraph 10.0 for an expanded discussion on the definitions of the phases of flight.

1.2 Enroute Descent Requirement. A terrain alert shall be provided in time so as to assure that the aeroplane can level off (L/O) with a minimum of 500 feet altitude clearance over the terrain/obstacle when descending toward the terrain/obstacle at any speed within the operational flight envelope of the aeroplane. The test conditions assume a descent along a flight path that has terrain that is 1000 feet below the expected level off altitude. If the pilot initiates the level off at the proper altitude, no TAWS alert would be expected. However, if the pilot is distracted or otherwise delays the level off, a TAWS alert is required to permit the pilot to recover to level flight in a safe manner.

a. See Table A. Column A represents the test condition. Columns B, C, and D are for information purposes only. Column E represents the Minimum Altitude for which TAWS alerts must be posted to perform their intended function. Column F represents the Maximum altitude for which TAWS alerts may be provided in order to meet the nuisance alert criteria. See appendix 3, Section 4.0

b. For each of the Descent rates specified below, recovery to level flight at or above 500 feet terrain clearance is required.

c. Test Conditions for 1.2:

| | |
|---|---|
| Assumed Pilot response time: | 3.0 seconds minimum |
| Assumed constant G pull-up: | 0.25 g's |
| Minimum Allowed Terrain Clearance: | 500 feet AGL |
| Descent rates: | 1000, 2000, 4000, and 6000 fpm |

Assumed Pilot Task for Column F: Level off at 1000 feet above the terrain per TERPS Required Obstacle Clearance (ROC).

NOTE 1: The actual values for the aeroplane altitude, distance and time from the terrain cell when caution and warning alerts are posted and the minimum terrain clearance altitude must be recorded.

NOTE 2: Enroute operations are considered to exist beyond 15 NM from the departure runway until 15 NM from the destination airport. Use of the nearest runway logic is permissible provided suitable logic is incorporated to ensure that the transitions to the terminal logic will typically occur only when the aeroplane is in terminal airspace.

NOTE 3: The values shown in column E may be reduced by 100 feet (to permit a level off to occur at 400 feet above the obstacle) provided that it can be demonstrated that the basic TAWS Mode 1 alert (sink rate) is issued at, or above, the altitude specified in column E for typical terrain topographies.

NOTE 4: Class B Equipment Considerations. The values shown in Column F are appropriate for Autopilot or Flight Director operations with an Altitude Capture function typical of many CS-25 certificated aeroplanes (Large Aeroplanes). The values are based upon 20 percent of the aeroplanes vertical velocity. If TAWS is installed on an aeroplane without such an Autopilot or Flight Director function, consideration should be given to computing the alerts based upon 10 percent of the vertical velocity which is more appropriate to manual flight and small general aviation aeroplane operations.

TABLE A

| Enroute Descent Alerting Criteria | | | | | |
|---|---|---|---|---|---|
| A | B | C | D | E | F |
| VERT SPEED (FPM) | ALT LOST WITH 3 SEC PILOT DELAY | ALT REQ'D TO L/O WITH 0.25G | TOTAL ALT LOST DUE TO RECOVERY MANEUVER | MINIMUM TAWS WARNING ALERT HEIGHT (ABOVE TERRAIN) | MAXIMUM CAUTION ALERT HEIGHT (ABOVE TERRAIN) |
| 1000 | 50 | 17 | 67 | 567 | 1200 |
| 2000 | 100 | 69 | 169 | 669 | 1400 |
| 4000 | 200 | 278 | 478 | 978 | 1800 |

1.3 Enroute Level Flight Requirement. During level flight operations (vertical speed is +/- 500 feet per minute), a terrain alert should be posted when the aeroplane is within 700 feet of the terrain and is predicted to be equal to or less than 700 feet within the prescribed alerting time or distance. See Table B for Test Criteria.

NOTE 1: The actual values for the aeroplane altitude, distance and time from the terrain cell when caution and warning alerts are posted must be recorded.

TABLE B

| Enroute Level Flight Alerting Criteria | | | |
|---|---|---|---|
| GROUND SPEED (KT) | HEIGHT OF TERRAIN CELL (MSL) | TEST RUN ALTITUDE (MSL) | ALERT CRITERIA |
| 200 | 5000 | 6000 | NO ALERT |
| 250 | 5000 | 5800 | NO ALERT |
| 300 | 5000 | 5800 | NO ALERT |
| 200 | 5000 | 5700 (+0/-100) | MUST ALERT |
| 250 | 5000 | 5700 (+0/-100) | MUST ALERT |
| 300 | 5000 | 5700 (+0/-100) | MUST ALERT |
| 400 | 5000 | 5700 (+0/-100) | MUST ALERT |
| 500 | 5000 | 5700 (+0/-100) | MUST ALERT |

