AEROSPACE RECOMMENDED PRACTICE

ARP5021™	REV. B

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Superseding ARP5021A

(R) Oxygen Cylinder Installation Guide

RATIONALE

The aim of this issue is to take into account the actual airworthiness requirements and provide information from international standards pertaining to oxygen cylinders.

ARP5021B has been reaffirmed to comply with the SAE Five-Year Review policy.

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1. SCOPE

This document provides guidance for oxygen cylinder installation on commerical aircraft based on airworthiness requirements, and methods practiced within aerospace industry.

It covers considerations for oxygen systems from beginning of project phase up to production, maintenance, and servicing.

The document is related to requirements of DOT-approved oxygen cylinders, as well to those designed and manufactured to standards of ISO 11119. However, its basic rules may also be applicable to new development pertaining to use of such equipment in an oxygen environment.

For information regarding oxygen cylinders itself, also refer to AIR825/12.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AIR825/12	Oxygen System Integration and Performance Precautions
AIR825/13	Guide for Evaluating Combustion Hazards in Aircraft Oxygen Systems
AIR1059	Oxygen Cylinder Quality, Serviceability, Maintenance Transfilling and Marking
AIR5742	Packaging and Transportation of Oxygen Equipment
AS1046	Minimum Standard for Portable Gaseous, Oxygen Equipment
AS1219	Aircraft Oxygen Replenishment Coupling for Civil Transport Aircraft (Design Standard)
AS8010	Aviator's Breathing Oxygen Purity Standard

2.1.2 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

FAA Order 8000.40C	Maintenance of Pressure Cylinders in Use as Aircraft Equipment

2.1.3 ISO Publications

Copies of these documents are available online at http://webstore.ansi.org/.

ISO 9001	Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation and Servicing
ISO 11119-1/-2/-3	Gas Cylinders - Refillable Composite Gas Cylinders and Tubes - Design, Construction and Testing

2.1.4 U.S. Government Publications

Copies of these documents are available online at https://quicksearch.dla.mil.

MIL-PRF-27210 Oxygen, Aviator's Breathing, Liquid and Gas

2.1.5 Other Publications

Federal Specification RR-C-901C, which identifies oxygen cleaning requirements.

Compressed Gas Association Publications, CGA C-1, C-6, C-6.2, and C-6.8; CGA-540, CGA-577, and CGA-701.

European Industrial Gases Association (EIGA), External Prefill Inspection for Composite Cylinders, IGC 131/05/E.

GENERAL COMMENT: The DOT specifications are contained in the Code of Federal Regulations, Transportation, 49, within Parts 100 to 199, and any special permits are granted by the Department of Transportation (DOT) for composite cylinders. In addition, the DOT authorizes the use of UN cylinders designed and manufactured according to ISO 11119-1/-2/-3.

2.2 Definitions

COMPOSITE CYLINDER: Pressure vessel consisting of a gas tight metal (e.g., aluminum) container reinforced by filament material such as fiberglass, kevlar, carbon, or hybrid fibers.

HYDROSTATIC TEST: Periodic pressure test within the life of the component to verify its serviceability.

OXYGEN CYLINDER: Pressure vessel to store breathing gas (oxygen) under high pressure. Such equipment is available in various sizes and designed according to DOT specifications.

2.3 Airworthiness Requirements

Relevant FAA/EASA airworthiness requirements are cited in 3.2.1 of this document.

3. REQUIREMENTS

3.1 Compatibility with Aircraft Environment

3.1.1 Pre-Design Analysis

Prior to the design of oxygen cylinder installation, an analysis should be made to determine that the installation will be compatible with conditions on the aircraft during operation, servicing, and maintenance.

During oxygen system definition, one of the most important issues influencing the overall system architecture is the location of the oxygen source in an aircraft.

System availability and aircraft safety are dependent to a high degree on careful selection of oxygen cylinder location.

The analysis should include an oxygen hazard analysis (OHA) according to guidelines provided by "Guide for Oxygen Compatibility Assessments on Oxygen Components and Systems NASA/TM-2007- 213740 03.2007 NASA." The OHA should be considered for TC/STC (Type Certificate/Supplemental Type Certificate) designs in relation to airworthiness requirements mentioned in 3.2.1, in particular to CS 25.869(c), CS 25.1301, CS 25.1309, CS 25.1453.

