AEROSPACE STANDARD	AS861™	REV. C
	Issued 1964-08 Reaffirmed 2016-05 Revised 2023-05 Superseding AS861B	

(R) Minimum General Standards for Oxygen Systems

RATIONALE

This extensive revision is an attempt to bring the document up to date with most recent technologies, practices, and procedures which have been applied to the design, fabrication, testing, and packaging of oxygen breathing equipment. In addition, the general document format has been updated to follow the latest SAE editorial policies and procedures, including the correction of minor typos.

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1. SCOPE

This standard covers all types of oxygen breathing equipment used in non-military aircraft. It is intended that this standard supplements the requirements of the detail specification or drawings of specific components or assemblies (e.g., regulators, masks, cylinders, etc.). Where a conflict exists between this standard and detail specifications, detail specifications shall take precedence.

1.1 Purpose

This standard defines minimum general standards for the design, fabrication, testing, and packaging of oxygen breathing equipment.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. Unless otherwise indicated, 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.

AIR171 Glossary of Technical and Physiological Terms Related to Aerospace Oxygen Systems

AIR825/13 Guide for Evaluating Combustion Hazards in Aircraft Oxygen Systems

AIR5742 Packaging and Transportation of Oxygen Equipment

ARP1176 Oxygen System and Component Cleaning

AS8010 Aviator's Breathing Oxygen Purity Standard

2.1.2 EASA Publications

Available from European Union Aviation Safety Agency, Konrad-Adenauer-Ufer 3, D-50668 Cologne, Germany (for visitors and for mail over 1 kg) and Postfach 10 12 53, D-50452 Cologne, Germany (for mail 1 kg or less); Tel: +49 221 8999 000, www.easa.europa.eu.

CS-23 Certification Specifications for Normal, Utility, Aerobatic and Commuter Aeroplanes

CS-25 Certification Specifications for Large Airplanes

CS-ETSO Certification Specifications for European Technical Standard Orders

2.1.3 FAA Publications

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

14 CFR Part 21 Certification Procedures for Products, Articles, and Parts

14 CFR Part 23 Airworthiness Standards, Normal, Utility, Acrobatic and Commuter Category Airplanes

14 CFR Part 25 Airworthiness Standards, Transport Category Airplanes

AC 25-24 Sustained Engine Imbalance

PS-ANM-25.1441-01 Mitigating Fire Hazards in Gaseous Oxygen Systems

2.1.4 Transport Canada Publications

Transport Canada documents are available from Transport Canada, Tower C, Place de Ville, 330 Sparks Street Ottawa, Ontario K1A 0N5, Tel: 1-800-305-2059, www.tc.gc.ca.

AWM Chapter 525 Airworthiness Manual Chapter 525, Transport Category Airplanes

2.1.5 U.S. Government Publications

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

A-A-59503 Nitrogen, Technical

MIL-DTL-5541 Chemical Conversion Coatings on Aluminum and Aluminum Alloys

MIL-DTL-15024 General Specification for Plates, Tags, and Bands for Identification of Equipment

MIL-DTL-81706 Chemical Conversion Materials for Coating Aluminum and Aluminum Alloys

MIL-PRF-8625 Anodic Coatings for Aluminum and Aluminum Alloys

MIL-STD-129 Military Marking for Shipment and Storage

MIL-STD-810 Test Method Standard for Environmental Engineering Considerations and Laboratory Tests

MIL-STD-889 Dissimilar Metals

QPL-81706 Qualified Product List of Products Qualified under Performance Specification MIL-DTL-81706

2.1.6 RTCA Publications

Available from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

RTCA DO-160 Environmental Conditions and Test Procedures for Airborne Equipment

2.1.7 Airlines for America (A4A) Publications

Available from Airlines for America (A4A), 1301 Pennsylvania Avenue, NW, Suite 1100, Washington, DC 20004, Tel: 202-626-4000, www.airlines.org.