1.4 Terminal Area (Intermediate Segment) Descent Requirement. A terrain alert shall be provided in time so as to assure that the aeroplane can level off (L/O) with a minimum of 300 feet altitude clearance over the terrain/obstacle when descending toward the terrain/obstacle at any speed within the operational flight envelope of the aeroplane. The test conditions assume a descent along a flight path that has terrain that is 500 feet below the expected level off altitude. If the pilot initiates the level off at the proper altitude, no TAWS alert would be expected. However, if the pilot is distracted or otherwise delays the level off, a TAWS alert is required to permit the pilot to recover to level flight in a safe manner.

a. See Table C: Column A represents the test condition. Columns B, C, and D are for information purposes only. Column E represents the Minimum Altitude for which TAWS alerts must be posted to perform their intended function. Column F represents the Maximum altitude for which TAWS alerts may be provided in order to meet the nuisance alert criteria. See appendix 3, Section 4.0.

b. For each of the Descent rates specified below, recovery to level flight at or above 300 feet terrain clearance is required.

c. Test Conditions for 1.4:

Assumed Pilot response time: 1.0 second minimum
Assumed constant G pull-up: 0.25 g's
Minimum Allowed Terrain Clearance: 300 feet AGL
Descent rates: 1000, 2000, and 3000 fpm
Assumed Pilot Task for Column F: Level off at 500 feet above the terrain per TERPS Required Obstacle Clearance (ROC).

NOTE 1: The actual values for the aeroplane altitude, distance and time from the terrain cell when caution and warning alerts are posted and the minimum terrain clearance altitude must be recorded.

NOTE 2: For Class B Equipment Considerations. The values shown in Column F are appropriate for Autopilot or Flight Director operations with an Altitude Capture function typical of many CS-25 certificated aeroplanes (Large Aeroplanes). The values are based upon 20 percent of the aeroplanes vertical velocity. If TAWS is installed on an aeroplane without such an Autopilot or Flight Director function, consideration should be given to computing the alerts upon 10 percent of the vertical velocity which is more appropriate to manual flight and small general aviation aeroplane operations.

TABLE C

| Terminal Descent Area Alerting Criteria | | | | | |
|---|---|---|---|---|---|
| A | B | C | D | E | F |
| VERT SPEED (FPM) | ALT LOST WITH 1 SEC PILOT DELAY | ALT REQ'D TO L/O WITH 0.25G | TOTAL ALT LOST DUE TO RECOVERY MANEUVER | MINIMUM TAWS WARNING ALERT HEIGHT (ABOVE TERRAIN) | MAXIMUM TAWS CAUTION ALERT HEIGHT (ABOVE TERRAIN) |
| 1000 | 17 | 17 | 34 | 334 | 700 |
| 2000 | 33 | 69 | 102 | 402 | 900 |
| 3000 | 50 | 156 | 206 | 506 | 1100 |

1.5 Terminal Area (Intermediate Segment) Level Flight Requirement. During level flight operations (vertical speed less than +/-500 feet per minute), a terrain alert should be posted when the aeroplane is less than 350 above the terrain and is predicted to be within less than 350 feet within the prescribed alerting time or distance. See Table D for Test Criteria.

NOTE 1: The actual values for the aeroplane altitude, distance and time from the terrain cell when caution and warning alerts are posted must be recorded.

TABLE D

| Terminal Area Level Flight Alerting Criteria | | | |
|---|---|---|---|
| GROUND SPEED (KT) | HEIGHT OF TERRAIN CELL (MSL) | TEST RUN ALTITUDE (MSL) | ALERT CRITERIA: |
| 150 | 1000 | 1500 | NO ALERT |
| 200 | 1000 | 1500 | NO ALERT |
| 250 | 1000 | 1500 | NO ALERT |
| 100 | 1000 | 1350 | MUST ALERT |
| 150 | 1000 | 1350 | MUST ALERT |
| 200 | 1000 | 1350 | MUST ALERT |
| 250 | 1000 | 1350 | MUST ALERT |

1.6 Final Approach Segment Descent Requirement. A terrain alert shall be provided in time to assure that the aeroplane can level off (L/O) with a minimum of 100 feet altitude clearance over the terrain/obstacle when descending toward the terrain/obstacle at any speed within the operational flight envelope of the aeroplane.

a. See Table E. Column A represents the test condition. Columns B, C, and D are for information purposes only. Column E represents the Minimum Altitude for which TAWS alerts must be posted to perform their intended function. Column F represents the Maximum altitude for which TAWS alerts may be provided in order to meet the nuisance alert criteria. See appendix 3, Section 4.0.

b. For each of the Descent rates specified below, recovery to level flight at or above 100 feet terrain clearance is required.

c. Test Conditions for 1.6:

| | |
|---|---|
| Assumed Pilot response time: | 1.0 seconds minimum |
| Assumed constant G pull-up: | 0.25 g's |
| Minimum Allowed Terrain Clearance: | 100 feet AGL |
| Descent rates: | 500, 750, 1000, and 1500 fpm |

Assumed Pilot Task for Column F: Level off at 250 feet above the terrain per TERPS Required Obstacle Clearance (ROC).