Prior to system design the oxygen cylinder installation should be evaluated by a hazard, particular risk, and/or zonal analysis, covering repercussions of:

a. Uncontained engine burst.

b. Compatibility with surrounding systems (e.g., electrical power, hydraulics, fuel, hot air).

c. Cylinder burst should not lead to a hazardous or catastrophic effect.

d. Consequences of oxygen leakage, in particular that the installation area, is sufficiently ventilated to ensure the oxygen concentration will not exceed 25%.

NOTE: The importance of area ventilation is to ensure that oxygen concentration greater than 25% will not be exceeded due to cylinder leakage.

e. Structural damage during crash landing.

f. Failure analysis should be established in correlation with the OHA to show that no fire hazard will evolve due to the presence of a cylinder in an aircraft system installation. The OHA is intended to show that no intrinsic fire risk exists for a system in operating conditions with regards to equipment failures and shows that the occurrence of an uncontrolled oxygen fire at aircraft level is extremely improbable and does not result from a single equipment failure.

g. Flight loads.

h. Vibration and acceleration.

i. Removal and reinstallation of oxygen cylinders.

3.1.2 Design Verification

Subsequent to the design of oxygen cylinder installation a review should be made to confirm that assumptions and targets established as a result of the pre-design analysis have been considered and can be accomplished.

3.2 Design Objectives and Installation Precautions

3.2.1 Airworthiness Requirements

The design for oxygen cylinder installation including fixation in the aircraft should comply with FAR/CS airworthiness requirements of FAA/EASA, mainly:

a. 25.561 Emergency Landing Conditions

b. 25.601 Design and Construction (General)

c. 25.603 Design and Construction (Material)

d. 25.611 Design and Construction (Accessibility Provisions)

e. 25.869 Fire Protection Systems

f. 25.899 Electrical Bonding and Protection Against Lightning and Static Electricity

g. 25.903 Engines (Turbine Engine Installation)

h. 25.1301 Equipment (Function and Installation)

i. 25.1309 Equipment (Equipment System and Installation)

j. 25.1441 Oxygen Equipment and Supply/AMC 25.1441(b) Risk Assessment Related to Oxygen Fire Hazards in Gaseous Oxygen Systems

k. 25.1453 Protection of Oxygen Equipment from Rupture

l. 23.1451 Fire Protection for Oxygen Equipment (applicable to aircraft certified as per FAR/CS 23 requirements)

3.2.2 Design Objectives

Design objectives as stated in the following are applicable to approved DOT-type cylinders as well to cylinders designed and manufactured to ISO standards. With regards to development of new pressure vessel technology, based on different materials, the objectives may be completed and advanced testing methods may also be taken into account.

3.2.2.1 Oxygen cylinder(s), associated lines, and equipment shall be protected against high temperatures and shall not be installed in designated fire zones.

3.2.2.2 The support(s) of the oxygen cylinder(s) shall be designed to withstand the flight, landing, and crash loads.

3.2.2.3 The cylinder and associated equipment should be located and mounted to the air frame structure in such a manner so as to reduce the possibility of rupture in the event of a retracted nose landing gear landing.

3.2.2.4 Orientation of the oxygen cylinder(s) shall be such that the pressure gauge is readable without removing the cylinder(s) from attachments and connections to lines. If installed in a separate compartment (e.g., behind cargo compartment lining), readability of the pressure gauge should be ensured.

3.2.2.5 Sufficient ventilation of the installation area should be ensured in case of leakage (refer to AIR825/13).

3.2.2.6 Maintenance on other systems should not necessitate the removal of oxygen cylinders, their supports, or associated components. Maintenance requirements, including time for removal/installation, should be derived from OEM manuals.

3.2.2.7 Access to oxygen cylinder(s) for checks, maintenance, and removal/reinstallation should not require disassembling of other systems.

