Designation: G114 – 14

Standard Practices for Evaluating the Age Resistance of Polymeric Materials Used in Oxygen Service[1]

This standard is issued under the fixed designation G114; 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 These practices describe procedures that are used to determine the age resistance of plastic, thermosetting, elastomeric, and polymer matrix composite materials exposed to oxygen-containing media.

1.2 While these practices focus on evaluating the age resistance of polymeric materials in oxygen-containing media prior to ignition and combustion testing, they also have relevance for evaluating the age resistance of metals, and nonmetallic oils and greases.

1.3 These practices address both established procedures that have a foundation of experience and new procedures that have yet to be validated. The latter are included to promote research and later elaboration in this practice as methods of the former type.

1.4 The results of these practices may not give exact correlation with service performance since service conditions vary widely and may involve multiple factors such as those listed in subsection 5.8.

1.5 Three procedures are described for evaluating the age resistance of polymeric materials depending on application and information sought.

1.5.1 *Procedure A: Natural Aging*—This procedure is used to simulate the effect(s) of one or more service stressors on a material's oxygen resistance, and is suitable for evaluating materials that experience continuous or intermittent exposure to elevated temperature during service.

1.5.2 *Procedure B: Accelerated Aging Comparative Oxygen Resistance*—This procedure is suitable for evaluating materials that are used in ambient temperature service, or at a temperature that is otherwise lower than the aging temperature, and is useful for developing oxygen compatibility rankings on a laboratory comparison basis.

1.5.3 *Procedure C: Accelerated Aging Lifetime Prediction*—This procedure is used to determine the relationship between aging temperature and a fixed level of property change, thereby allowing predictions to be made about the effect of prolonged service on oxidative degradation.

1.6 The values stated in SI units are to be regarded as the standard, however, all numerical values shall also be cited in the systems in which they were actually measured.

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 and health practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given in Section 10.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D395 Test Methods for Rubber Property—Compression Set
D412 Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension
D638 Test Method for Tensile Properties of Plastics
D1349 Practice for Rubber—Standard Conditions for Testing
D1708 Test Method for Tensile Properties of Plastics by Use of Microtensile Specimens
D2240 Test Method for Rubber Property—Durometer Hardness
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)
D3039 Test Method for Tensile Properties of Polymer Matrix Composite Materials
D3045 Practice for Heat Aging of Plastics Without Load
D4809 Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)

[1] These practices are 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.

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
G125 Test Method for Measuring Liquid and Solid Material Fire Limits in Gaseous Oxidants
G126 Terminology Relating to the Compatibility and Sensitivity of Materials in Oxygen Enriched Atmospheres

2.2 *CGA Standard:*

CGA G-4.3 Type I QVL E Commodity Specification for Oxygen[3]

2.3 *Military Standard:*

MIL-PRF-27210 Amendment 1—Oxygen, Aviator's Breathing, Liquid and Gas[4]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *aging*—see Terminology G126.

3.1.2 *accelerated aging*—a type of artificial aging whereby the effect of prolonged exposure during service is simulated by aging at elevated temperature.

3.1.3 *artificial aging*—see Terminology G126.

3.1.4 *oxidative degradation*—physical or mechanical property changes occurring as a result of exposure to oxygen-containing media.

3.1.5 *oxygen-containing media*—air media containing greater than 21 mole % oxygen, or oxygen-enriched media containing greater than 25 mole % oxygen.

3.1.6 *oxygen resistance*—resistance of a material to ignite spontaneously, propagate by sustained combustion, or undergo oxidative degradation.

3.1.7 *oxygen service*—applications involving the production, storage, transportation, distribution, or use of oxygen-containing media.

3.1.8 *natural aging*—see Terminology G126.

3.1.9 *physical aging*—aging that occurs during normal storage and which is a function of time after molding or curing.

4. Summary of Practice

4.1 These practices can be used to evaluate systematically the effect of natural aging (Procedure A) or accelerated aging (Procedures B and C) on oxygen resistance. To apply its principle, the user first characterizes the material, then subjects the material to an aging stressor or stressors, followed by re-characterizing the material. Caution must be taken in interpreting results because interactions occurring in service may be different from those simulated during aging.

4.2 It is always more accurate, although not always practical, to determine the effect of natural aging (Procedure A) without resorting to accelerated aging (Procedures B and C). Accelerated aging procedures are more useful for determining material rankings (Procedure B) or for making lifetime predictions (Procedure C).

4.3 *Summary of Practice for Evaluating the Effect of Aging in Incident Studies:*

4.3.1 In incident studies, in which initial characterization data are not available, historical or average property data may be used to draw coarser conclusions about the effect of aging on oxygen resistance.

4.4 *Practices for Natural Aging (Procedure A) and Accelerated Aging for Comparative Oxygen Resistance (Procedure B):*

4.4.1 The effect of aging is reported as positive or negative depending upon whether the property used to evaluate oxygen resistance increases or decreases, and the magnitude of the effect is reported as the degree to which the measured property changes relative to that of the unaged material.

4.5 *Practice for Accelerated Aging for Lifetime Prediction (Procedure C):*

4.5.1 The time necessary to produce a fixed level of property change is determined at a series of elevated aging temperatures, and the time necessary to produce the same level of property change at some lower temperature is then determined by linear extrapolation.

4.5.2 A practice for evaluating the effect of accelerated aging on physical and mechanical properties under conditions of variable time and temperature has been validated for significance and is described in detail. This practice is similar to that given in Practice D3045 but is specific to aging in oxygen-containing media.

4.5.3 A practice for evaluating the effect of accelerated aging on ignition and combustion properties under conditions of variable time and temperature has not been validated for significance, but may yield meaningful results. The practice described is included to promote research and possible development into an established method.

4.5.4 There can be very large errors when accelerated aging Arrhenius approaches are used to estimate the time necessary to produce a fixed level of property change at some lower temperature. This estimated time to produce a fixed level of property change or "failure" at the lower temperature is often called the "service life." Because of the errors associated with these calculations, this time should be considered to be the "maximum expected" rather than "typical."

NOTE 1—Errors in accelerated aging Arrhenius approaches arise from changes in this oxidative degradation mechanism at elevated temperature.

5. Significance and Use

5.1 This practice allows the user to evaluate the effect of service or accelerating aging on the oxygen resistance of polymeric materials used in oxygen service.

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

[4] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://www.dsp.dla.mil.