



AEROSPACE RECOMMENDED PRACTICE

ARP1176™**REV. B**

Issued 1999-03
Revised 2020-10
Reaffirmed 2025-09

Superseding ARP1176A

(R) Oxygen System and Component Cleaning

RATIONALE

This document has been revised to reflect current industry recommended practices regarding the cleaning of components and systems for oxygen service.

ARP1176B has been reaffirmed to comply with the SAE Five-Year Review policy.

TABLE OF CONTENTS

1.	SCOPE.....	3
1.1	Purpose.....	3
2.	REFERENCES.....	3
2.1	Applicable Documents.....	3
2.1.1	SAE Publications.....	3
2.1.2	ASTM Publications.....	3
2.1.3	U.S. Government Publications.....	4
2.1.4	NASA Publications.....	4
2.1.5	ISO Publications.....	4
2.1.6	ASQ Publications.....	4
2.1.7	CGA Publications (Compressed Gas Association).....	4
2.1.8	2.1.8 Other Publications.....	5
2.2	Definitions.....	5
3.	CLEANLINESS LEVELS.....	7
3.1	General Requirements.....	7
3.2	Cleaning Process Consideration Factors.....	7
3.3	Recommended Cleaning for Articles.....	7
3.4	Coding.....	8
4.	CLEANING METHODS AND PROCEDURES.....	10
4.1	Clean Room and Controlled Clean Area.....	10
4.1.1	Structure.....	11
4.1.2	Maintenance.....	12
4.1.3	Temperature and Humidity.....	13
4.1.4	Ventilation and Air Filtration.....	13
4.1.5	Ventilation and Air Pressure.....	13
4.1.6	Personnel Requirements.....	13
4.1.7	Tools and Equipment.....	14
4.2	Selecting Suitable Cleaning Agents.....	14
4.2.1	Cleaning Agents.....	15

SAE Executive Standards Committee Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2025 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, or used for text and data mining, AI training, or similar technologies, without the prior written permission of SAE.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
http://www.sae.org

SAE WEB ADDRESS:

Full document details: SAE ARP1176B

For more information on this standard, visit
<https://www.sae.org/standards/content/ARP1176B/>

Documents

Standard, visit Sharing Hub

4.3	Selecting the Proper Cleaning Method	15
4.3.1	Composition of the Article to be Cleaned.....	16
4.3.2	Complexity of Construction	16
4.3.3	Properties of the Cleaning Agent	16
4.3.4	Limitations of the Cleaning Agents	16
4.4	Different Methods of Cleaning	16
4.4.1	Solvent Cleaning	16
4.4.2	Detergent and Water Cleaning	18
4.5	Methods for Rinsing and Drying.....	18
5.	CLEANLINESS INSPECTIONS AND TESTS.....	19
5.1	Cleaning Process Control	19
5.1.1	Process Qualification	19
5.1.2	Sampling Plans	20
5.2	Visual Inspections	20
5.2.1	White Light Inspections.....	20
5.2.2	Black Light or Ultraviolet Light Test	20
5.2.3	Wipe Inspection.....	20
5.3	Cleanliness Verification Testing.....	20
5.3.1	Non-Volatile Residue (NVR) Test	21
5.3.2	Particulate Test	21
5.4	Water Break Test	21
5.5	Acidity or Alkalinity (pH) Test.....	22
5.6	Halogen Test.....	22
5.7	Total Organic Carbon Analysis Test	22
6.	MARKING AND PACKAGING	22
6.1	Marking	22
6.2	Packaging	22
7.	CLEANING AND TESTING EXAMPLES	22
7.1	Example 1: Cleaning Process for Metallic Articles	22
7.2	Example 2: Cleaning Process for Non-Metallic Articles.....	23
7.3	Example 3: Cleanliness Verification Test using NVR and Particulate Testing	23
8.	OTHER ISSUES FOR CLEANING AIRCRAFT OXYGEN EQUIPMENT	24
8.1	Methods for Cleaning of Oxygen Cylinders	24
9.	NOTES	24
9.1	Revision Indicator.....	24
Figure 1	Cleanliness level code	8
Table 1	Minimum recommended cleanliness levels	8
Table 2	NVR levels	9
Table 3	Particulate levels	9
Table 4	Clean Room and Controlled Area Requirements	10
APPENDIX A		25
APPENDIX B		26
APPENDIX C		27

1. SCOPE

This SAE Aerospace Recommended Practice (ARP) provides recommended practices for the cleaning of aircraft oxygen equipment, both metallic and non-metallic articles, such as oxygen lines (tubes, hoses, etc.), components (including regulator and valve parts), cylinders, and ground-based equipment that may be used to support aircraft oxygen systems. This document also specifies work area details, methods for selecting suitable cleaning agents, cleaning methods, and test methods for verifying levels of cleanliness. The cleanliness coding scheme specified in this document provides a method for documenting minimum cleanliness level requirements and for identifying compliance.

