



# AEROSPACE INFORMATION REPORT

AIR825™/5

REV. A

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Reaffirmed 2023-08

Superseding AIR825/5

## Liquid Oxygen Systems

### RATIONALE

AIR825/5A has been reaffirmed to comply with the SAE Five-Year Review policy.

### FOREWORD

This document is one of a set of related documents. These documents comprehensively address the "Introduction to Oxygen Equipment for Aircraft", and are referred to as slash (/) documents, rather than chapters. The documents may be obtained as a set or individually. As the field of oxygen systems for aircraft has evolved, it became cumbersome for one document to cover the full range of subject matter. The reader who is seeking overall familiarity with oxygen systems for aircraft should read all of these documents that combine to form a general reference to oxygen systems. The reader who is familiar with oxygen systems for aircraft may want to obtain only the slash documents that pertain to topics that are of specific interest.

The document set is written as an introductory level, suitable for anyone who would like to understand the basics of oxygen systems in aircraft, and specifically for the engineer who has just recently been assigned to aircraft oxygen systems. Many of these documents point the reader toward more detailed treatments located in other SAE documents.

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Documents

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## 1. SCOPE:

This Aerospace Information Report provides general information to aircraft designers and engineers, regarding LOX, its properties, its storage and its conversion to gas. Much useful information is included herein for aircraft designers regarding important design considerations for a safe and effective installation to an aircraft. The associated ground support equipment needed to support operations of LOX equipped aircraft is also discussed. It is important to realize that LOX equipped aircraft cannot be supported unless this support infrastructure is also available. A significant part of this document will address the specific advantages, disadvantages and precautions relating to LOX systems. These are important issues that must be considered in deciding which oxygen system to install to the aircraft. Also, many commercial and military aircraft use aeromedical LOX equipment that is mostly portable equipment. Aeromedical LOX equipment is not addressed herein as it is beyond the scope of this document.

## 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, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AS8010      Aviator's Breathing Oxygen Purity Standard

#### 2.1.2 U.S. Government Publications: Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

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

#### 2.1.3 NFPA Publications: Available from National Fire Protection Association, 11 Tracy Drive, Avon, MA 02322.

NFPA Standard No. 401 B

## 2.2 Related Publications:

The following publications are provided for information purposes only and are not a required part of this SAE Aerospace Technical Report.

|             |                                                                                         |
|-------------|-----------------------------------------------------------------------------------------|
| MIL-D-19326 | Design and Installation of Liquid Oxygen Systems in Aircraft, General Specification for |
| TR-56-260   | Air Force Handbook of LOX Systems, Volumes I & II                                       |
| STANAG 3056 | Marking of Airborne and Ground Gas and Cryogenic Fluid Containers                       |
| STANAG 3545 | Characteristics of Breathable Liquid Oxygen                                             |
| STANAG 3976 | Lubricants for Use in Oxygen Systems with Oxygen Rich Environments – AEP-15             |
| STANAG 3978 | Purging Liquid Oxygen Storage and transport Tanks and Aircraft                          |

## 2.3 Definitions:

LOX: An abbreviation for liquid oxygen

NATO: An abbreviation for North Atlantic Treaty Organization

STANAG: A NATO Standardization Agreement

## 3. LIQUID OXYGEN (LOX):

When choosing a source of oxygen supply for any type of aircraft, various types of systems are considered and trade studies conducted. Oxygen may be supplied from either gaseous, liquid, solid or chemical block sources, or concentrated from air by on-board oxygen concentrators for use in aircraft systems. However, the use of solid oxygen is considered impractical. It is almost impossible to provide in practice with a freezing point of  $-227.2\text{ }^{\circ}\text{C}$  ( $-377\text{ }^{\circ}\text{F}$ ) and its use offers no further advantage when compared to the liquid state. Gaseous oxygen has been commonly used in aircraft installations ever since flights were made at altitudes requiring supplemental oxygen for occupant survival. Gaseous oxygen is presently the most common source of supply used in commercial aircraft. A practical LOX system for aircraft use was developed in the 1950's for application to past military aircraft design programs. Size and weight penalties of gaseous oxygen equipment needed to support long military missions demanded the advanced technological development of practical aircraft LOX systems. Now LOX supply systems are installed in many military aircraft. New fighter and bomber aircraft designs are actively pursuing the on-board oxygen generating system (OBOGS) designs. OBOGS equipped aircraft concentrate oxygen from pressurized air sources. However, many military transport aircraft still need LOX systems because of the large number of crewmembers and passengers to support for extended time periods. OBOGS is limited to smaller aircraft because of its limitations of flow and ability to store oxygen for use when in nonuse conditions. Consideration has been given to LOX systems in the current commercial jet transport aircraft designs, but the need to constantly replenish supply due to losses from boil off has made them impractical for use on commercial aircraft.

