Designation: G93/G93M – 19

Standard Guide for Cleanliness Levels and Cleaning Methods for Materials and Equipment Used in Oxygen-Enriched Environments[1]

This standard is issued under the fixed designation G93/G93M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide covers the selection of methods and apparatus for cleaning materials and equipment intended for service in oxygen-enriched environments. Contamination problems encountered in the use of enriched air, mixtures of oxygen with other gases, or any other oxidizing gas may be solved by the same cleaning procedures applicable to most metallic and nonmetallic materials and equipment. Cleaning examples for some specific materials, components, and equipment, and the cleaning methods for particular applications, are given in the appendixes.

1.2 This guide includes levels of cleanliness used for various applications and the methods used to obtain and verify these levels.

1.3 This guide applies to chemical-, solvent-, and aqueous-based processes.

1.4 This guide describes nonmandatory material for choosing the required levels of cleanliness for systems exposed to oxygen or oxygen-enriched atmospheres.

1.5 This guide proposes a practical range of cleanliness levels that will satisfy most system needs, but it does not deal in quantitative detail with the many conditions that might demand greater cleanliness or that might allow greater contamination levels to exist. Furthermore, it does not propose specific ways to measure or monitor these levels from among the available methods.

1.6 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* Federal, state, and local safety and disposal regulations concerning the particular hazardous materials, reagents, operations, and equipment being used should be reviewed by the user. The user is encouraged to obtain the Material Safety Data Sheet (MSDS) from the manufacturer for any material incorporated into a cleaning process. Specific cautions are given in Section 8.

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1193 Specification for Reagent Water

D2200 Practice for Use of Pictorial Surface Preparation Standards and Guides for Painting Steel Surfaces

E312 Practice for Description and Selection of Conditions for Photographing Specimens Using Analog (Film) Cameras and Digital Still Cameras (DSC) (Withdrawn 2017)[3]

F312 Test Methods for Microscopical Sizing and Counting Particles from Aerospace Fluids on Membrane Filters

F331 Test Method for Nonvolatile Residue of Solvent Extract from Aerospace Components (Using Flash Evaporator)

G63 Guide for Evaluating Nonmetallic Materials for Oxygen Service

G88 Guide for Designing Systems for Oxygen Service

G122 Test Method for Evaluating the Effectiveness of Cleaning Agents

G127 Guide for the Selection of Cleaning Agents for

[1] This guide is under the jurisdiction of ASTM Committee G04 on Compatibility and Sensitivity of Materials in Oxygen Enriched Atmospheres and is the direct responsibility of Subcommittee G04.02 on Recommended Practices.

Current edition approved Oct. 1, 2019. Published October 2019. Originally approved in 1987. Last previous edition approved in 2011 as G93 – 03(2011). DOI: 10.1520/G0093_G0093M-19.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

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

2.2 *CGA Documents:*[4]
CGA Pamphlet G-4.1 Cleaning Equipment for Oxygen Service
CGA Pamphlet G-4.4 Industrial Practices for Gaseous Oxygen Transmission and Distribution Piping Systems

2.3 *SAE Document:*[5]
ARP 598 The Determination of Particulate Contamination in Liquids by the Particle Count Method

2.4 *ISO Document:*[6]
ISO 14644-1 Cleanrooms and Associated Controlled Environments—Part 1: Classification of Air Cleanliness

3. Terminology

3.1 *Definitions:*

3.1.1 *contaminant, n*—unwanted molecular or particulate matter that could adversely affect or degrade the operation, life, or reliability of the systems or components upon which it resides.

3.1.2 *contamination, n—(1)* the amount of unwanted molecular or particulate matter in a system; *(2)* the process or condition of being contaminated.

3.1.2.1 *Discussion*—Contamination and cleanliness are opposing properties; increasing cleanliness implies decreasing contamination.

3.1.3 *direct oxygen service, n*—service in contact with oxygen-enriched atmosphere during normal operation.

3.1.3.1 *Discussion*—Examples are oxygen compressor piston rings or control valve seats.