NOTE 1: The actual values for the aeroplane altitude, distance and time from the terrain cell when caution and warning alerts are posted and the minimum terrain clearance altitude must be recorded.

NOTE 2: For Class B equipment Considerations. The values shown in Column F are appropriate for Autopilot or Flight Director operations with an Altitude Capture function typical of many CS-25 certificated aeroplanes (Large Aeroplanes). The values are based upon 20 percent of the aeroplanes vertical velocity. If TAWS is installed on an aeroplane without such an Autopilot or Flight Director function, consideration should be given to computing the alerts based upon 10 percent of the vertical velocity which is more appropriate to manual flight and small general aviation aeroplane operations.

TABLE E

| Final Approach Descent Alerting Criteria | | | | | |
|---|---|---|---|---|---|
| A | B | C | D | E | F |
| VERT SPEED (FPM) | ALT LOST WITH 1 SEC PILOT DELAY | ALT REQ'D TO L/O WITH 0.25G | TOTAL ALT LOST DUE TO RECOVERY MANEUVER | MINIMUM TAWS WARNING ALERT HEIGHT (ABOVE TERRAIN) | MAXIMUM TAWS CAUTION ALERT HEIGHT (ABOVE TERRAIN) |
| 500 | 8 | 4 | 12 | 112 | 350 |
| 750 | 12 | 10 | 22 | 122 | 400 |
| 1000 | 17 | 18 | 35 | 135 | 450 |
| 1500 | 25 | 39 | 64 | 164 | 550 |

1.7 Final Approach Level Flight Requirement. During level flight operations at the Minimum Descent Altitude (MDA), a terrain alert should be posted when the aeroplane is within 150 feet of the terrain and is predicted to be within less than 150 feet within the prescribed alerting time or distance. See Table F for test criteria.

NOTE 1: The actual values for the aeroplane altitude, distance and time from the terrain cell when caution and warning alerts are posted must be recorded.

TABLE F

| Final Approach Level Flight Alerting Criteria | | | | |
|---|---|---|---|---|
| GROUND SPEED (KT) | HEIGHT OF TERRAIN CELL (MSL) | DISTANCE TERRAIN FROM RWY (NM) | TEST RUN ALTI-TUDE (MSL) | ALERT CRITERIA |
| 120 | 400 | 2.0 | 650 | NO ALERT |
| 140 | 400 | 2.0 | 650 | NO ALERT |

| | | | | |
|---|---|---|---|---|
| 160 | 400 | 2.0 | 650 | NO ALERT |
| 120 | 400 | 2.0 | 600 | MAY ALERT |
| 140 | 400 | 2.0 | 600 | MAY ALERT |
| 160 | 400 | 2.0 | 600 | MAY ALERT |
| 100 | 400 | 2.0 | 550 | MUST ALERT |
| 120 | 400 | 2.0 | 550 | MUST ALERT |
| 140 | 400 | 2.0 | 550 | MUST ALERT |
| 160 | 400 | 2.0 | 550 | MUST ALERT |

2.0 Forward Looking Terrain Avoidance Imminent Terrain Impact Test Conditions. The following test conditions must be conducted to evaluate level flight performance during all phases of flight:

NOTE 1: The actual values for the aeroplane altitude, distance and time from the terrain cell when caution and warning alerts are posted must be recorded.

NOTE 2: Based upon a one second pilot delay and a 0.25 g incremental pull to constant 6.0 degree climb gradient, compute and record the aeroplane altitude at the terrain cell, the positive (or negative) clearance altitude, and the aeroplane position and time (after the alert), when the alert envelope is cleared.

2.1 Test Criteria. For each of the test cases below, a positive clearance of the terrain cell of interest is required.

2.2 Additional Test Criteria. Repeat each of the test cases below with the altitude error (-100 feet or -200 feet). A positive clearance of the terrain cell of interest is required.

TABLE G

| Imminent Terrain Impact Alerting Criteria | | | | |
|---|---|---|---|---|
| GROUND SPEED (KT) | HEIGHT OF TERRAIN CELL (MSL) | DISTANCE TERRAIN FROM RWY (NM) | TEST RUN ALTITUDE (MSL) | ALERT CRITERIA |
| 200 | 10000 | 30 | 9000 | MUST ALERT |
| 250 | 10000 | 30 | 9000 | MUST ALERT |
| 300 | 10000 | 30 | 9000 | MUST ALERT |
| 400 | 10000 | 30 | 8000 | MUST ALERT |
| 500 | 10000 | 30 | 8000 | MUST ALERT |
| 150 | 2000 | 10 | 1500 | MUST ALERT |
| 200 | 2000 | 10 | 1500 | MUST ALERT |
| 250 | 2000 | 10 | 1500 | MUST ALERT |
| 100 | 600 | 5 | 500 | MUST ALERT |
| 120 | 600 | 5 | 500 | MUST ALERT |
| 140 | 600 | 5 | 500 | MUST ALERT |
| 100 | 600 | 4 | 200 | MUST ALERT |
| 120 | 600 | 4 | 200 | MUST ALERT |
| 140 | 600 | 4 | 200 | MUST ALERT |
| 160 | 600 | 4 | 200 | MUST ALERT |
| 160 | 600 | 5 | 500 | MUST ALERT |

