Designation: G94 – 22

Standard Guide for Evaluating Metals for Oxygen Service[1]

This standard is issued under the fixed designation G94; 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 applies to metallic materials under consideration for oxygen or oxygen-enriched fluid service, direct or indirect, as defined in Section 3. It is concerned primarily with the properties of a metallic material associated with its relative susceptibility to ignition and propagation of combustion. It does not involve mechanical properties, potential toxicity, outgassing, reactions between various materials in the system, functional reliability, or performance characteristics such as aging, shredding, or sloughing of particles, except when these might contribute to an ignition.

1.2 This document applies only to metals; nonmetals are covered in Guide G63.

NOTE 1—The American Society for Testing and Materials takes no position respecting the validity of any evaluation methods asserted in connection with any item mentioned in this guide. Users of this guide are expressly advised that determination of the validity of any such evaluation methods and data and the risk of use of such evaluation methods and data are entirely their own responsibility.

NOTE 2—In evaluating materials, any mixture with oxygen exceeding atmospheric concentration at pressures higher than atmospheric should be evaluated from the hazard point of view for possible significant increase in material combustibility.

1.3 *Units*—The values stated in SI units are to be regarded as the standard.

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

1.5 *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]

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)

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

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

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

G88 Guide for Designing Systems for Oxygen Service

G93 Guide for Cleanliness Levels and Cleaning Methods for Materials and Equipment Used in Oxygen-Enriched Environments

G124 Test Method for Determining the Combustion Behavior of Metallic Materials in Oxygen-Enriched Atmospheres

G126 Terminology Relating to the Compatibility and Sensitivity of Materials in Oxygen Enriched Atmospheres

G128 Guide for Control of Hazards and Risks in Oxygen Enriched Systems

2.2 *ASTM Special Technical Publications (STPs) on the Flammability and Sensitivity of Materials in Oxygen-Enriched Atmospheres:*

ASTM STPs in this category are listed as: 812, 910, 986, 1040, 1111, 1167, 1197, 1319, 1395, and 1454

[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.

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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.

2.3 *CGA Documents:*[3]

G-4.4 (EIGA Doc. 13) Oxygen Pipeline and Piping Systems

G-4.8 Safe Use of Aluminum Structured Packing for Oxygen Distillation

G-4.9 Safe Use of Brazed Aluminum Heat Exchangers for Producing Pressurized Oxygen

P-8.4 (EIGA Doc. 65) Safe Operation of Reboilers/Condensers in Air Separation Plants

2.4 *ASTM Adjuncts:*

Test Program Report on the Ignition and Combustion of Materials in High-Pressure Oxygen[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *autoignition temperature, n*—the lowest temperature at which a material will spontaneously ignite in oxygen under specific test conditions (see Terminology G126).

3.1.2 *direct oxygen service, n*—in contact with oxygen during normal operations. Examples: oxygen compressor piston rings, control valve seats (see Terminology G126).

3.1.3 *exemption pressure, n*—the maximum pressure for an engineering alloy at which there are no oxygen velocity restrictions (from CGA 4.4 and EIGA doc 13/02).

3.1.4 *impact-ignition resistance, n*—the resistance of a material to ignition when struck by an object in an oxygen atmosphere under a specific test procedure (see Terminology G126).

3.1.5 *indirect oxygen service, n*—not normally in contact with oxygen, but which might be as a result of a reasonably foreseeable malfunction, operator error, or process upset. Examples: liquid oxygen tank insulation, liquid oxygen pump motor bearings (see Terminology G126).

3.1.6 *maximum use pressure, n*—the maximum pressure to which a material can be subjected due to a reasonably foreseeable malfunction, operator error, or process upset (see Guide G63).

3.1.7 *maximum use temperature, n*—the maximum temperature to which a material can be subjected due to a reasonably foreseeable malfunction, operator error, or process upset (see Terminology G126).

3.1.8 *nonmetallic, adj*—applies to any material, other than a metal, or any composite in which the metal is not the most easily ignited component and for which the individual constituents cannot be evaluated independently (see Terminology G126).

3.1.9 *operating pressure, n*—the pressure expected under normal operating conditions (see Terminology G126).

3.1.10 *operating temperature, n*—the temperature expected under normal operating conditions (see Terminology G126).

3.1.11 *oxygen-enriched, adj*—applies to a fluid (gas or liquid) that contains more than 25 mol % oxygen (see Terminology G126).

3.1.12 *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 oxygen and other materials (see Terminology G126).

3.1.13 *reaction effect, n*—the personnel injury, facility damage, product loss, downtime, or mission loss that could occur as the result of an ignition (see Terminology G126).

3.1.14 *threshold pressure, n*—there are several different definitions of threshold pressure that are pertinent to the technical literature. It is important that the user of the technical literature fully understand those definitions of threshold pressure which apply to specific investigations being reviewed. Two definitions for threshold pressure, based on interpretations of the bulk of the current literature, appear below.

3.1.14.1 *threshold pressure, n—in a promoted ignition-combustion test series conducted over a range of pressures*, this is the maximum pressure at which no burns, per the test criteria, were observed and above which burns were experienced or tests were not conducted.

3.1.14.2 *threshold pressure, n*—the minimum gas pressure (at a specified oxygen concentration and ambient temperature) that supports self-sustained combustion of the entire standard sample (see Test Method G124).

4. Significance and Use

4.1 The purpose of this guide is to furnish qualified technical personnel with pertinent information for use in selecting metals for oxygen service in order to minimize the probability of ignition and the risk of explosion or fire. It is intended for use in selecting materials for applications in connection with the production, storage, transportation, distribution, or use of oxygen. *It is not intended as a specification for approving materials for oxygen service.*

5. Factors Affecting Selection of Materials

5.1 *General:*

5.1.1 The selection of a material for use with oxygen or oxygen-enriched atmospheres is primarily a matter of understanding the circumstances that cause oxygen to react with the material. Most materials in contact with oxygen will not ignite without a source of ignition energy. When an energy-input exceeds the configuration-dependent threshold, then ignition and combustion may occur. Thus, the material's flammability properties and the ignition energy sources within a system must be considered. These should be viewed in the context of the entire system design so that the specific factors listed in this guide will assume the proper relative significance. In summary, it depends on the application.

5.2 *Relative Amount of Data Available for Metals and Nonmetals:*

5.2.1 Studies of the flammability of gaseous fuels were begun more than 150 years ago. A wide variety of applications have been studied and documented, including a wide range of important subtleties such as quenching phenomena, turbulence, cool flames, influence of initial temperature, etc., all of which have been used effectively for safety and loss prevention. A

[3] Available from Compressed Gas Association (CGA), 8484 Westpark Drive, Suite 220, McLean, VA 22102, http://www.cganet.com.

[4] Available from ASTM International Headquarters. Order Adjunct No. ADJG0094. Original adjunct produced in 1986.