### 3.1 LOX Properties:

LOX is a light, blue, transparent, water like fluid, produced by the fractional distillation of purified liquid air. AS8010B, MIL-PRF-27210, and STANAG 3545 define the requirements for quality of the LOX.

At sea level, atmospheric pressure 101.3 kPa (760 mm Hg or 14.7 psia), LOX has the following properties:

a. Boiling Point:

-183 °C (-297 °F)

b. Density:

1140.5 kg/m<sup>3</sup> at -183 °C (71.2 lb/ft<sup>3</sup> at -297 °F)  
1.14 kg/dm<sup>3</sup> or 2.5 lb/L (9.54 lb/gal (US) (11.32 lb/gal (Imperial)))

c. Volume Expansion:

1 L LOX = 860 L gaseous oxygen at 21.1 °C, 101.3 kPa  
= 30.36 ft<sup>3</sup> gaseous oxygen at 70 °F, 14.7 psia

d. Latent Heat of Vaporization:

213 J/g (91.7 BTU/lb)

At higher pressures, the boiling point of LOX will increase. The critical temperature of -118 °C (-180 °F) is attained at a pressure of 5.07 MPa (735 psi) (50 atmospheres). Regardless of further pressure increase, oxygen will not remain in a liquid state above this temperature.

Pure LOX does not produce irritating vapors but adsorbs various types of odoriferous substances that may be in containers or the ambient. These odors can be released when LOX is converted into the gaseous state for breathing. Additionally, LOX can contain substances that would pose a risk of combustion if the contaminate level is allowed to be excessive. These reasons are why quality control of contaminants must be addressed when purchasing LOX for aviation breathing systems.

### 3.2 LOX Converters and Ground Servicing Equipment:

The utilization of LOX in airborne installations has been facilitated by the development of a practical system for the conversion of cold LOX to gaseous oxygen at an acceptable ambient temperature for breathing. This system depends on no external source of energy other than the surrounding atmosphere for converting the LOX to gas. Ground storage and airborne containers operate on the same basic principle of liquid to gaseous state conversion for their respective purposes. Operation of a typical LOX converter and component parts of the system to provide gaseous oxygen to the aircraft supply line is shown in Figures 1 and 2.