3.0 Premature Descent Alert Test Conditions. The purpose of this test is to verify that the pilot will be alerted to a „low altitude condition“ at an altitude that is defined by the specific design PDA Alert surface. This ETSO will not define specific pass/fail criteria since, as stated in paragraph 3.2 of appendix 1, it does not define the surfaces for which alerting is required. The applicant must provide its proposed pass/fail criteria along with the proposed recovery procedures for the specific alerting criteria proposed by the applicant. In developing its test plan, the applicant should refer to paragraph 3.2 of appendix 1 that contain some general requirements for alerting and some cases when alerting is inappropriate. The applicant also may want to consider the recovery procedures specified in paragraphs 1.2, 1.4, and 1.6 of paragraph 1 of appendix 3. The following test conditions must be conducted to evaluate PDA performance.

3.1 Test Conditions for 3.0 Premature Descent Alerts.
Descent rates: 750, 1500, 2000, 3000 FPM
Assumed Runway Elevation: Sea Level, Level Terrain

NOTE: For each test condition listed in Table H, compute and record the PDA alert altitude and the recovery altitude to level flight.

TABLE H

| **Premature Descent Alerting Criteria** | | | | |
|---|---|---|---|---|
| GROUND SPEED (KT) | VERT. SPEED (FPM) | DISTANCE FROM RWY THRESHOLD (Touchdown) (NM) | PDA ALERT HEIGHT (MSL) | RECOVERY ALTITUDE (MSL) |
| 80 | 750 | 15 | | |
| 100 | 1500 | 15 | | |
| 120 | 750 | 15 | | |
| 140 | 1500 | 15 | | |
| 160 | 750 | 15 | | |
| 200 | 1500 | 15 | | |
| 250 | 2000 | 15 | | |
| 80 | 750 | 12 | | |
| 100 | 1500 | 12 | | |
| 120 | 750 | 12 | | |
| 140 | 1500 | 12 | | |
| 160 | 750 | 12 | | |
| 80 | 750 | 4 | | |
| 100 | 1500 | 4 | | |
| 120 | 750 | 4 | | |
| 140 | 1500 | 4 | | |
| 80 | 750 | 2 | | |
| 100 | 1500 | 2 | | |
| 120 | 750 | 2 | | |
| 140 | 1500 | 2 | | |

4.0 Nuisance Alert Test Conditions - General. The following test conditions must be conducted to evaluate TAWS performance during all phases of flight. The following general criteria apply:

4.1 4000FPM. It must be possible to descend at 4000 FPM in the enroute airspace and level off 1000 feet above the terrain using a normal level off procedure (leading the level off by 20 percent of the vertical speed) without a caution or warning alert. See Table A.

4.2 2000FPM. It must be possible to descend at 2000 FPM in the Terminal area and level off 500 feet above the terrain using the normal level off procedure described in 4.1 above, without a caution or warning alert. See Table C.

4.3 1000FPM. It must be possible to descend at 1000 FPM in the Final Approach Segment and level off at the Minimum Descent Altitude (MDA) using the normal level off procedure described in 4.1 above, without a caution or warning alert. See Table E.

5.0 <u>Nuisance Test Conditions for Horizontal and Vertical Flight Technical Errors.</u> It shall be shown, by analysis, simulation or flight testing, that the system will not produce nuisance alerts when the aeroplane is conducting normal flight operations in accordance with published instrument approach procedure. This assumes the normal range in variation of input parameters.

5.1 Test Cases. As a minimum, the following cases (1 –9) shall be tested twice; one set of runs will be conducted with no lateral or vertical errors while another set of runs will be conducted with both lateral and vertical Flight Technical Errors (FTE). A lateral FTE of 0.3 NM and a vertical FTE of -100 feet (aircraft is closer to terrain) up to the FAF and a lateral FTE of 0.3 NM and a vertical FTE of -50 feet from the FAF to the Missed Approach Point (MAP) shall be simulated. For all listed VOR, VOR/DME and Localizer based approaches, from the FAF to the MAP the aeroplane will descend at 1000 FPM until reaching either MDA (run #1) or MDA-50 feet (run #2). The aeroplane will then level off and fly level until reaching the MAP. Localizer updating of lateral position errors (if provided) may be simulated.