3.2.3 Installation Precautions

The installation on the aircraft should ensure that precautions have been realized as following:

a. Proximity to combustibles, moving aircraft parts, and electrical wiring/equipment shall comply with requirements of AIR825/12 and AIR825/13.

b. Unambiguous information (e.g., placards) shall be provided regarding the location of the equipment, handling, accessibility, and a caution that oxygen equipment needs particular attention.

3.3 Testing

Leakage testing and function checks related to equipment, interconnection lines, and oxygen cylinder(s) should be performed at intervals required by the maintenance program for the aircraft type.

The DOT/ISO specifies hydrostatic test requirements and service life limitations for the various types of cylinders used in aircraft oxygen systems. The date of manufacture and hydrostatic test dates are stamped on the shoulder of steel cylinders. The date of manufacture is included on the cylinder label of composite cylinders; subsequent hydrostatic test dates are shown on retest labels, which are attached to the composite overwrap. The not-to-be exceeded hydrostatic test dates are:

a. A maximum of 5 years for steel (3AA) cylinders (refer to CGA pamphlet C-6)

b. A maximum of 3 years for steel (3HT) or 5 years for composite cylinders FRP TYPE FC (e.g., SP-8162) (also refer to CGA pamphlet C-6.8)

c. As per DOT exemption

Cylinders may not be refilled or topped off unless they have a current hydrotest.

Steel cylinders (3AA) have an unlimited service life, provided they pass the periodic hydrotest. Steel (3HT) cylinders have a 24 year service life or 4380 pressurizations, and composite cylinders FRP TYPE FC (e.g., E-8162) have a 15 year service life, provided they pass the periodic hydrotest and/or comply with appropriate DOT exemption.

If a cylinder is to be removed for maintenance but not tested, it should not be vented completely. Some residual pressure, approximately 0.2 MPa (29 psi), shall remain, so that the cylinder will not be contaminated.

NOTE: Other types of cylinders may have different hydrostatic tests and service lives, refer also to CGA pamphlet C-6.2 and ISO 11119.

3.4 Maintenance and Servicing

3.4.1 Refilling Cylinders

The cylinders may be filled or recharged by adding oxygen to the cylinder when installed on the aircraft (transfilling) or the cylinder may be removed for remote recharging and reinstallation into the aircraft.

3.4.1.1 On-Aircraft Transfilling

The cylinders will be refilled as per the aircraft manufacturers procedures and AIR1059.

Oxygen cylinders should only be serviced with oxygen per AS8010 or MIL-PRF-27210, and consideration should be given to the use of an inline filter to prevent contaminant ingestion.

3.4.1.1.1 Transfilling Equipment

Systems designed for transfilling shall have external access to the filling port. The filling port shall conform to AS1046, AS1219, or CGA Connection No. 540. For each cylinder, there shall be a contents indicator or gage that shows the pressure or contents during refilling. Adequate protection shall be provided to prevent damage or contamination to the fill port before, during, and after transfilling.

3.4.1.2 Off-Aircraft Refilling

Cylinder refilling shall be performed by trained personnel following aircraft manufacturer's procedures or other industry standard procedures. Recommendations contained in AIR1059 should be taken into account.

3.4.1.2.1 Removing and Reinstalling Cylinders

Cylinder removal and reinstallation shall be performed as specified by the aircraft manufacturer's procedures. The procedures shall be safe and uncomplicated. Where practical, quick release or disconnect brackets can be used to allow efficient removal and reinstallation. When the cylinder has been removed, provisions shall be taken to cover the open fittings of the cylinder and the aircraft connectors to protect them from damage and contamination until reinstallation of the cylinder.

NOTE: Before reinstalling the cylinder, the right torque value for the brackets, depending on fill pressure, shall be determined.

WARNING: Use of Teflon tape at cylinder pneumatic interface is prohibited, as its use in this area could pose a serious fire hazard.

3.4.2 Hydrostatic Testing

DOT/ISO

Cylinders having periodic testing requirements shall be removed and tested in accordance with the retest period required for the cylinder type. Note that cylinders which have reached their service life limits shall be removed and destroyed per applicable procedures to ensure that they may not be reused unknowingly as oxygen pressure vessels.

CGA C-2 contains recommendations for disposition of unserviceable cylinders.