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Standard Guide for the Selection of Cleaning Agents for Oxygen-Oxygen-Enriched Systems¹

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1. Scope

1.1 The purpose of this guide is to establish a procedure to select cleaning agents, both solvents and water-based detergents, for oxygen service, oxygen-enriched systems. This includes ~~of~~ laboratory-scale tests for cleaning effectiveness, materials compatibility, and oxygen compatibility.

1.2 The effectiveness of a particular cleaning agent depends upon the method by which it is used, the nature and type of the contaminants, and the characteristics of the article being cleaned, such as size, shape, and material. Final evaluation of the cleaning agent should include testing of actual products and production processes.

1.3 Different cleaning agents may be required for different cleaning activities, such as aqueous ultrasonic cleaning, spray cleaning, hand wiping, and flushing of oxygen lines in field applications.

1.4 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

[D471 Test Method for Rubber Property—Effect of Liquids](#)

[D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents](#)

[D1193 Specification for Reagent Water](#)

[D1460 Test Method for Rubber Property—Change in Length During Liquid Immersion](#)

[D2512 Test Method for Compatibility of Materials with Liquid Oxygen \(Impact Sensitivity Threshold and Pass-Fail Techniques\)](#)

[D2863 Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics \(Oxygen Index\)](#)

~~[D2934 Test Method for Compatibility of Vulcanized Rubber Seals—Compatibility with Service Fluids \(Withdrawn 1993\)](#)~~³

[D4809 Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter \(Precision Method\)](#)

[F483 Practice for Total Immersion Corrosion Test for Aircraft Maintenance Chemicals](#)

[G5 Reference Test Method for Making Potentiodynamic Anodic Polarization Measurements](#)

[G31 Guide for Laboratory Immersion Corrosion Testing of Metals](#)

[G59 Test Method for Conducting Potentiodynamic Polarization Resistance Measurements](#)

[G63 Guide for Evaluating Nonmetallic Materials for Oxygen Service](#)

[G72 Test Method for Autogenous Ignition Temperature of Liquids and Solids in a High-Pressure Oxygen-Enriched Environment](#)

[G74 Test Method for Ignition Sensitivity of Nonmetallic Materials and Components by Gaseous Fluid Impact](#)

[G86 Test Method for Determining Ignition Sensitivity of Materials to Mechanical Impact in Ambient Liquid Oxygen and Pressurized Liquid and Gaseous Oxygen Environments](#)

[G93 Practice for Cleaning Methods and Cleanliness Levels for Material and Equipment Used in Oxygen-Enriched Environments](#)

[G94 Guide for Evaluating Metals for Oxygen Service](#)

[G121 Practice for Preparation of Contaminated Test Coupons for the Evaluation of Cleaning Agents](#)

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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.

5.3.1 Nonmetallic materials commonly used in ~~oxygen service~~oxygen-enriched systems are discussed in Guide **G63**; and Handbook MNL36.

5.3.2 ~~Nonmetallic materials representative of numerous applications in oxygen systems and suitable for inclusion in a test protocol are as follows:~~Materials compatibility tests should include those nonmetallic materials used in the oxygen-enriched system that are expected to come in contact with the candidate cleaning agent. As a minimum, materials representative of each family of these nonmetals should be tested.

- 5.3.2.1 Ethylene Propylene Rubber (EPDM);
- 5.3.2.2 Perfluoroelastomer (Kalrez[®], Chemraz[®]);
- 5.3.2.3 PCTFE, Polychlorotrifluoroethylene (Kel-F[®]);
- 5.3.2.4 Chloroprene Rubber (Neoprene);
- 5.3.2.5 Polyamid Polymer (Nylon);
- 5.3.2.6 PTFE, Polytetrafluoroethylene (Teflon[®]), and
- 5.3.2.7 Fluoroelastomer (Viton[®] A, Fluorel).