TABLE I

| Nuisance Alert Test Conditions for Horizontal and Vertical Flight Technical Errors | | |
|---|---|---|
| Case | Location | Operation |
| 1 | Quito, Ecuador | VOR 'QIT'-ILS Rwy 35 |
| 2 | Katmandu, Nepal | VOR-DME Rwy 2 |
| 3 | Windsor Locks, CN | VOR Rwy 15 |
| 4 | Calvi, France | LOC DME Rwy 18 / Circle |
| 5 | Tegucigalpa, Honduras | VOR DME Rwy 1 / Circle |
| 6 | Eagle, CO | LOC DME-C |
| 7 | Monterey, CA | LOC DME Rwy 28L |
| 8 | Juneau, AK | LDA-1 Rwy 8 |
| 9 | Chambery, France | ILS Rwy 18 |

6.0 <u>Test Conditions Using Known Accident Cases</u>. The aircraft configuration and flight trajectory for each case may be obtained from the Operations Assessment Division, DTS-43, Volpe National Transportation Systems Center, Cambridge, Massachusetts or at the FAA web page at the following address: http://www.faa.gov/avr/air/airhome.htm or http://www.faa.gov and then select „Regulation and Certification", select „Aircraft Certification".

6.1 Test Report. The test report should include as many of the following parameters use to recreate the events. They are (1) latitude; (2) longitude; (3) altitude; (4) time from terrain at caution and warning alerts; (5) distance from terrain at caution and warning alerts; (6) ground speed; (7) true track; (8) true heading; (9) radio altitude; (height above terrain) (10) gear position; and (11) flap position.

6.2 Computation and Recording. In addition to the above when the warning is posted, for each test case, based upon a one second pilot delay and a 0.25 g incremental pull to a constant 6.0 degree climb gradient, do the following. Compute and record the aeroplane altitude at the terrain cell, the positive (or negative) clearance altitude, and the aeroplane position and time (after the alert), when the alert envelope is cleared.

> NOTE: The terrain cell of interest is the one associated with the accident and not necessarily the terrain cell that caused the warning.

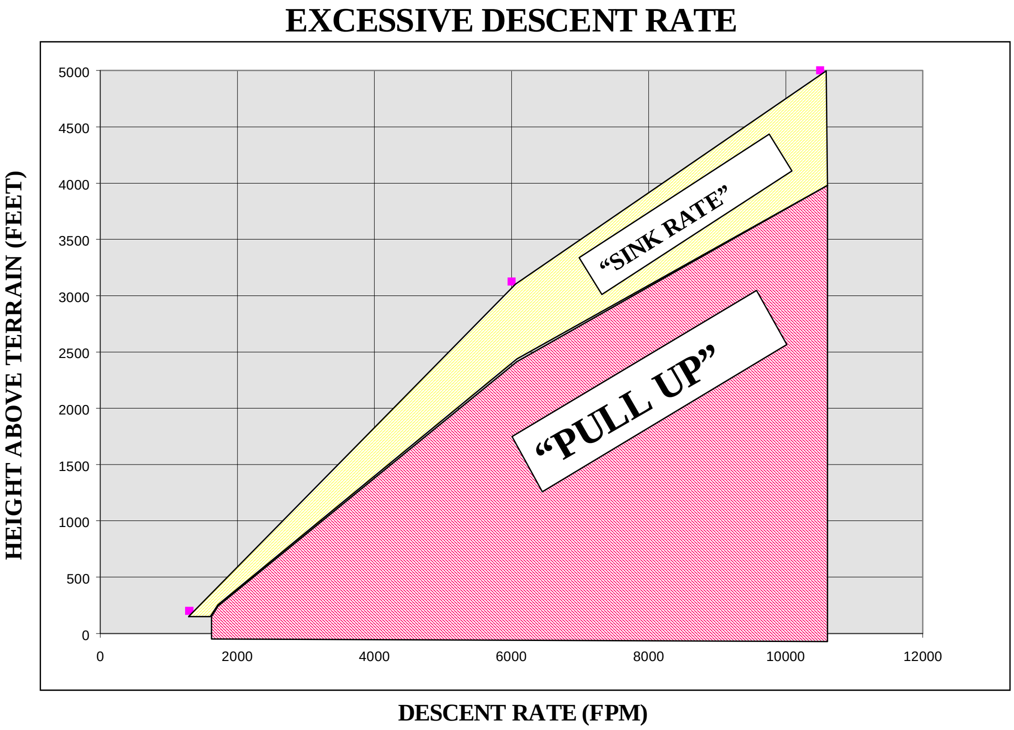
6.3 Test Criteria. In each of the test cases below, it shall be necessary to demonstrate that the aeroplane profile clears the terrain cell of interest.

