Certification Memorandum

Minimum qualification standards for oxygen cylinders used on board aircraft

EASA Proposed CM No.: Proposed CM-ECS-001 Issue 01 issued 23 May 2018

Regulatory requirement(s): CS-23, CS-25, CS-27 and CS-29

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Log of issues

Issue	Issue date	Change description
01	23.05.2018	First issue.

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1. Introduction

1.1. Purpose and scope

The purpose of this Certification Memorandum is to provide specific guidance and minimum qualification standards for oxygen cylinders to be acceptable as part of aircraft installations, either in built-in oxygen systems or as stand-alone portable devices.

1.2. References

It is intended that the following reference materials should be used in conjunction with this Certification Memorandum. They are referenced in the CM text as superscript in square bracket. Footnotes are instead referenced as superscript only.

Reference		Title	Issue	Date
[1]	COMMISSION REGULATION (EU) No 965/2012	Commission Regulation laying down technical requirements and administrative procedures related to air operations pursuant to Regulation (EC) No 216/2008 of the European Parliament and of the Council.	N/A	05.10.2012
[2]	EASA CS-23	Certification specifications for Normal Category Aeroplanes	Amendment 5	29.03.2017
[3]	EASA CS-25	Certification specifications and Acceptable Means of compliance for Large Aeroplane	Amendment 20	24.08.2017
[4]	EASA CS-27	Certification specifications and Acceptable Means of compliance for Small Rotorcraft	Amendment 4	30.11.2016
[5]	EASA CS-29	Certification specifications and Acceptable Means of Compliance for Large Rotorcraft	Amendment 4	30.11.2016
[6]	FAA AC 29-2C	Advisory Circular: Certification of Transport category rotorcraft	Change 6	25.07.2014
[7]	FAA AC 27-1B	Advisory Circular: Certification of Normal category rotorcraft	Change 6	25.07.2015
[8]	ETSO 2C512	Portable Gaseous Oxygen System		
[9]	SAE AS1046	Minimum Standard for Portable Gaseous Oxygen Equipment	Rev. C	12-2006
[10]	49 CFR Part 178 – Subpart C	Code of Federal Regulation: Specification for packaging – Specification for Cylinders		

Reference	Title	Issue	Date
[11] EASA Generic Interpretative material/Means of compliance	Oxygen fire hazards		
[12] 49 CFR Part 173	Code of Federal Regulation: Shippers – General Requirements for Shipments and Packaging		
[13] 49 CFR Part 175	Code of Federal Regulations: Carriage by aircraft		
[14] ISO 7866	Gas cylinders -- Refillable seamless aluminium alloy gas cylinders -- Design, construction and testing	2nd Edition	2012
[15] ISO 9809-1	Gas cylinders -- Refillable seamless steel gas cylinders -- Design, construction and testing -- Part 1: Quenched and tempered steel cylinders with tensile strength less than 1 100 MPa	2nd Edition	2010
[16] ISO 9809-2	Gas cylinders -- Refillable seamless steel gas cylinders -- Design, construction and testing -- Part 2: Quenched and tempered steel cylinders with tensile strength greater than or equal to 1 100 MPa	2nd Edition	2010
[17] ISO 9809-3	Gas cylinders -- Refillable seamless steel gas cylinders -- Design, construction and testing -- Part 3: Normalized steel cylinders	2nd Edition	2010
[18] DOT-CFFC	Basic requirements for fully wrapped Carbon-Fibre reinforced aluminium lined cylinders	5th Edition	March 2007
[19] DOT-FRP-1	Basic requirements for fibre reinforced plastic (FRP) Type 3FC (fully wrapped) composite cylinder	Revision 2	15 February 1987
[20] DOT-FRP-2	Basic requirements for fibre reinforced plastic (FRP) Type 2HW (Hoop wrapped) composite cylinder	Revision 1	4 January 1987
[21] ISO 11119-1	Gas cylinders— Refillable composite gas cylinders and tubes — Design, construction and testing —Part 1: Hoop-wrapped fibre reinforced	2nd Edition	01.08.2012

Reference	Title	Issue	Date
	composite gas cylinders and tubes up to 450 l.		
[22] ISO 11119-2[1]	Gas cylinders— Refillable composite gas cylinders and tubes — Design, construction and testing —Part 2: Fully wrapped fibre reinforced composite gas cylinders and tube up to 450 l with load-sharing metal liners.	2nd Edition	15.07.2012
[23] ISO 11119-3	Gas cylinders — Refillable composite gas cylinders and tubes — Part 3: Fully wrapped fibre reinforced composite gas cylinders and tubes up to 450 l with non-load-sharing metallic or non-metallic liners.	2nd Edition	15.04.2013
[24] RTCA/DO-160/ED-14[2]	Environmental conditions and test procedures	Issue G	May 2011