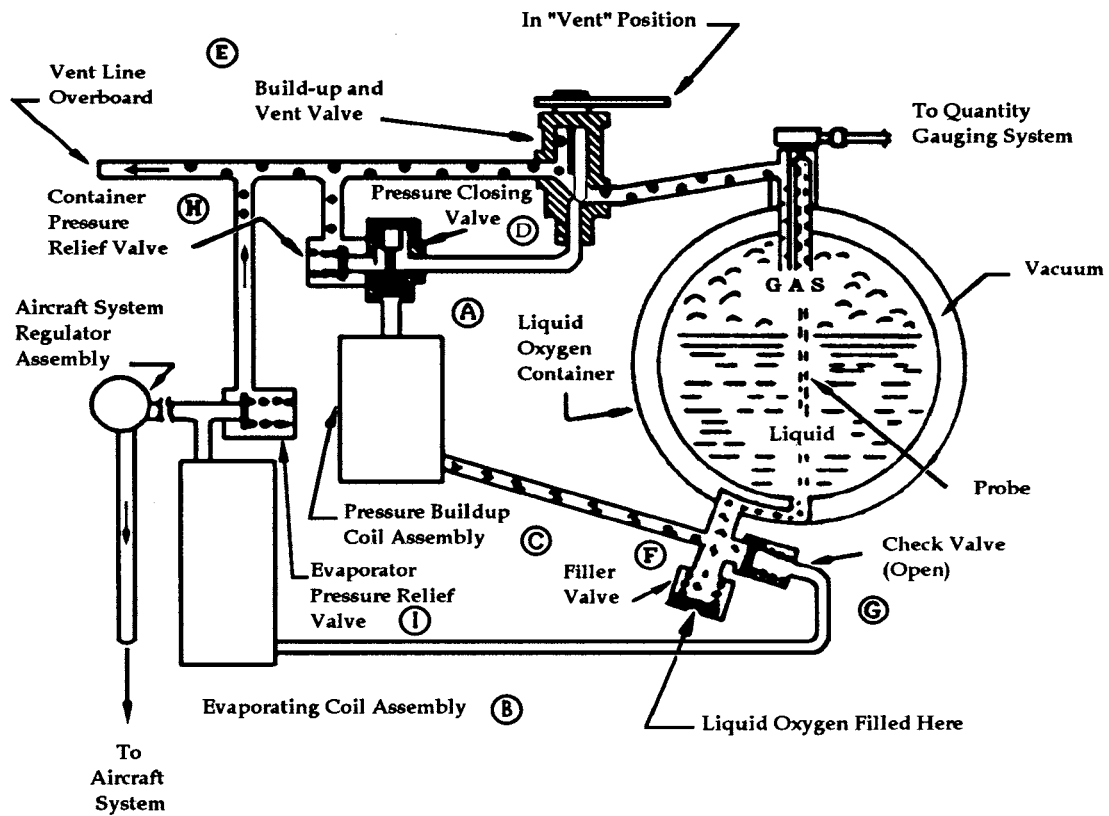


FIGURE 1 - Converter Filling Procedure

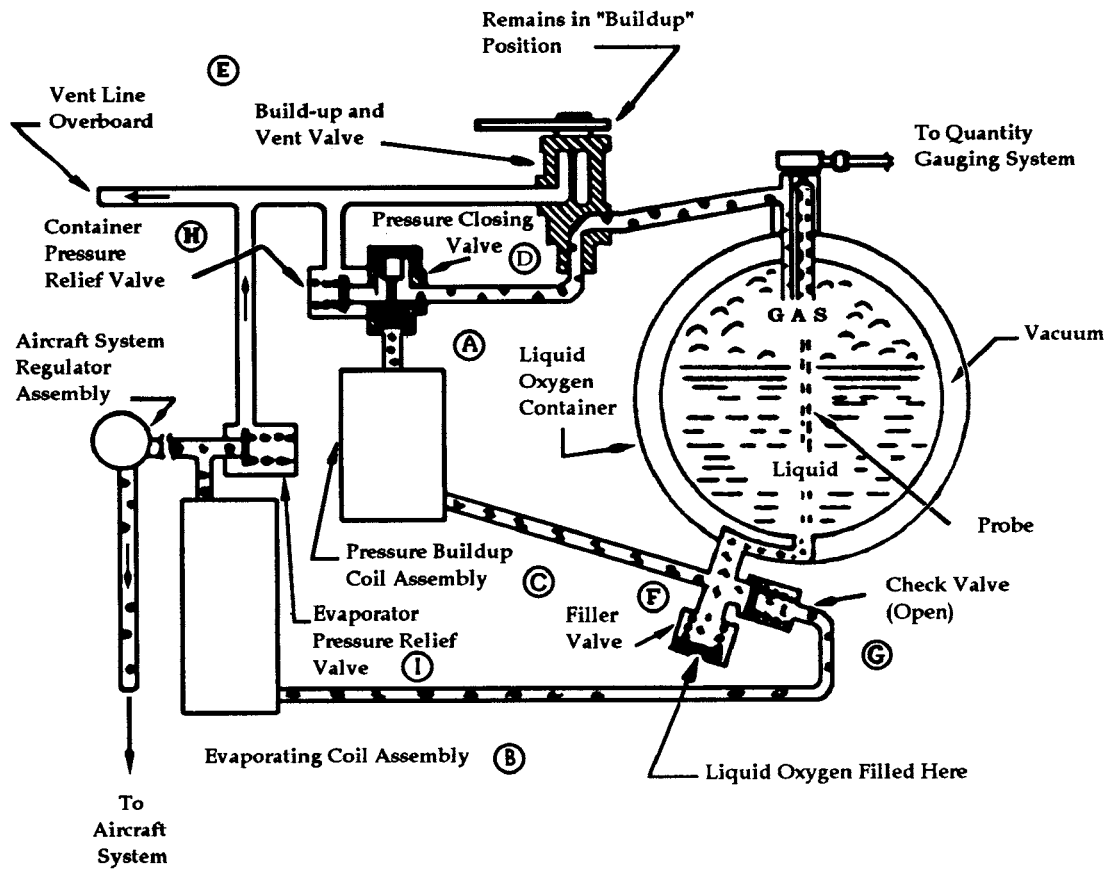


FIGURE 2 - System Supply Procedure