ATA SPEC2000 E-Business Specification for Materials Management

2.2 Definitions and Abbreviations

The following definitions, abbreviations, acronyms, and terminologies, which form a part of this document to the extent specified herein, are provided to ensure clarity and completeness of understanding.

An additional list of accepted definitions can be found in AIR171, which presents a glossary of many technical and physiological terms that are used in this document; terms can also be found in literature covering issues related to aviation oxygen systems and associated topics.

2.2.1 Definitions

COMPONENT: Item with a predefined functionality assembled from multiple parts. Function and performance of the component can be fully tested on this level. Components are usually only shop replaceable. Examples: chemical oxygen generators, and passenger oxygen masks.

EQUIPMENT: Item with a predefined functionality assembled from parts and components. Function and performance of the equipment can be fully tested on this level. Items of equipment are usually line replaceable. Examples: passenger oxygen containers, seats, coffee makers, and PBE.

IRIDITE: A non-chrome chemical process (NCP) that produces a protective chromate conversion film coating on aluminum and its alloys.

PART: Item with one or more pieces joined together, which are not normally subject to disassembly without destruction of their designed use. Examples: hinges, adaptors, glued items, and welded items.

PIECE: Item without lower levels of construction. Examples: screws, washers, poppets, and seals.

SYSTEM: Combination of interrelated items (parts and items of equipment) arranged to perform a specific function. Systems are not considered as replaceable in their entirety, and the items forming the system need to be replaced singularly. Examples: gaseous crew oxygen system, aircraft galleys, and aircraft lavatories.

2.2.2 Abbreviations

14 CFR	Title 14 (Aeronautics and Space Section) of the Code of Federal Regulations (formerly referred to as FARs)
AC	Advisory Circular
ACMM	Abbreviated Component Maintenance Manual
AMC	Acceptable Means of Compliance
AMM	Aircraft Maintenance Manual
AMS	American Military Standards
AN	Army Navy (Standard)
AS	Aerospace Standards
ATA	Air Transport Association
AWM	Airworthiness Manual (TCCA equivalent to 14 CFR Part 25)
CAN-TSO	Canadian Technical Standard Order
CAR	Canadian Aviation Regulation (TCCA equivalent to 14 CFR other than Part 25)
CMM	Component Maintenance Manual
CS	Certification Specification (EASA equivalent to 14 CFR)
EASA	European Aviation Safety Agency
ETSO	European Technical Standard Order
FAA	Federal Aviation Administration

FAR	Federal Aviation Regulations (replaced with 14 CFR)
ICA	Instructions for Continued Airworthiness
ISO	International Organization for Standardization
MPS	Minimum Performance Standards
MS	Military Standard
NAS	National Aerospace Standards
NCP	Non-Chrome Chemical Process
OHA	Oxygen Hazards Analysis
PBE	Protective Breathing Equipment
QTN	Qualification Technical Note
QTR	Qualification Test Report
REACH	Registration, Evaluation, Authorisation, and Restriction of Chemicals; regulation (EC 1907/2006) of the European Union, adopted to improve the protection of human health and the environment.
RTCA	Radio Technical Commission for Aeronautics
SSA	System Safety Assessment
TCCA	Transport Canada Civil Aviation
TSO(A)	Technical Standard Order (Authorization)
UN	United Nations (Recommendations on the Transport of Dangerous Goods)

3. GENERAL REQUIREMENTS

3.1 Materials and Workmanship

3.1.1 Materials

a. Wherever possible, materials conforming to appropriate government or industry specifications or standards (e.g., REACH) shall be used. In all cases, materials shall be of the type, grade, and quality which experience and/or tests have demonstrated to be suitable for the purpose intended.

b. Only materials having physical and chemical properties compatible with an oxygen environment shall be used.

c. Any material which is subject to accelerated deterioration or is otherwise adversely affected by continuous service usage with oxygen shall not be used.