3.1.4 *nonmetal, n*—any material other than a metal, nonpolymeric alloy, or any composite in which the metallic component is not the most easily ignited component and for which the individual constituents cannot be evaluated independently, including ceramics (such as glass), synthetic polymers (such as most rubber, thermoplastics, and thermosets), and natural polymers (such as naturally occurring rubber, wood, and cloth).

3.1.4.1 *Discussion*—Nonmetallic is the adjective use of this term.

3.1.5 *oxygen compatibility (also oxidant compatibility), n*—the ability of a substance to coexist with both oxygen and a potential source(s) of ignition at an expected pressure and temperature with a magnitude of risk acceptable to the user.

3.1.6 *qualified technical personnel, n*—persons such as engineers and chemists who, by virtue of education, training, or experience, know how to apply physical and chemical principles involved in the reactions between oxidants and other metals.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cleanliness, n*—the degree to which an oxygen system is free of contaminant.

3.2.2 *fibers, n*—particulate matter with a length of 100 μm or greater, and a length-to-width ratio of 10 to 1 or greater.

3.2.3 *particulate, n*—a general term used to describe a finely divided solid of organic or inorganic matter.

3.2.3.1 *Discussion*—These solids are usually reported as the amount of contaminant by the population of a specific micrometer size. See methods described in Test Methods F312 or ARP 598 for particle size and population determination.

4. Summary of Guide

4.1 General methods, apparatus, and reagents for cleaning materials and equipment used in oxygen-enriched environments are described in this guide. Exact procedures are not given because they depend on the contaminant type and material to be cleaned, cleaning agent used, and degree of cleanliness required. Methods may be used individually, or may be combined or repeated to achieve the desired results. Examples of cleaning procedures that have been successfully used for specific materials, components, and equipment in selected applications are described in the appendices. An index of the specific materials, components, equipment, and applications covered in these examples is given in Table X1.1.

4.2 For the purpose of this guide, both solid and fluid contaminants have been subclassed into three categories: organics, inorganics, and particulates. A list of common contamination levels is given in Table 1.

4.3 Cleanliness specifications that have been used in the past are identified, levels of cleanliness that can be achieved are listed along with factors that suggest potential upper limits for allowable system contamination, and the practical difficulties in adopting and achieving adequately clean systems are reviewed. Cleanliness specifications used by suppliers and manufacturers often differ; it is therefore important to communicate and agree upon which specification is to be used for a given system and to adhere to the most conservative measures.

TABLE 1 Oil Film Contamination Level Specifications[A]

Concentration, mg/m² (mg/ft²)	Source
0.14 (0.013)	1967 Navy Standard per Presti and DeSimone **(1)**
10.8 (1)	NASA KSC 123 per Report MTB 306-71 **(2)**
16.1 (1.5)	Recommended by Presti and DeSimone **(1)**
43.1 (4)	Air Force 1950s value per LeSuer **(3)**
75.3 (7)	Recommended by Walde **(4)**
108 (10 mg/ft² or per item)	Union Carbide Guideline **(5,6)**
50 to 100 (4.6 to 9.3)	Compressed Gas Association Pamphlet G-4.8 **(7)**
500 (47.5)	Compressed Gas Association Pamphlet G-4.1 **(8)**

[A] The boldface numbers in parentheses refer to the list of references at the end of this standard.

[4] Available from Compressed Gas Association (CGA), 4221 Walney Rd., 5th Floor, Chantilly, VA 20151-2923, http://www.cganet.com.

[5] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.

[6] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, http://www.iso.ch.

5. Significance and Use

5.1 The purpose of this guide is to furnish qualified technical personnel with pertinent information for the selection of cleaning methods for cleaning materials and equipment to be used in oxygen-enriched environments. This guide furnishes qualified technical personnel with guidance in the specification of oxygen system cleanliness needs. It does not actually specify cleanliness levels.

5.2 Insufficient cleanliness of components used in oxygen systems can result in the ignition of contaminants or components by a variety of mechanisms such as particle, mechanical, or pneumatic impact. These mechanisms are explained in detail in Guide G88.

5.3 Adequate contamination control in oxygen systems is imperative to minimize hazards and component failures that can result from contamination. Contamination must also be minimized to ensure an acceptable product purity.

5.4 Removal of contaminants from materials and components depends on system configuration, materials of construction, and type and quantity of contaminant.