1.3. Abbreviations

AC	Advisory Circular
AS	Airspace Standard (SAE)
CEN	European Committee for Standardization
CFR	Code of Federal Regulation (USA)
CM	Certification Memorandum
CRI	Certification Review Item
CS	Certification Specification (EASA)
DOT	US Department of Transportation
EASA	European Aviation Safety Agency
(H)EMS	(Helicopter) Emergency Medical Service
ETSO	European Technical Standard Order

[1] Amendment 1 was issued during 2014 to align the drop test to the new standard as published in the more recent ISO 11119-3 text.

[2] Change 1 was issued on January 2015 to remove some User Guides and to include them in the newly created ED-234. Removing the current User Guide material from ED-14G and placing in its own document, ED-234, would have reduced the confusion regarding the differences between requirements and guidance. There is no technical difference in the requirements compared to issue G.

FAA	Federal Aviation Administration
HMR	Hazardous Material Regulations
ISO	International Standardization Organization
MG	Miscellaneous Guidance
PGOS	Portable Gaseous Oxygen System
PHMSA	Pipeline and Hazardous Material Safety Administration, DoT
SAE	Society of Automotive Engineering
TC	Type Certificate or Technical Committee as applicable
TSO	Technical Standard Order
UN	United Nations

1.4. Definitions

Oxygen Cylinder/Receptacle	Pressure vessel to store breathable gas (oxygen) under high pressure. Herein the words cylinder and receptacle are used with the same meaning.
Oxygen as *supplemental source*	Oxygen is used to compensate for the reduction of partial oxygen pressure in the lungs when flying above 10 000 ft. as a result of any aircraft structural or system failure. Operating rules [1] prescribe when oxygen has to be used and for how long.
Composite Cylinder	A pressure vessel usually consists of a gas-tight metal (e.g. aluminium) container or liner reinforced by filament material as fiberglass, Kevlar, carbon, or hybrid fibres. Some designs could have either no liner, a non-metallic liner or a non load-sharing metallic liner.
Liner	The inner portion of a composite cylinder, comprising a metallic vessel, whose purpose is either to contain the gas or transmit the gas pressure to the external fibres. Normally manufactured with steel or aluminium.
Load-sharing liner	A liner which has a burst pressure greater than or equal to 5 % of the nominal burst pressure of the finished composite cylinder
Hoop wrapped composite or type 2 composite cylinder	A pressure cylinder with a load-sharing metal liner and composite reinforcement on the cylindrical portion only
Fully wrapped composite or type 3 composite cylinder	A pressure cylinder with a load-sharing metal liner and composite reinforcement on both the cylindrical and dome ends to be able to take both circumferential and longitudinal stress.

2. Background

EASA currently has neither specific acceptable initial qualification standards nor recurrent maintenance standards for oxygen cylinders/receptacles:

- as part of aircraft installations (so-called built-in oxygen systems) used as *supplemental oxygen sources* or
- as part of portable devices[3].

Besides the use of oxygen as a supplemental source, there are other applications where oxygen cylinders are transported or installed on board aircraft as part of medical equipment to provide either first-aid assistance to passengers with respiratory deficiencies (not caused by an earlier depressurization event) or as part of an Emergency Medical Service (EMS) installation[4]. In this respect, the EASA CS-23/CS-25/CS-27/CS-29 certification specifications do not require oxygen installation for first aid or medical use but operating rules may specifically call for such installation[5].

As for specific rotorcraft applications, oxygen installation safety requirements are not currently included in either the EASA CS-27[4] or the CS-29[5] airworthiness standards for rotorcraft since the use of oxygen on rotorcraft as a "*supplemental source*" is not envisaged due to the "usual" flight ceiling operational envelope of rotorcraft[6]. Nevertheless, EMS configurations are currently one of the most requested modifications on rotorcraft, and are seldom performed by TC holders. Since FAA AC27-1B [7] and AC 29-2C [6] are referenced in Book 2 of respectively EASA CS-27 and EASA CS-29 as acceptable means of compliance with the EASA certification specifications, the Miscellaneous Guidance MG 6 in the above advisory circulars are also currently used by applicants and accepted by EASA to demonstrate an acceptable level of safety from an EMS installation on rotorcraft. The US guidance material suggests that high pressure oxygen cylinders should be DOT approved, i.e., designed and manufactured according to DOT specifications under Title 49 CFR Part 178, Subpart C[10].