d. Non-metallic materials shall be resistant to lubricants, hydraulic fluids, fuels, chemicals, fire, and environmental temperature conditions likely to be encountered in service.

e. Wherever possible, consideration shall be given to designs that do not require lubricants to meet operational and service life requirements. When a requirement for lubricants exists, only those approved specifically for use in oxygen systems shall be utilized.

f. The curing date and—where applicable (e.g., for life-limited parts)—the manufacturing date (month and year) shall be stamped legibly on all rubber or rubber-like parts, except those which have insufficient area.

g. Dissimilar metals shall not be used in direct contact with each other unless they have been protected adequately against electrolytic corrosion. MIL-STD-889 provides more detailed information on dissimilar metals and materials compatibility. The following is a grouping of metals wherein the metals in the same group are considered similar to each other and the metals in different groups dissimilar to each other:

Group I: Magnesium and its alloys; aluminum alloys 5052, 5056, 5356, 6061, and 6063.

Group II: Cadmium, zinc, aluminum, and their alloys (including the aluminum alloys listed in Group I).

Group III: Iron, lead, tin, and their alloys (except corrosion resistant steels).

Group IV: Copper, chromium, nickel, silver, gold, platinum, titanium, cobalt, rhodium, and their alloys; corrosion resistant steels; graphite.

h. Air Force, Navy, or military standard parts identified by AN or MS part numbers shall be used in the design of all oxygen components and assemblies wherever practicable. Otherwise, it is acceptable to use standard parts as per accredited aerospace industry specifications, such as National Aerospace Standards (NAS), American Military Standards (AMS), Aerospace Standards (AS), and International Organization for Standardization (ISO).

3.1.1.1 Finish

All materials which are not inherently corrosion resistant shall be finished with a protective treatment or coating to minimize the effects of exposure to oxygen and the atmospheric conditions which may be encountered in service. It is advised that any applied surface finishes be compliant with applicable REACH or other material regulations.

a. Protective coatings subject to cracking, peeling, or scaling with age or with extremes of atmospheric conditions shall not be used.

b. Generally, protective finishes shall be applied to individual parts prior to assembly (if parts are assembled by mechanical means) and after assembly (if parts are assembled by fusion methods).

c. Aluminum alloys must be protected with a chemical conversion coating (e.g., Iridite) per MIL-DTL-5541 or anodized per MIL-PRF-8625. Clear anodized protective coatings are preferred. Coloring by a thinly dispersed organic dye in the aluminum oxide coating is acceptable. Surface dye or paint are not acceptable as protective finishes on any parts or surfaces which will be exposed directly to oxygen under pressure. MIL-DTL-81706 covers chemical conversion materials used in the formation of coatings by the reaction of the material with the surfaces of aluminum and aluminum alloys. QPL-81706 identifies products meeting the requirements for qualification in MIL-DTL-81706.

d. Plating such as silver, gold, or zinc on low carbon steel or copper-bearing alloys is acceptable in liquid oxygen environment, provided that it is not used on wear surfaces. Colored plating is not acceptable.

e. Cadmium plating must never be used in the design of oxygen equipment.

3.1.2 Workmanship

Workmanship shall be in accordance with high-grade manufacturing practices. Particular attention shall be given to neatness and cleanliness, and every effort shall be made to assure high-quality soldering, wiring, welding, brazing, painting, plating, etc.

All surfaces of equipment shall be free of oil, grease, dirt, or other foreign materials. Parts in contact with oxygen shall be cleaned as per ARP1176.

3.1.3 Construction

All oxygen assemblies and/or components shall be constructed so that parts will not become loose during normal service usage. The assemblies shall withstand stresses, strains, jars, vibrations, and other conditions caused by shipping, storage, installation, and service.