5.5 Examples of cleaning procedures contained herein may be followed or specified for those materials, components, and equipment indicated. The general cleaning text can be used to establish cleaning procedures for materials, components, equipment, and applications not addressed in detail. See Guide G127 for discussion of cleaning agent and procedure selection.

6. Interferences

6.1 *Disassembly:*

6.1.1 It is imperative that oxygen systems be cleaned as individual components or piece parts, preferably before assembly. Assembled systems must be disassembled for cleaning if construction permits. Flushing an assembled system can deposit and concentrate contaminants in stagnant areas. Nonvolatile cleaning agents may remain in trapped spaces and later react with oxygen. Cleaning solutions may degrade nonmetals in an assembly. Caustic and acid cleaning solutions may cause crevice corrosion in assemblies.

6.1.2 Manufactured products (that is, valves, regulators, and pumps) should be cleaned preferably by the manufacturer before final assembly and test. All joints should be structured to prevent recontamination. The part must then be packaged in oxygen-compatible materials (see 12.1) and identified to protect it from contamination in transit and storage. The purchaser should approve the cleaning procedure and packaging to assure that they satisfy system requirements. Some purchasers may require the product manufacturer to certify cleanliness level and oxygen compatibility of all component materials.

6.1.3 Manufactured products cleaned by the purchaser must be disassembled for cleaning if construction permits. The purchaser should follow the manufacturer's instructions for disassembly, inspection for damage, reassembly, and testing.

6.2 *Cleaners:*

6.2.1 Mechanical cleaning methods such as abrasive blasting, tumbling, grinding, and wire brushing are very aggressive and should be avoided on finished machined articles. Such methods can damage sealing surfaces, remove protective coatings, and work-harden metals. Sensitive surfaces must be protected before mechanical cleaning methods are applied.

6.2.2 Chemical cleaners, both acid and caustic, can damage metal parts if not neutralized upon completion of cleaning. Corrosion, embrittlement, or other surface modifications are potentially harmful side effects of chemical cleaning agents. Crevice corrosion can occur and sealing surfaces can be etched enough to destroy the finish necessary to seal the part. See Test Method G122 and Guide G127 for methods used to evaluate cleaners for use on various materials used in oxygen service.

6.2.3 Solvent cleaning solutions often damage plastics and elastomers. The manufacturer should be consulted or sample parts should be tested to ensure that the solvent is not harmful to the item being cleaned.

6.3 *Lubricants:*

6.3.1 Mechanical components are normally assembled with lubricants on seals, threads, and mating surfaces. The manufacturer should be consulted to determine the kind of lubricant originally used on the article to ensure that the cleaning solutions and methods selected are effective in removing the lubricant and will not damage the component.

6.3.2 Oxygen-compatible lubricants should be selected in accordance with Guide G63. The component manufacturer should also be consulted to ensure that the selected lubricant provides adequate lubrication for component performance. Oxygen-compatible lubricants often have markedly different lubricating properties from conventional lubricants.

6.4 *Environment and Assembly Requirements:*

6.4.1 Equipment intended for oxygen service must be handled carefully during all phases of a cleaning procedure. The environment should be clean and dust-free. Nearby grinding, welding, and sanding should be prohibited. Parts should not be allowed to stand in the open unprotected after they have been cleaned. Care should be taken to avoid contamination by oil deposits from rotating machinery or oil aerosols in the air. Do not touch part surfaces that will be in direct oxygen service except with clean gloves or handling devices.

6.4.2 In some cases, laminar-flow clean rooms may be necessary in which the entire room is purged with filtered air. In horizontal flow clean rooms, parts are cleaned and verified in a sequence in which successive cleaning operations are at locations progressively closer to the filtered air source so that the part and the environment each become steadily cleaner. In laminar vertical flow clean rooms, the layout of the successive cleaning operations is not as critical. See ISO 14664 for further information.

7. Conditioning

7.1 Factors to consider before selecting cleaning methods include:

7.1.1 Type of contaminant, that is, inorganic, organic, particulate, film, or fluid,

7.1.2 Base material or coating of the part to be cleaned,

7.1.3 Initial condition of the part to be cleaned,

7.1.4 Required final cleanliness of the part,