TABLE J

| Known Accident Cases | | | |
|---|---|---|---|
| LOCATION | IATA CODE | DATE | AIRCRAFT REGISTRATION NUMBER |
| La Paz, Bolivia | | 1/1/85 | N819EA |
| Flat Rock, NC | | 8/23/85 | N600CM |
| Windsor, MA | | 12/10/86 | N65TD |
| Eagle, CO | | 3/27/87 | N31SK |
| Tegucigalpa, Honduras | | 10/21/89 | N88705 |
| Halawa Point, HI | | 10/28/89 | N707PV |
| San Diego, CA | | 3/16/91 | N831LC |
| Rome, GA | | 12/11/91 | N25BR |
| Gabriels, NY | | 1/3/92 | N55000 |
| Alamogordo, NM | | 6/24/92 | N108SC |
| E. Granby, CT | | 11/12/95 | N566AA |
| Buga, Columbia | | 12/20/95 | N651AA |
| Nimitz Hill, Guam | | 8/6/97 | H7468 |

7.0 Class B Equipment Test Requirements for Excessive Descent Rate: Use the following performance envelopes down to a „Height above Terrain“ value of 100 feet . Instead of using Height of Terrain as determined by a radio altimeter, determine „Height above Terrain“ as determined by subtracting the Terrain Elevation (from the Terrain Data Base) from the current QNH barometric altitude (or equivalent). The curve represents the minimum heights at which alerting must occur.

NOTE: Class B equipment may be designed to meet the requirements of DO-161A for Excessive Descent Rate in lieu of the requirements of 7.0




8.0 Class B Equipment Test Requirements for Negative Climb Rate or Altitude Loss After Takeoff. Use the existing performance envelopes specified in DO-161A based upon a „Height above Runway " using barometric altitude (or equivalent) and runway elevation in lieu of radio altimeter inputs.

9.0 Class B Equipment Test Requirements for the Altitude Callouts. Instead of using Height of Terrain as determined by a radio altimeter, determine Height above runway as determined by subtracting the Runway Elevation (from the Airport Data Base) from the current barometric altitude (or equivalent). When the Height above Terrain value first reaches 500 feet a single voice alert („Five Hundred ") or equivalent shall be provided.

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# CS-ETSO

# INDEX 2

# European Technical Standard Orders

**ETSO-2C11e**
**Date: 24.10.03**

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** 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-2C19b**
**Date: 24.10.03**

**European Aviation Safety Agency**

# European Technical Standard Order

**Subject:** PORTABLE WATER-SOLUTION TYPE FIRE EXTINGUISHERS

**1 - Applicability**

This ETSO gives the requirements which new models of portable water-solution type fire extinguishers 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 document: AS-245A, „Water Solution Type Hand Fire extinguisher", dated November 1, 1948, revised December 15, 1956 and supplemented by this ETSO.

3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1

3.1.3- Computer Software:

None.

3.2 - Specific

Following AS-245A paragraphs are supplemented as indicated:

§ 4.1.1: For both types, minimum tank capacity is one (1) liter.

§ 4.1.2: Burst pressure must be equal or greater than „b" times Design pressure (see following table).
Design pressure is compatible with maximum pressure encountered in use of extinguisher
and ensures a long service of equipment when charged.

§ 4.3.1: In case of water spray extinguishers, minimum discharge duration is of fifteen (15) seconds.

§ 4.3.2: In case of water spray extinguishers, minimum discharge horizontal distance is of one and
half (1.5) metre.

§ 5.2: Proof pressure must be equal or greater than „p" times Design pressure (see following table).

Table: „b“ and „p“ factors indicated depend on extinguisher type:

| | b | p |
|---|---|---|
| Type I | 2,7 | 1,5 |
| Type II | 2,4 | 1,2 |

**4 - Marking**

4.1 - General

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

4.2 - Specific

As specified in the SAE Aerospace Standard document:AS-245A.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3

**ETSO-2C34f**
**Date: 24.10.03**

# European Aviation Safety Agency

## European Technical Standard Order

Subject: 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
Date: 24.10.03

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# European Technical Standard Order

**Subject:** RADIO 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**
**Date: 24.10.03**

# European Aviation Safety Agency

## European Technical Standard Order

Subject: 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-2C37e**
**Date: 24.10.03**

# European Aviation Safety Agency

# European Technical Standard Order

**Subject:** VHF RADIO COMMUNICATION TRANSMITTING EQUIPMENT OPERATING WITHIN THE RADIO FREQUENCY RANGE 117.975-137 MEGAHERTZ

**1 - Applicability**

This ETSO gives the requirements which VHF radio transmitting equipment operating within 117.975- 137MHz 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-23B dated March 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 paragraph 1.2.

4.2 - Specific

None.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

**ETSO-C38e**
**Date: 24.10.03**

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** VHF RADIO COMMUNICATION RECEIVING EQUIPMENT OPERATING WITHIN THE RADIO FREQUENCY RANGE 117.975-137 MEGAHERTZ

**1 - Applicability**

This ETSO gives the requirements which VHF radio receiving equipment operating within 117.975-137MHz 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-23B dated March 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 paragraph 1.2.

4.2 - Specific

None.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

**ETSO-2C40c**
**Date: 24.10.03**

# European Aviation Safety Agency

# European Technical Standard Order

**Subject:** 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-l17.95 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 (±2.7° Vs±3.0°).
- 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**
**Date: 24.10.03**

# European Aviation Safety Agency

# European Technical Standard Order

**Subject:** 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 l 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-2C63c**
**Date: 24.10.03**

# European Aviation Safety Agency

# European Technical Standard Order

**Subject:** AIRBORNE WEATHER AND GROUND MAPPING PULSED RADARS

**1 - Applicability**

This ETSO gives the requirements which airborne weather and ground mapping pulsed radars 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-38.