1.1 Purpose

The purpose of this document is to provide recommended methods for the cleaning of both aircraft and ground-based oxygen equipment that support aircraft oxygen systems and to outline the minimum accepted practices for articles that are cleaned for oxygen service. Oxygen equipment cleaning operations must perform to a minimum level of safety suitable for precluding toxic and fire hazards for the application and conditions for which the equipment is intended.

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.

AIR5742	Packaging and Transportation of Oxygen Equipment
ARP598	Aerospace Microscopic Sizing and Counting of Particulate Contamination for Fluid Power Systems
AS9138	Aerospace Series - Quality Management Systems Statistical Product Acceptance Requirements

2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM G93	Standard Practice for Cleaning Methods for Materials and Equipment Used in Oxygen-Enriched Environments
ASTM G120	Standard Practice for Determination of Soluble Residual Contamination in Materials and Components by Soxhlet Extraction
ASTM G121	Practice for Preparation of Contaminated Test Coupons for the Evaluation of Cleaning Agents for Use in Oxygen-Enriched Systems and Components
ASTM G122	Standard Test Method for Evaluating the Cleaning Effectiveness of Cleaning Agents
ASTM G127	Standard Guide for the Selection of Cleaning Agents for Oxygen Systems
ASTM G128	Standard Guide for the Control of Hazards and Risks in Oxygen Systems

- ASTM G131 Standard Practice for Cleaning of Materials and Components by Ultrasonic Techniques
- ASTM G136 Standard Practice for the Determination of Soluble Residual Contaminants of Materials and Components by Ultrasonic Extraction
- ASTM G144 Test Method for Determination of Residual Contamination of Materials and Components by Total Carbon Analysis Using a High Temperature Combustion Analyzer

2.1.3 U.S. Government Publications

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

- BB-A-1034 Compressed Air, Breathing
- CGA-G4 Oxygen
- A-A-59503 Nitrogen, Technical
- MIL-STD-1330 Precision Cleaning and Testing of Shipboard Oxygen, Helium, Helium-Oxygen, Nitrogen, and Hydrogen Systems
- MIL-STD-1916 DOD Preferred Methods for Acceptance of Product
- MIL-HDBK-407 Contamination Control Technology Precision Cleaning Methods and Procedures

2.1.4 NASA Publications

NASA Technical Services, NASA STI Program STI Support Services, Mail Stop 148, NASA Langley Research Center, Hampton, VA 23681-2199, 757-864-9658, Fax: 757-864-6500, <http://ntrs.nasa.gov/>.

- NASA JSC/WSTF Specification No. 022 Chemical and Cleanliness Requirements for WSTF Test Hardware and Facility Equipment, 17 Feb 1987

2.1.5 ISO Publications

Available from International Organization for Standardization, ISO Central Secretariat, 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, Tel: +41 22 749 01 11, www.iso.org.

- ISO 14644-1 Cleanrooms and Associated Controlled Environments - Part 1: Classification of Air Cleanliness
- ISO 14644-2 Cleanrooms and Associated Controlled Environments - Part 2: Specifications for Testing and Monitoring to Prove Continued Compliance with ISO 14644-1

2.1.6 ASQ Publications

Available from American Society for Quality, 600 North Plankinton Avenue, Milwaukee, WI 53203, Tel: 800-248-1946 (United States or Canada), 001-800-514-1564 (Mexico), or +1-414-272-8575 (all other locations), www.asq.org.

- ANSI/ASQ Z1.4 Sampling Procedures and Tables For Inspection By Attributes

2.1.7 CGA Publications (Compressed Gas Association)

Available from CGA, 14501 George Carter Way, Suite 103, Chantilly, VA 20151, Tel: 703-788-2700, www.cganet.com.

