



## Standard Guide for the Selection of Cleaning Agents for Oxygen Systems<sup>1</sup>

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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. 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 *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:

- D 471 Test Method for Rubber Property—Effect of Liquids<sup>2</sup>
- D 543 Test Method for Resistance of Plastics to Chemical Reagents<sup>3</sup>
- D 1193 Specification for Reagent Water<sup>4</sup>
- D 1460 Test Method for Rubber Property—Change in Length During Liquid Immersion<sup>2</sup>
- D 2512 Test Method for Compatibility of Materials with Liquid Oxygen (Impact Sensitivity Threshold and Pass-Fail Techniques)<sup>5</sup>
- D 2863 Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-like Combustion of Plastics (Oxygen Index)<sup>6</sup>
- D 2934 Practice for Rubber Seals—Compatibility with Service Fluids<sup>7</sup>
- D 4809 Test Method for Heat of Combustion of Liquid

Hydrocarbon Fuels by Bomb Calorimeter (Intermediate Precision Method)<sup>8</sup>

G 5 Reference Test Method for Making Potentiostatic and Potentiodynamic Anodic Polarization Measurements<sup>9</sup>

G 31 Practice for Laboratory Immersion Corrosion Testing of Metals<sup>9</sup>

G 59 Practice for Conducting Potentiodynamic Polarization Resistance Measurements<sup>9</sup>

G 63 Guide for Evaluating Nonmetallic Materials for Oxygen Service<sup>10</sup>

G 72 Test Method for Autogenous Ignition Temperature of Liquids and Solids in a High-Pressure Oxygen-Enriched Environment<sup>10</sup>

G 74 Test Method for Ignition Sensitivity of Materials to Gaseous Fluid Impact<sup>10</sup>

G 93 Practice for Cleaning Methods for Material and Equipment Used in Oxygen-Enriched Environments<sup>10</sup>

G 94 Guide for Evaluating Metals for Oxygen Service<sup>10</sup>

G 121 Practice for Preparation of Contaminated Test Coupons for the Evaluation of Cleaning Agents<sup>10</sup>

G 122 Test Method to Evaluate the Effectiveness of Cleaning Agents<sup>10</sup>

#### 2.2 CGA Document:

CGA Pamphlet G-4.1 Cleaning Equipment for Oxygen Service

### 3. Significance and Use

3.1 The purpose of this guide is to provide information that may be considered when selecting and qualifying a cleaning agent for an oxygen system.

3.2 Insufficient cleanliness can result in the ignition of contaminants or components by a variety of mechanisms. Therefore, an acceptable level of contamination for each condition of use in oxygen service should be defined. The acceptable level of contamination may depend on various factors, such as:

- 3.2.1 The nature and type of the contaminants,
- 3.2.2 The location and degree of contamination,
- 3.2.3 The type of substrate material,
- 3.2.4 The configuration and end use of the equipment or part to be cleaned, and

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 09.01.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 08.01.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 11.01.

<sup>5</sup> *Annual Book of ASTM Standards*, Vol 15.03.

<sup>6</sup> *Annual Book of ASTM Standards*, Vol 08.02.

<sup>7</sup> *Annual Book of ASTM Standards*, Vol 09.02.

<sup>8</sup> *Annual Book of ASTM Standards*, Vol 05.03.

<sup>9</sup> *Annual Book of ASTM Standards*, Vol 03.02.

<sup>10</sup> *Annual Book of ASTM Standards*, Vol 14.02.

3.2.5 The operating parameters of the oxygen system (pressure, temperature, phase, concentration, fluid velocity, etc.).

#### 4. Selection of Cleaning Agent

4.1 Before a specific cleaning agent is selected for testing, the following attributes should be considered.

- 4.1.1 Toxicity,
- 4.1.2 Carcinogenicity,
- 4.1.3 Recyclability,
- 4.1.4 Waste disposal,
- 4.1.5 Ozone depletion,
- 4.1.6 Inertness (flammability and combustibility),
- 4.1.7 Corrosivity and compatibility with metallic and non-metallic engineering materials,
- 4.1.8 Availability and technical support from supplier,
- 4.1.9 Cost effectiveness, and
- 4.1.10 Compliance with local, state and federal regulations.

4.2 It is desirable that the cleaning agent could be applied by a variety of methods, such as wiping, immersion, spraying, etc. Consequently, the cleaning agent manufacturer's instructions for applying the cleaner shall be considered.

#### 5. Selection of Substrate Materials

5.1 Substrate materials used for cleaning effectiveness and compatibility tests should be representative of those used in the end application.

##### 5.2 *Metallic Materials:*

5.2.1 Metallic materials commonly used in oxygen systems are listed in Guide G 94.

5.2.2 Alloys representative of numerous applications in oxygen systems and suitable for inclusion in a test protocol are as follows:

- 5.2.2.1 304 stainless steel,
- 5.2.2.2 Aluminum alloy 6061 (or 5051),
- 5.2.2.3 Carbon steel 1018,
- 5.2.2.4 Admiralty brass CDA 443,<sup>11</sup>
- 5.2.2.5 Monel 400,
- 5.2.2.6 4130X low alloy steel,
- 5.2.2.7 Inconel 718,
- 5.2.2.8 Copper,
- 5.2.2.9 Tin-bronze, and
- 5.2.2.10 Cobalt alloy 188.

##### 5.3 *Nonmetallic Materials:*

5.3.1 Nonmetallic materials commonly used in oxygen service are discussed in Guide G 63.

5.3.2 Nonmetallic materials representative of numerous applications in oxygen systems and suitable for inclusion in a test protocol are as follows:

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

#### 6. Cleaning Effectiveness Tests

##### 6.1 *Selection of Test Contaminants:*

6.1.1 Numerous contaminants encountered in oxygen systems that could result from manufacturing, assembly, fabrication, and construction processes are listed in Practice G 93. Typical contaminants include:

- 6.1.1.1 Hydrocarbon oils and greases,
- 6.1.1.2 Fluorinated fluids and greases,
- 6.1.1.3 Inks,
- 6.1.1.4 Machine cutting oils,
- 6.1.1.5 Carbon deposits,
- 6.1.1.6 Silicone oils and greases,
- 6.1.1.7 Phosphate esters,
- 6.1.1.8 Waxes,
- 6.1.1.9 Dye penetrants,
- 6.1.1.10 Chlorotrifluoroethylene based oils and greases.

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, 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 service shall be evaluated for removal efficiency.

##### 6.2 *Test Methods:*

6.2.1 A suggested starting level of contamination is 1000 mg/m<sup>2</sup>. 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/m<sup>2</sup> must be precleaned using more aggressive cleaning agents with mechanical scrubbing (Practice G 93). 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 G 121.

6.2.3 The cleaning effectiveness of a cleaning agent shall be evaluated using the test method outlined in Test Method G 122.

6.2.4 A test basis shall 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 8.2 and 8.3) should be performed to evaluate its compatibility with the oxygen 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

<sup>11</sup> Available from the Copper Development Association, 405 Lexington Ave, New York, NY 10017.