6. Cleaning Effectiveness Tests

6.1 Selection of Test Contaminants:

6.1.1 Numerous contaminants encountered in ~~oxygen~~oxygen-enriched systems that could result from manufacturing, assembly, fabrication, and construction processes are listed in Practice **G93**. Typical ~~contaminants~~contaminant types include:

- 6.1.1.1 Hydrocarbon oils and ~~greases~~greases (mineral oil, hydraulic fluids, lubricants, water-displacing compounds),
- 6.1.1.2 Fluorinated fluids and greases,
- 6.1.1.3 Inks,
- 6.1.1.4 Machine cutting ~~oils~~oils (hydrocarbon- or water-based),
- 6.1.1.5 Carbon deposits,
- 6.1.1.6 Silicone oils and greases,
- 6.1.1.7 Phosphate ~~esters~~esters (fire-resistant hydraulic fluids),
- 6.1.1.8 Waxes,
- 6.1.1.9 Dye penetrants,
- 6.1.1.10 Chlorotrifluoroethylene based oils and ~~greases~~greases,
- 6.1.1.11 Pariculate (sand, metal shavings, fibers, etc.), and
- 6.1.1.12 Tape residue.

NOTE 1—Some contaminants are more difficult to remove after aging or exposure to heat. Selection of a cleaning agent should consider removal efficiency for both the type and condition of contaminants typically encountered at the facility.

6.1.2 Among typical contaminants, hydrocarbons are the prime candidates for the test protocol. When dealing with other contaminants, the user should attempt to classify the type of contamination expected on the equipment to be cleaned.

6.1.3 As a preliminary test, mineral oil or a mixture of common cutting oils may be used as a contaminant. It may be carried in a suitable volatile solvent as a means to introduce it into a system. In addition, vacuum pump oil, or a compressor oil are suggested as contaminants for the evaluation program. In a more refined test at later stages, fluorinated oils/greases, dye penetrants, or a mixture of as many contaminants as necessary may be prepared in a suitable solvent. Eventually, actual contaminants encountered on an engineering component or system for ~~oxygen~~oxygen-enriched service ~~shall~~should be evaluated for removal efficiency.

6.2 Test Methods:

6.2.1 A suggested starting level of contamination is 1000 mg/m². This is a hydrocarbon level that is consistent with contamination levels associated with final cleaning and it is twice the acceptable level specified for oxygen service in CGA pamphlet G-4.1. Heavily contaminated surfaces with levels in excess of 1000 mg/m² must be precleaned using more aggressive cleaning agents with mechanical scrubbing (Practice **G93**). Precleaning is not a cleaning step with which this guide is concerned.

6.2.2 Contaminants may be applied to the specimens by any of the means specified in Practice **G121**.

6.2.3 The cleaning effectiveness of a cleaning agent ~~shall~~may be evaluated using the test method outlined in Test Method **G122**.

6.2.4 A test basis ~~shall~~should be established for each contaminated sample by using an acceptable solvent as a control cleaning agent.

7. Material Compatibility Tests

7.1 If a cleaning agent's ability to remove the selected contamination is deemed promising, additional testing (see Sections **8-28.2.2** and **8.3**) should be performed to evaluate its compatibility with the ~~oxygen~~oxygen-enriched systems.

7.2 Metallic Materials:

7.2.1 Significant corrosion damage may occur during cleaning operations. Corrosion rates may be affected by temperature, contaminants, degree of aeration, concentration and presence of residual stress (see **Note 12**). To avoid this, assessments should

be made of the corrosion severity of cleaning environments for the engineering materials of interest. Weight gain-loss measurements can be performed as per Practice [F483](#) or [G31](#). Where applicable, Test Method [G5](#) can be applied (see [Note 23](#)).

7.2.2 The electrochemical technique of potentiodynamic polarization resistance (Practice [G59](#)) can be used to determine the corrosion rate of conductive cleaning agents on metal substrates. The corrosion rate (in mils per year, mpy) should be determined using the solution parameters which would be used in actual cleaning practices. The cleaning solution may be tested: (1) ~~as-is~~; (2) ~~deaerated~~; (3) ~~aerated~~-as is; (2) aerated; or (3) de-aerated. It is recommended, however, that the corrosion test be performed under as-is conditions in order to simulate the actual cleaning process. The pH and conductivity of the cleaning agent should be measured both before and after the corrosion test. If these ~~property~~-values change, the test is considered invalid. A separate experiment should be performed.