- CGA-G4 Oxygen

2.1.8 Other Publications

"Evaluation of Solvent Alternatives for Cleaning of Oxygen Systems," by Harold Beeson, NASA Johnson Space Center, White Sands Test Facility, Las Cruces, New Mexico; Paul Biesinger and Rafaol Delgado, Allied-Signal Technical Services Corp. Team, White Sands Test Facility, Las Cruces, New Mexico, and Neil Antin, Naval Sea Systems Command, CO3L, Arlington, Virginia; 1997, <https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19990075880.pdf>.

IATA Resolution 618, International Air Transport Association, 800 Place Victoria, Montreal, QC H4Z1M1.

ADR European Agreement, United Nations Economic Commission for Europe, CH-1211 Geneva 10, Switzerland.

2.2 Definitions

AQUEOUS CLEANING: A cleaning process using clean non-ionic water to clean equipment. A cleaning agent may be added to the water to increase the capability of the water to clean as mentioned in the aqueous cleaning solution definition.

AQUEOUS CLEANING SOLUTION: An aqueous cleaning solution is a water based cleaner whose constituents are soluble inorganic compounds such as silicates or phosphates or soluble organic compounds such as non-ionic surfactant or combinations thereof. Examples of aqueous cleaning solutions include commercial detergents which generally contain both soluble inorganic and organic compounds and navy oxygen cleaner (NOC) which contains only soluble inorganic compounds.

ARTICLE: A material, part, component, or appliance.

CLEAN: Cleaned to a specified cleanliness level by the removal of contaminants. Clean refers to the absence of scale, particulate, oil, and grease contaminants to a level below that which adversely affects the operation or reliability of the component or system. The process of cleaning should not affect the form, fit, or function of the item being cleaned.

CLEANING AGENT: Any compound or substance, which promotes the removal of contaminants through mechanical or chemical action, may be called a cleaning agent.

CLEANING METHOD: A procedure for bringing a suitable cleaning agent in contact with all surfaces to be cleaned under the proper conditions and for a sufficient length of time to remove contaminants and loose particles to the required cleanliness level.

CLEAN ROOM: A clean room is a permanent area where a high degree of cleanliness is continuously achieved by employing varying degrees of control and monitoring of environmental conditions such as ventilation, filtration, temperature, humidity, pressure, personnel, clothing, and room maintenance. See Section 4 for clean room requirements.

CLEANING SOLVENT: A cleaning solvent is any material that exhibits the capability to dissolve other substances through chemical action and, for the purposes of this document, is 100% volatile. An example is a hydrocarbon solvent such as isopropyl alcohol (IPA), which is very flammable.

CLEANLINESS: The degree of success in preventing contamination from being present in an oxygen system is cleanliness. Cleanliness and contamination are inverse properties in that increasing cleanliness implies decreasing contamination.

CLEANLINESS LEVEL: An established maximum allowable distribution of contamination of a non-volatile residue of a specified threshold per area or particles of a given size, quantity and distribution per specified volume or area.

COMPONENT: An integral unit part of an assembly or system is a component. Examples include tubes, ducts, tanks, valves, actuators, reservoirs, and accumulators.

CONTAMINANT: A foreign or unwanted substance that can have deleterious effects on system operation, life, reliability or safety.

CONTAMINATION: The amount of material (that typically is not oxygen compatible) in a system that is not intended to be there. Contamination and cleanliness are inverse properties in that increasing cleanliness implies decreasing contamination.

CONTROLLED CLEAN AREA: A controlled clean area is an area where a high degree of cleanliness is temporarily achieved and maintained by the use of boundaries, air filtration, and the enforcement of controls on personnel access, operations, and area maintenance. Controlled clean areas are most often used for cleaning oxygen equipment where a high degree of cleanliness is necessary, but the requirements are not as stringent as an ISO Class 8 clean room. See Section 4 for controlled clean area requirements.

FIBERS: Particulate matter with a length of 100 µm or greater, and a length-to-width ratio of 10 to 1 or greater.

FILTRATION: The process of removing contaminants from a gas or liquid by passing them through porous media.