Considerations shall be given to address construction factors that affect the avoidance of ignition and fire, promoting safe designs, operations, and maintenance on aircraft and ground support oxygen systems. Such considerations shall be recorded—by performing an oxygen hazards analysis (OHA) in accordance with AIR825/13—for demonstration of compliance with CS 25.1441(b), as specified in AMC 25.1441(b) Risk Assessment Related to Oxygen Fire Hazards in Gaseous Oxygen Systems. AMCs, which are part of EASA CS-25 Book 2, provide guidance material and acceptable means of compliance for demonstrating compliance with specific requirements. FAA PS-ANM-25.1441-01, which provides additional guidance material on the matter, also identifies the need for performing an OHA to demonstrate compliance.

3.2 Environmental Requirements

Oxygen assemblies and/or components shall be designed and constructed to operate or function in accordance with the requirements of the detail specification and/or drawings under environmental conditions likely to be encountered in storage and when installed for service. Temperature, altitude, vibration, sand and dust, salt spray, humidity, and fungus are among challenges that should be considered.

Since most recent oxygen-related application products incorporate electrical features into the design, which allows for performance optimization of specific functions/items, the qualification of such equipment must include demonstration of compliance for related requirements, such as magnetic effect, power input, voltage spike, etc.

RTCA DO-160 and MIL-STD-810 are the most common standards used by the industry to define test methods and procedures and demonstrate environmental compliance. The use of one or the other may depend on the specific application and/or purchaser preference; a combination of both is also commonly seen in equipment specifications.

On the other hand, FAA TSO authorizations (TSOAs) typically define what minimum performance standards (MPS) the equipment must first meet for approval and identification with the applicable TSO marking. In some instances, TSO MPS items do include specific environmental qualification to an extent, although only the approved equipment specification truly defines the complete set of applicable tests. In that case, should the equipment specification lack the detailed information, the minimum set of applicable tests can certainly be used as is. CS-ETSO Index 1 provides a list of all of the European TSOs (ETSOs) which are technically similar to FAA TSOs, and Index 2 provides a list of all those ETSOs which are not technically similar to FAA TSOs. Also, due to bilateral agreement provisions, there may be mutual acceptance of certificating authorities' TSOs (e.g., starting in 2016, FAA automatically accepts all CAN-TSOs issued by Transport Canada Civil Aviation).

It shall be noted that such environmental qualification standards typically define a range of environmental categories meant to reflect the worst-case conditions for typical aircraft installations; therefore, when choosing a category, special consideration shall be given to the specific equipment design and/or system configuration—otherwise, an unforeseen failure may be encountered during qualification testing. In that case, the following sections provide a few key notes about certain requirements that are often overlooked or misunderstood.

3.2.1 Temperature

The temperature envelope defined for the aircraft certification is not necessarily the same one to be applied to the equipment qualification. For instance, an oxygen cylinder's maximum operating temperature will be limited by its actual design specification (e.g., pressure limiting device), which is strictly dependent on temperature. Similarly, an oxygen mask will have its minimum operating temperature limited by the extensive use of elastomers (e.g., seals and membranes), which cannot perform intended functions at extremely low temperatures.

Therefore, when defining requirements for extreme temperature operation (e.g., airplane operations after ground cold soak, which is typically conducted to demonstrate compliance with AWM 525.1301-1) or low and high temperature exposure, the selected method/procedure may still require some tailoring, which shall then be reflected in the equipment specification.

3.2.2 Acceleration

Acceleration tests are typically meant to verify that the equipment materials are structurally sound and can withstand, without degradation, the steady state inertia loads induced by acceleration, deceleration, and maneuvering of typical aircraft operation. Acceleration tests are also meant to demonstrate that used materials will not become a hazard or be hazardous after exposure to crash inertia loads.