On the European side, EASA CS-23[2] and CS-25[3] do not contain any specific requirements for the design and manufacture of oxygen cylinders; CS 25.1453[7] only specifies proof and burst factors for cylinders.

More recently, some new guidance material/acceptable means of compliance has been issued by EASA that applies both for large aircraft and for large and small rotorcraft oxygen system installations [11]; this would help to mitigate the oxygen fire risk associated with internal and external ignition factors. Nevertheless, this new guidance material does not require any minimum design and manufacturing qualification level for oxygen cylinders.

Finally, EASA ETSO 2C512[8], which in turn refers to the SAE AS 1046[9] Rev. C standard, covers a portable gaseous oxygen system (PGOS) as a whole, i.e. the oxygen bottle and the related dispensing unit (oxygen mask); the oxygen cylinder as per ref. [9]: "....*shall conform to Department of Transportation (DOT) Specifications 3A or 3AA or to any other DOT specifications for transportable cylinders for oxygen service. Local regulations including any applicable nation's* requirements *may also apply*....."

This Certification Memorandum is intended to clarify the EASA policy regarding minimum qualification standards both for metallic and composite receptacles. This document is not intended to introduce any new

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[3] For example to comply with *CS 25.1447(c)(4): Portable oxygen equipment must be immediately available for each cabin crew member. The portable oxygen equipment must have the oxygen dispensing unit connected to the portable oxygen supply.* Here the portable oxygen bottle is intended to be used by cabin crew, when requested by operating rules, for their mobility into a depressurised cabin, i.e. as a supplemental oxygen source [1].

[4] Emergency medical service configurations are used in search & rescue missions and air ambulance transportation missions – see also HEMS as defined in Annex 1 of Comm. Reg. (EU) No 965/2012[1].

[5] The Large Aeroplane requirement, CS 25.1443(d), prescribes the oxygen minimum mass flow rate if first-aid oxygen equipment is installed.

[6] Normally limited to 10 000 ft.

[7] CS 25.1453 : *Protection of oxygen equipment from rupture*

certification processes for oxygen bottles or any consequent additional burden for the applicant. EASA merely intends to accept for transportation/installation certain pressurised receptacles that have undergone a qualification process according to well-recognised international standards.

3. EASA recommended minimum qualification standard for metallic receptacles

3.1. Regulation background

The US Department of Transportation has set various standards for pressure receptacles in 49 CFR Part 178 Subpart C [10]. The transportation of compressed oxygen is regulated as a Hazardous Material by the Pipeline and Hazardous Material Safety Administration - PHMSA[8], according to the table in Title 49 CFR §172.101. Oxygen is highly regulated because, as an oxidizer, it can enhance an existing fire and can support the rapid combustion of all materials.

In addition, the transportation of compressed oxygen by aircraft is specifically regulated under the provisions of Title 49 CFR §173.302(f) in Subpart G-Gases; Preparation and packaging. According to that regulation, only metallic cylinders meeting the following design and manufacturing standards:

- DOT specification for 3A, 3AA, 3E and 3HT[9] seamless steel cylinders
- DOT specification 3AL aluminium alloy cylinders,
- DOT specification 39 steel or aluminium cylinders,
- UN pressure receptacles ISO 9809-1[15], ISO 9809-2[16], ISO 9809-3[17] seamless steel receptacle
- ISO 7866[14] aluminium alloy

are authorized for the transportation of compressed oxygen by aircraft.

3.2. EASA policy

For the transportation and/or installation of compressed oxygen, EASA recognises acceptable pressure cylinders qualified according to the standards listed in 3.1 without any further verification.

In addition, CS 23/25.1453 shall also be complied with when applicable.

Applicants who propose for transportation/installation metallic receptacles qualified according to an alternative standard shall demonstrate their equivalency to the standards above, or show that they provide an equivalent level of safety in relation to the specific application[10].

Environmental qualification tests should also be considered to make the cylinder suitable for the expected in-use environmental conditions [24].

4. EASA recommended minimum qualification standard for composite receptacles

There is an increasing demand for the transportation of compressed oxygen within composite receptacles to benefit from their lower weight.

[8] The Pipeline and Hazardous Material Safety Administration is a US DoT Agency, which rules on Hazardous Material.
[9] The 3HT cylinder is only specifically approved for aviation use.
[10] The equivalence in term of safety would account for the difference between the *minimum acceptable* and the *proposed* standard in relation to the operating conditions in normal and failure situations of the oxygen system.

4.1. Regulation background

At the time when the PHMSA, in co-ordination with the FAA, amended the Hazardous Material Regulation (HMR)[11] so that only certain categories of steel/aluminium cylinders were approved for carrying compressed oxygen on board aircraft (see §3.1), many commenters complained about this newly introduced rule.