In addition to requirements of EUROCAE document ED-38, all materials used except small parts (such as knobs, fasteners, seals, grommets and small electrical parts) that would not contribute significantly to the propagation of a fire, must be self-extinguishing when tested in accordance with applicable requirements of CS 25 Appendix F.

3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1

3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2

3.2 - Specific

None

**4 - Marking**

4.1 - General

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

4.2 - Specific

None.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

**ETSO-2C66b**
**Date: 24.10.03**

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** 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**
**Date: 24.10.03**

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** 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

DECEMBER 15, 1962

## Federal Aviation Agency Standard For Hydraulic Hose Assemblies

**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] | 160° F. |
| IB | High [2] | 160° 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 fluid[3] 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.

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 conforrn 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

[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.

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 l6 and larger size assemblies may be tested at -40° F. in lieu of the above specified temperature.

**5.0** ***Test Requirements, Type IIIA 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 l-hour wherein ambient and fluid temperatures are 400°±10° 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±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°±10° 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°±2° 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°±2° 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.*** Fire-resistant 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.*

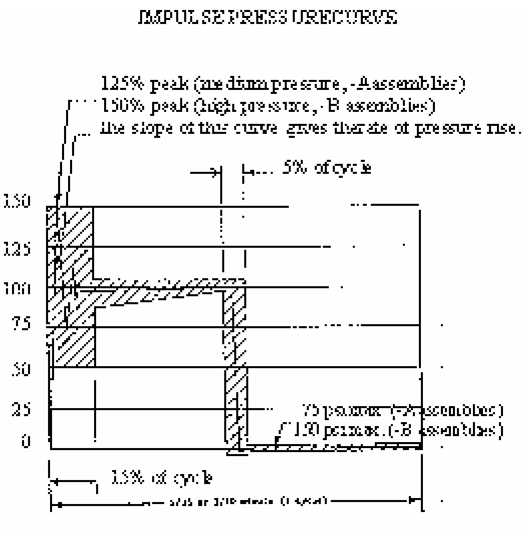
| *Type Hose Assembly* | *Hoze Size* | *Maximum Operating Pressure* | *Flow Rate GPM* |
|---|---|---|---|
| IA and IIA | -3 | 1,500 | 7 x (ID)$^2$ |
| | -4 | 1,500 | " |
| | -5 | 1,500 | " |
| | -6 | 1,500 | " |
| | -8 | 1,500 | " |
| | -10 | 1,500 | " |
| | -12 | 1,000 | " |
| | -16 | 800 | " |
| | -20 | 600 | 3 x (ID)$^2$ |
| | -24 | 500 | 1 x (ID)$^2$ |
| IB and IIB | All | 3,000 | 1 x (ID)$^2$ |
| IIIA | -3 to -10 | 1,500 | 1 x (ID)$^2$ |
| | -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? | 5¾ | 4? | 5¾ |
| -10 | 23½ | 30 | 23½ | 30 | 5½ | 6½ | 5½ | 6½ |
| -12 | 27½ | 33 | 27½ | 33 | 6½ | 7¾ | 6½ | 7¾ |
| -16 | 18 | 24 | 18 | 24 | 7? | 9? | 7? | 9? |
| -20 | 18 | — | 18 | — | 9 | — | 11 | — |
| -24 | 18 | — | 18 | — | 11 | — | 14 | — |
| -32 | 18 | — | — | — | 13¼ | — | — | — |

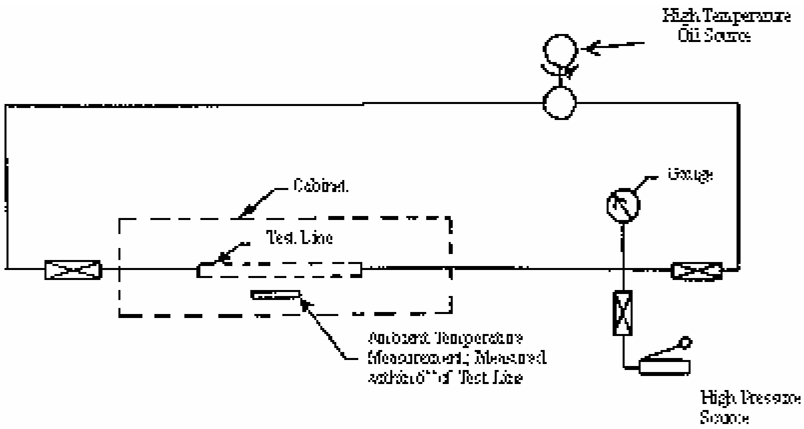
TABLE I



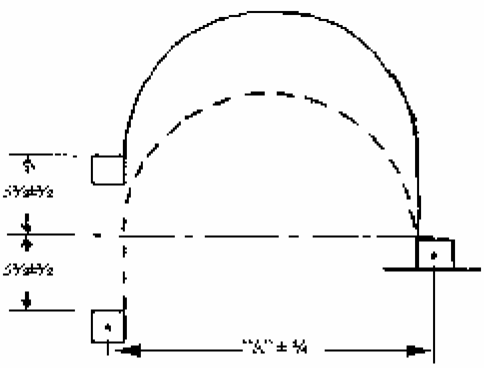

The curve shown above is the approximate pressure-time cycle determined to be of proper severity for impulse testing of hose assemblies. The pressure-time curve shall be confined to the shaded area indicated.