However, it shall be noted that MIL-STD-810 clearly points out that “acceleration loads are expressed in terms of dimensionless load factors, usually labeled as ‘g’ loads, that sometimes lead to the mistaken assumption that acceleration requirements can be satisfied by shock tests or vice versa, since they are also expressed in ‘g’ terms.” MIL-STD-810 defines shock as “a rapid motion that excites dynamic (resonant) response of the materiel, but with very little overall deflection (stress)”; therefore, “shock test criteria and test methods cannot be substituted for acceleration criteria and test methods or vice versa.” In other words, the test results from acceleration tests cannot be used to justify results for shock tests, and vice versa. However, the acceleration requirements defined in MIL-STD-810 are indeed to address aircraft acceleration loads, or—more precisely—to validate that the design of airborne equipment will properly sustain/work under typical aircraft acceleration loads.

3.2.3 Sustained Engine Imbalance

In addition to demonstrating proper equipment performance for typical vibration loads encountered during normal aircraft operation (i.e., no failure scenario), it shall also be shown that after partial or complete loss of an engine fan blade (including collateral damage) or after shaft support failure, the airplane is capable of continued safe flight and landing.

The evaluation should show that during continued operation at windmilling engine rotational speeds, the induced vibrations will not cause damage that would jeopardize continued safe flight and landing. The flight crew shall not be prevented from operating the airplane in a safe manner, including the ability to read and accomplish checklist procedures, as required.

Applicable vibration testing scope shall be tailored to account for dedicated sustained engine imbalance loads, which will vary according to specific engine design and location on aircraft (i.e., wing or rear fuselage mounted). Additional guidance on the matter can be found in AC 25-24.

3.2.4 Combined Temperature, Altitude, and Humidity

As previously mentioned, some aircraft (airborne) oxygen equipment also incorporates electronic and electromechanical features, and as such shall be thoroughly qualified per applicable requirements; these may or may not include a combined temperature, altitude, and humidity test. This stress test helps to determine the combined effects of temperature, humidity, vibration, and altitude with regard to safety, integrity, and performance during ground and flight operations.

It shall be noted, however, that this test is not intended to be used in lieu of dedicated tests for other applicable methods considered in isolation (e.g., altitude test), unless the equipment requirement specification is properly tailored to do so. On the other hand, isolated tests should be not used to claim demonstration of compliance to this test even though the isolated test conditions may seem to be worse, since the combined effect of them cannot be predicted.

Finally, even though the equipment may have electronic and/or electromechanical features incorporated into its design, discretion shall still be used when deciding whether or not such a test should be mandated for the equipment. Since the applicability of such a test requirement will depend on several parameters (such as equipment criticality, failure impact, design complexity, etc.), it shall be thoroughly considered prior to being added to the equipment specification.

3.3 Performance

3.3.1 Endurance

The component shall meet the endurance requirements of the applicable specification governing its design. Demonstration of compliance shall typically be established by means of testing. However, proven in-service data, or a combination of data and test, may be a suitable substitute to replace or reduce scope of testing.

3.3.2 Service Life

The component shall meet the service-life requirements of the applicable specification controlling its design. It shall be noted, however, that in some instances, the service life may also include storage time. In that case, the component shall also meet the requirements of 3.3.2.1 and 3.3.2.2 of this specification.

3.3.2.1 Storage Period

The storage period—also known as shelf period or shelf life—is defined as the period of time the component will stay stored in controlled conditions that will not affect performance after installation. When not defined by the applicable specification, it shall follow the component manufacturer's recommendation.

3.3.2.2 Service Period

The service period is defined as the period of time or number of cycles during which the component will be in use or operate, as required by the applicable specification.

It shall be noted that, depending on the actual system configuration/operation, the service period may not have a strict/direct relation to the predicted aircraft operation time or number of cycles. This shall be taken into account in the applicable specification, as well as any supporting reliability and safety analysis.

3.3.3 Life Limit

Life limit is defined as the period after which performance is no longer guaranteed to remain acceptable, typically driven by material properties' deterioration over time. In that case, a mandatory replacement limit shall be specified for the type design, and the instructions for continued airworthiness (ICA) provided in the applicable aircraft maintenance manuals (AMMs).