They believed that composite cylinders were no longer permitted, despite the fact that the vast majority of cylinders in aerospace were made of composite materials. Those commenters stated that composite cylinders performed as well as the steel/aluminium receptacles but with lower weight and cost and were likely to be increasingly used in the future. The PHMSA position on this aspect was that, although composite cylinders were not directly referenced in the newly adopted rule[11], they could continue to be used on board aircraft under the Special Permit (or Exemptions) approval process.

A Special Permit approval under the HMR authorises the manufacture, marking, sale and use of a non-DOT-stamped composite cylinder when it conforms with the following specifications: DOT-CFFC [18], DOT-FRP-1[19] or DOT-FRP-2[20], except as specified therein[12]. Usually a Special Permit establishes deviations from some specific provisions in the above referenced standards and/or adds specific operating/maintenance instructions. Composite cylinder applicable definitions are contained in §1.4.

On June 12, 2006, the PHMSA recognised the ISO standards by issuing the final rule *Hazardous Materials: Requirements for UN Cylinders*. Within that regulation, the PHMSA agency added, among other items, in 49 CFR Part 178- Subpart C – Cylinder[10], a new section, namely §178.71, which authorized the use of United Nations (UN) Cylinders, including composite cylinders designed & manufactured under the following specifications ISO 11119-1[21], ISO 11119-2[22], ISO 11119-3[23] albeit with certain restrictions[13].

According to the preamble to the final rule, the proposal was "*...to incorporate the UN standards so that a shipper might use either a DOT specification cylinder or a UN standard pressure receptacle, as appropriate, for individual gases and circumstances. The goal of such rulemaking was to promote greater flexibility and permit the use of advanced technology for the manufacture of pressure receptacles, to provide for a broader selection of pressure receptacles, to reduce the need for special permits, and to facilitate international commerce in the transportation of compressed gases without sacrificing the current level of safety and without imposing undue burden on the regulated community*." Nevertheless, as already mentioned, the use of ISO-standard composite receptacles for the transportation by aircraft of compressed oxygen and oxidizers was not allowed, as only cylinders designed and manufactured according to the standards referred to in Title 49 CFR §173.302(f) were allowed for the transportation of oxygen by aircraft.

4.2. EASA policy

Based on the above considerations, EASA has determined that composite cylinders/receptacles qualified according to the following standards would be acceptable and considered suitable for the transportation of oxygen by aircraft, or for the installation of equipment containing oxygen on aircraft:

1. Any composite cylinder qualified according to ISO-11119-1 or -2 or -3 standards.
2. Any composite cylinder qualified according to any national or European norm, which mirrors or conforms to the international standards as in item 1 above[14].

[11] US Federal Register Volume 72 FR 4442, Jan. 31, 2007 as amended at 72 FR 55091, Sept. 28, 2007.
[12] Typical stamps according to DOT are for example those listed in §3.1. Indeed DOT-CFFC, DOT FRP-1 and DOT FRP-2. The technical specifications for composite cylinders are not directly referenced in 49 CFR §178.71.
[13] 71 FR 33858, June 12, 2006
[14] For example, EN 12245:2009+A1:2011: Transportable gas cylinders - Fully wrapped composite cylinders developed by CEN/TC 23

3. Composite cylinders holding an approval under a DOT Special Permit, which includes clauses permitting their usage for oxygen on aircraft, are also acceptable[15].

In addition, CS 23/25.1453 shall also be complied with when applicable.

Applicants who propose for transportation/installation composite receptacles qualified according to an alternative standard shall demonstrate their equivalency to the standards above, or that they provide an equivalent level of safety in relation to the specific application[10].

As for metallic cylinders, environmental qualification tests should also be considered to ensure that the cylinder is suitable for the in-use expected environmental conditions [24].

4.3. Whom this Certification Memorandum concerns/affects

This Certification Memorandum applies, in principle, to all kinds of applications of oxygen cylinders when transported or installed on CS-23, CS-25, CS-27 or CS-29 products as part of built-in or portable systems.

The applicability of this CM is from the date of its publication in the EASA publication register on the EASA internet website.

5. Remarks

1. Suggestions for amendment(s) to this EASA Certification Memorandum should be referred to the Certification Policy and Safety Information Department, Certification Directorate, EASA. E-mail CM@easa.europa.eu.
2. For any questions concerning the technical content of this EASA Certification Memorandum, please contact:

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[15] An acceptable specific clause might read as follows: Transportation of oxygen is only authorised when in accordance with 49 CFR §175.501[13].