NOTE : Cycling tolerance = 35±5 or 70±10 cycles per minute.

FIGURE I




Typical Setup for High Temperature Pressure Testing
Figure II




| Hose Size | "A" Inches | Assem Length Inches |
|---|---|---|
| -4 | 5½ | 20 |
| -6 | 10 [illegible] | 27 |
| -8 | 12¾ | 30 |
| -10 | 14 | 33 |
| -12 | 16 [illegible] | 37 |
| -16 | 20¾ | 45 |

Assembly Flex Test Setup
Figure III

**European Aviation Safety Agency**

# European Technical Standard Order

**Subject:** LOW RANGE RADIO ALTIMETERS

**1 - Applicability**

This ETSO gives the requirements which 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 dated March 1980.

In addition to Chapter 5 of EUROCAE document ED-30, all materials used except small parts (such as knobs, fasteners, seals, grommets and small electrical parts) that would not contribute significantly to the propagation of a fire, must be self-extinguishing when tested in accordance with applicable requirements of CS 25 Appendix F.

3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1

3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2

3.2 - Specific

None

**4 - Marking**

4.1 - General

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

4.2 - Specific

None.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

**ETSO-2C91a**
**Date: 24.10.03**

**European Aviation Safety Agency**

# European Technical Standard Order

**Subject:** EMERGENCY LOCATOR TRANSMITTER (ELT) EQUIPMENT

**1 - Applicability**

This ETSO gives the requirements which emergency locator transmitter 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-62 (or RTCA DO-183 Section 2.0, change 1 dated Jan. 17, 1983) as amended and supplemented by this ETSO:

(i) In lieu of optional Paragraph 2.2.2.2b of DO-183 for modulation characteristics the following applies as a requirement for this ETSO: to aid SAR satellite detection the ELT shall have clearly defined sideband components which are symmetric about the output signal spectrum and distinct from the carrier component at both the 121.5 and 243 MHz frequencies. The ELT spectrum at 121.5 MHz shall have at least 30% of its energy distribution within a bandwidth of ±30Hz about a fixed reference frequency corresponding to the carrier component over the audio/sweep modulation cycle. At 243 MHz 30% of the energy distribution shall fall within a bandwidth of ±60 Hz.

(ii) In addition to paragraph 1.0, General Standards, of RTCA DO-163, all materials used except small parts (such as knobs, fasteners, seals, grommets and small electrical parts) that would not contribute significantly to the propagation of a fire, must be self-extinguishing when tested in accordance with applicable requirements of CS 25 Appendix F.

3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1

3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2

3.2 - Specific

None

**4 - Marking**

4.1 - General

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

4.2 - Specific

None.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

ETSO-2C93b
Date: 24.10.03

# European Aviation Safety Agency

# European Technical Standard Order

**Subject:** 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**
**Date: 24.10.03**

# European Aviation Safety Agency

## European Technical Standard Order

**Subject:** 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-2C112a**
**Date : 24.10.03**

# European Aviation Safety Agency

## European Technical Standard Order

Subject: AIR TRAFFIC CONTROL RADAR BEACON SYSTEM/MODE SELECT (ATCRBS/MODE S) AIRBORNE EQUIPMENT

**1 - Applicability**

This ETSO gives the requirements which airborne Mode S air traffic control (ATC) transponder 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 - General

3.1.1 - Minimum Performance Standard

Standards set forth in EUROCAE document ED-73A, 'MOPS for SSR Mode S Transponders', dated February 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-2C122
Date: 24.10.03

# European Aviation Safety Agency

# European Technical Standard Order

**Subject:** 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-2C126**
**Date: 24.10.03**

**European Aviation Safety Agency**

# European Technical Standard Order

**Subject:** 406 MHz EMERGENCY LOCATOR TRANSMITTER (ELT)

**1 - Applicability**

This ETSO gives the requirements which devices that 406 MHz emergency locator transmitters (ELTs), 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-62, „MOPS for Aircraft Emergency Locator Transmitters (121.5/243 MHz and 406 MHz)“, dated May 1990.

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-2C128
Date: 24.10.03

# European
# Aviation
# Safety
# Agency

# European Technical Standard Order

**Subject:** 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.

# European Aviation Safety Agency

## European Technical Standard Order

Subject: 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**
**Date : 24.10.03**

# European Aviation Safety Agency

# European Technical Standard Order

Subject: 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