~~NOTE 1—The presence of residual stresses may promote stress corrosion cracking in susceptible materials. Information in the technical literature on corrosion rates and stress corrosion cracking may be used in evaluating corrosion susceptibility. Further testing, as outlined later in this guide, may be necessary.~~

~~NOTE 2—In order to reflect the actual material property, samples for corrosion tests should not be wet ground with 600-grit SiC papers to expose fresh surface. The surface roughness of test samples should be either in compliance with that recommended in Practice [G121](#), or, if possible, commensurate with that of the actual engineering components.~~

7.2.3 Corrosion rates of less than 32.5 micrometre per year (0.0025 in. per year) are usually desirable. However, to avoid setting up unduly conservative criteria that may eliminate potential cleaning agents, estimation of corrosion rate can be made based upon realistic, total accumulated contact time of the cleaner with a component or system throughout its service life. The rate of corrosion should be determined based upon the maximum allowable dimensional variations of the component or system.

~~NOTE 2—The presence of residual stresses may promote stress corrosion cracking in susceptible materials. Information in the technical literature on corrosion rates and stress corrosion cracking may be used in evaluating corrosion susceptibility. Further testing, as outlined later in this guide, may be necessary.~~

~~NOTE 3—In order to reflect the actual material property, samples for corrosion tests should not be wet ground with 600-grit SiC papers to expose fresh surface. The surface roughness of test samples should be either in compliance with that recommended in Practice [G121](#), or, if possible, commensurate with that of the actual engineering components.~~

7.3 Nonmetallic Materials:

7.3.1 When exposed to the cleaning agent under actual use conditions of temperature, time, concentration etc., some of the nonmetallics are susceptible to degradation and may experience physical, mechanical, and chemical and possibly thermal property changes. These changes are typically changes. Physical and mechanical changes can be reversible or irreversible, while chemical changes are generally irreversible. Depending on the material-solvent pair, these changes can be characterized by swelling, distortion, weight gain or loss, cracking, crazing, blistering, embrittlement and decomposition temperature shift. embrittlement, decomposition temperature shift, or leaching of additives and low-molecular-weight species (e.g. unreacted monomer, catalyst residues). To evaluate the compatibility of cleaning agents with nonmetallic materials, refer to Test Methods [D471](#), [D543](#), and [D1460](#), and Method . These test methods may not include a pass/fail criterion for each material property. Therefore, an engineering evaluation that considers whether any identified material property changes are acceptable in the application should be performed. Some of these material property changes can influence the oxygen compatibility of the nonmetallic material. If the influence of a material property change on oxygen compatibility is uncertain, the oxygen compatibility testing discussed in Guide [D2934G63](#) should be performed on the nonmetallic material (pre- and post-exposure to the cleaning solution and process) to support this evaluation.

7.3.2 Weight loss, shrinkage, cracking, crazing, blistering, or embrittlement are evidence that the cleaning agent is reacting with or leaching materials from the nonmetal and is therefore incompatible.

7.3.3 Corrosion rates of less than 63.5 micrometer per year (2.5 mpy) are usually desirable. However, to avoid setting up unduly conservative criteria which may eliminate potential cleaning agents, estimation of corrosion rate can be made based upon realistic, total accumulated contact time of the cleaner with a component. Swelling and weight gain may indicate that the nonmetal is absorbing some of the cleaning agent during exposure. Some slight swelling and weight gain may be acceptable if the cleaning agent does not adversely affect oxygen compatibility or component function. The drying method and length of drying time used in the test should be representative of the expected user cleaning process.

~~NOTE 4—Return to original dimensions after drying is indicative of a totally reversible solvent absorption/desorption process with no effect on properties or oxygen compatibility.~~

~~Warning—Prolonged exposure to solvents can result in time-dependent absorption and desorption processes, and lead to erroneous conclusions based on weight and dimensions alone.~~ system throughout its service life. The rate of corrosion should be determined based upon the maximum allowable dimensional variations of the component or system.

7.3.4 Cleaning agents that are effective at removing hydrocarbon, halocarbon, perhalogenated, or silicone contaminants will be incompatible with some nonmetals with analogous hydrocarbon, halocarbon, etc., content. This may require that the incompatible soft goods be removed from a component prior to cleaning and cleaned by another method. This may also require changing seal materials in the cleaning equipment when changing to a new cleaning agent.