3.3.3.1 Overhaul Period

Some components may be able to extend the predicted life by means of overhauling or through replacement of parts within that component. In that case, the overhaul period of the component is defined as the period of time, as required by the detail specification, that the component will be in use, or operate without overhaul or replacement of parts. If there is no provision to extend the life of the component through overhaul or replacement of parts, then the equipment is simply discarded at the end of the original life limit.

Once a component is overhauled or specific parts are replaced, its "life clock" will be reset and the component may be considered operationally sound until the next overhaul is due.

It shall be noted that overhaul requirements may also be driven by other limitations (such as maintenance requirements) as a result of safety analysis—e.g., system safety assessment (SSA)—which in turn makes use of specific time periods with guaranteed performance (commonly referred to as periodic check intervals). In that case, the overhaul requirement may not be associated with an actual life limit of the equipment.

3.4 Numbering and Identification

3.4.1 Component Manufacturer's Part Number

The component manufacturer shall assign part numbers to all items, either top assemblies or subassemblies. The number of digits in the part numbers shall not exceed 15, as per ATA SPEC2000.

3.4.2 Component Manufacturer's Part Number Change

A component manufacturer's part number shall not be changed without the purchaser's prior consent. The purchaser shall be made aware of any potential changes prior to implementation and according to their notice of change processes, which typically regulates any shipment of parts under a new part number.

Furthermore, in order to maintain its status, special attention shall be paid to any changes to TSO equipment. In that case, the component manufacturer holding the TSO authorization will be solely responsible to follow applicable authorities' procedures and ensure compliance.

3.4.3 Component Manufacturer's Amendment Number/Letter

The component manufacturer may assign an amendment number/letter to all major items or normally replaceable units (i.e., top assemblies). The number/letter shall be used to control/track changes to the design. These changes are typically considered minor and usually do not impact form, fit, and function. In some instances, major design changes can still be controlled/tracked using this process, provided the purchaser's change control processes allow for it.

The ACMM (Abbreviated Component Maintenance Manual) and/or CMM (Component Maintenance Manual) must be updated with changes in a timely manner to support the product.

3.4.4 Identification Plate

3.4.4.1 Material and Attachment

Unless otherwise specified, an identification plate or tag conforming to the requirements of MIL-DTL-15024 shall be attached securely to the component by means of rivets or screws. On parts where this means of attachment is not practicable, a suitable adhesive is acceptable. Unmountable tags shall be secured to the component in accordance with the detail specification or drawing.

3.4.4.2 Location

The identification tag or plate shall be attached so that it can be read easily and in an area not subject to damage during normal service usage. It shall be located where it does not interfere with moving parts, access holes, or servicing of the component.

3.5 Warning Tags

A concerted effort shall be made to design components so that special warning tags or decals are not required. However, if such tags or decals are necessary to obtain proper performance of the component, they shall conform to the requirements of 3.4.4.

4. DETAIL REQUIREMENTS

4.1 Human Factors

The item shall be designed and constructed with consideration given to the following design principles:

a. Replaceable items shall be designed so that they can be readily inspected, tested, serviced, adjusted, repaired, or replaced with minimum disturbance of other parts and minimum use of special tools or technical skills.

b. External contours, and those internal contours normally subject to contact by personnel, shall be designed to eliminate, so far as practicable, all sharp corners, edges, or other projections which might cause injury to personnel.

4.2 Acoustical Noise Levels

Sound levels generated by an item that will be located in areas occupied by personnel shall be sufficiently low so as not to interfere with oral communication, comfort, or audibility of sound warning signals, nor adversely affect personnel or adjacent equipment performance.

4.3 Strength Requirements

The component shall meet the strength requirements of the applicable specification governing its design.

4.4 Handling Resistance

The item shall be capable of withstanding any normal handling incidental to inspection, testing, storage, shipping, and installation without damage, failure, or permanent deformation. Unless otherwise specified, this requirement shall apply irrespective of the attitude of the item.