GASEOUS OXYGEN: Gaseous oxygen is a colorless, odorless, tasteless gas slightly heavier than air. Oxygen strongly supports and rapidly accelerates the combustion of many materials. If the correct oxygen pressure and temperature are present most materials react with oxygen.

GENERAL CLEAN ROOM: A room setup specifically to clean, assemble, and package oxygen equipment. There should be some control exercised to maintain room cleanliness to levels needed to clean oxygen system components/articles effectively and safely. General clean rooms are the most commonly used areas or rooms to clean aircraft oxygen equipment. See Section 4 for general clean room requirements.

GROSS CLEANING: Preliminary or rough cleaning to remove scale, rust, metal chips, dirt, etc. This cleaning is performed in a normal work area to visual inspection standards. It is inappropriate to perform gross cleaning in a controlled clean area or room.

LIQUID OXYGEN (LOX): An extremely cold, -297 °F (-183 °C), pale blue, clear liquid, slightly more dense than water and strongly paramagnetic. It strongly supports and rapidly accelerates the combustion of all flammable materials. Note that a hydrocarbon in contact with LOX will ignite explosively under the influence of pressure.

NON-VOLATILE RESIDUE (NVR): The organic and inorganic material remaining on the surface after evaporation of the solvent or volatile liquid.

NON-METALLICS: Organic and inorganic materials such as ceramics, glasses, polymer, rubber, cloth, wood and paper products.

OXYGEN COMPATIBILITY: The ability of a substance to coexist with both oxygen and a potential source(s) of ignition within the acceptable risk parameter of the user (at an expected pressure and temperature).

OXYGEN SERVICE: Surface or part of the equipment that comes in direct contact with oxygen is referred to as the part that sees oxygen service. Also referred to as the wetted surface.

PARTICULATE: A general term used to describe a finely divided solid of organic or inorganic matter, including metals. The amount of contamination for an item is usually reported as the population of a specific micrometer size. Refer to ARP598 for particle size and count determination.

PRECISION CLEANING: Final or fine cleaning accomplished in a controlled environment to remove minute quantities of contaminants to achieve the specified levels of cleanliness.

PURGE: To flow a gas through a system or line, tank, etc., for the purpose of eliminating cleaning fluid left as a residue or water and moisture as left from a cleaning operation or use of the equipment. The purging gas must be clean and free of contamination or organic material that may be included or added during a pumping operation.

PURITY: The percentage by volume of gases or by weight of liquids of the major constituent such as oxygen or liquid oxygen and the remainder is other gases such as inert gases and undesired materials or contamination. If the purity standard is met, the contamination included is within acceptable standards or purity limits.

ULTRASONIC CLEANING: A process where high frequency vibrations are used to produce a cleaning action. This requires a medium such as a solution of water and a cleaning agent to transmit the vibrations.

VISUALLY CLEAN: No contaminants or particulates are found when examined with the naked eye. This clean level should only be used for equipment operating at a pressure equal to or less than 10 psig (68.9 kPa).

3. CLEANLINESS LEVELS

3.1 General Requirements

All oxygen systems and components are required to meet an acceptable level of cleanliness established by the organization responsible for the installation of such equipment. The selection of the cleanliness level should consider the need to remove contaminants such as the following:

- Incompatible oils, grease, or any other combustible fluid or compound
- Organic particles that can oxidize or react with oxygen, such as:
 - Lint
 - Shredded paper
 - Any other combustible material
- Shreds of easily oxidizable metals, such as:
 - Aluminum
 - Magnesium
 - Iron
- Non-combustible particles that could become entrained and cause ignition due to impact with vulnerable components.

3.2 Cleaning Process Consideration Factors

Many oxygen system components, including supply plumbing and cylinders, can most effectively be cleaned when not installed in the system. Components containing plastic or elastomeric parts are subject to damage when exposed to some cleaning agents, and their resulting odors are difficult to satisfactorily remove. Contaminants such as oils, dust, metal chips, etc., cannot be easily removed by gas purging or liquid flushing within the installed system. Such contaminants can eventually become trapped in some narrow orifice causing either partial or complete failure of the system. In addition, if the contaminant is of a combustible type, the fire hazard is increased. Such contaminants can only be removed by complete disassembly of the affected components, followed by proper cleaning procedures and controlled handling of the clean components until reinstallation into the using system.

NVR (Non-Volatile Residue) testing must be used to verify that the cleaning process meets the required NVR level or better. The cleaning process verification and/or individual part cleanliness verification are necessary based upon individual components and their applications for use.

3.3 Recommended Cleaning for Articles

Appropriate cleanliness levels need to be determined and established based on the type of article and the application and conditions for which it is intended. Cleanliness levels should be specified within the technical documentation that controls the article's design requirements.

Cleanliness levels for articles being cleaned for oxygen service may also be referenced in the contract for the cleaning.

Minimum recommended cleanliness levels, based on the maximum operating pressure of the article being cleaned, are shown in Table 1.

Table 1 - Minimum recommended cleanliness levels

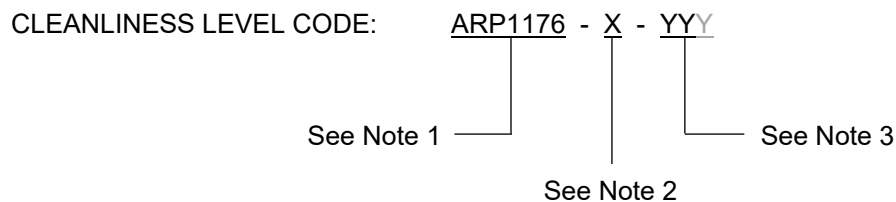
Pressure Level	NVR Level	Particulate Level	Cleanliness Level Code
<10 psig (68.9 kPa)	Visually Clean	Visually Clean	ARP1176-V
10 to 450 psig (68.9 kPa to 3.1 MPa)	≤3 mg/ft ² (0.032 g/m ²)		ARP1176-3
>450 psig (3.1 MPa)	≤3 mg/ft ² (0.032 g/m ²)	300	ARP1176-3-300

3.4 Coding

The coding scheme specified in this section is used to identify the level of cleanliness required for an article. See Figure 1 for details on how this coding scheme is defined.

The cleanliness level code requires that the maximum level of NVR (see Note 2) must be specified. The possible minimum and maximum levels of NVR that can be specified are Visually Clean and 1 mg/ft², respectively.

A Particulate Level is not required to be specified in the cleanliness level code unless a Particulate Level is required for the article being cleaned. The application and conditions for which the article is intended determines whether a Particulate Level is needed, and should be specified in the design requirements for the article.

**Figure 1 - Cleanliness level code**

Note 1: These characters reference the specification that define the cleanliness requirements.

Note 2: This single character references the maximum allowed level of NVR. See Table 2 for the defined levels of NVR, and see 5.3.1 for NVR test methods.

Note 3: These characters reference the maximum allowed Particulate Level. Either two or three characters will be used and is dependent on the Particulate Level required. See Table 3 for the defined Particulate Levels, and see 5.3.2 for particulate test methods.

NOTE: The original release of this Aerospace Recommended Practice referenced categories as the method for determining the minimum levels of cleanliness for an article. See Appendix C for the conversions between this historical method and the current cleanliness level coding scheme.

Table 2 - NVR levels

Character	NVR Level
V	Visually Clean
1	$\leq 1 \text{ mg/ft}^2$ (0.011 g/m ²)
2	$\leq 2 \text{ mg/ft}^2$ (0.022 g/m ²)
3	$\leq 3 \text{ mg/ft}^2$ (0.032 g/m ²)

Table 3 - Particulate levels

Particulate Level	Particulate Size (micrometers)	Maximum Particle Count
50	<15 15 thru 25 >25 thru 50 >50	Unlimited* 17 8 0
100	<25 25 thru 50 >50 thru 100 >100	Unlimited* 68 11 0
150	<50 50 thru 100 >100 thru 150 >150	Unlimited* 47 5 0
200	<50 50 thru 100 >100 thru 200 >200	Unlimited* 154 16 0
300	<100 100 thru 250 >250 thru 300 >300	Unlimited* 93 3 0

* "Unlimited" means particulate in this size range is not counted; however, if the accumulation of this particulate from the unlimited size range is sufficient to interfere with the analysis, the sample should be rejected (refer to MIL-STD-1330). Large amounts of "allowable particulate" can still cause a particle impact hazard. NASA has been able to ignite targets and components using collections of small particles in place of one large particle. An accumulation of the counted particulate can interfere with the proper operation of a component; therefore, there could be a limit on "unlimited."