Designation: G124 – 10

Standard Test Method for Determining the Combustion Behavior of Metallic Materials in Oxygen-Enriched Atmospheres[1]

This standard is issued under the fixed designation G124; 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 test method covers test apparatus and techniques to determine the minimum test gas pressure and sample temperature that supports self-sustained burning and the regression rate of the melting surface of a standardized sample of a metallic material that has been ignited using a promoter.

1.2 The data obtained from this test method are dependent on the precise test sample configuration and provide a basis for comparing the burning characteristics of metallic materials. No criteria are implied for relating these data for the suitability of a material's use in any actual system.

1.3 Requirements for apparatus suitable for this test method are given, as well as an example. The example is not required to be used.

1.4 This test method is for gaseous oxygen or any mixture of oxygen with inert diluents that will support burning, at any pressure or temperature within the capabilities of the apparatus used.

1.5 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 *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]

G63 Guide for Evaluating Nonmetallic Materials for Oxygen Service

G88 Guide for Designing Systems for Oxygen Service

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

3. Terminology

3.1 *Definitions:*

3.1.1 *burn length*, *n*—the burn length is the length of the sample that has been consumed by combustion.

3.1.1.1 *Discussion*—The burn length is determined by subtracting the post-test sample length from the pretest sample length (which does not include the promoter length or region used by the test sample support.)

3.1.2 *flammable material*, *n*—a material is defined in this standard as flammable if a standard rod sample burns more than 3 cm (1.2 in.) above the promoter (**1**, **2**).[3]

3.1.3 *highest no-burn pressure*, *n*—the maximum gas pressure (at a specified oxygen concentration and fixed sample temperature) at which a material does not burn more than 3 cm (1.2 in.) above the promoter in a minimum of five tests.

3.1.4 *highest no-burn temperature*, *n*—the maximum sample temperature (at a specified oxygen concentration and pressure) at which a material does not burn more than 3 cm (1.2 in.) above the promoter in a minimum of 5 tests.

3.1.5 *igniter*, *n*—a material used to ignite the promoter that can burn under an electrical influence, such as a small-diameter wire.

3.1.6 *lowest burn pressure*, *n*—the minimum gas pressure (at a specified oxygen concentration and fixed sample temperature) at which a material burns more than 3 cm (1.2 in.) above the promoter for one or more tests specimens.

3.1.7 *lowest burn temperature*, *n*—the minimum sample temperature (at a specified oxygen concentration and pressure) at which a material burns more than 3 cm (1.2 in.) above the promoter for one or more tests specimens.

3.1.8 *promoter*, *n*—an optional material that can add supplemental heat and increase the temperature to start burning of the metallic material being tested.

3.1.9 *regression rate of the melting interface*, *n*—the average rate at which the solid-liquid metal (melting) interface advances along the test sample length during a test.

[1] This test method 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 G04.01 on Test Methods.

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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.

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

3.1.10 *sample temperature*, *n*—*the initial temperature of the test sample being evaluated.*

3.1.10.1 *Discussion*—Various methods of measuring sample temperatures are used. The method selected must be reported with test data.

3.1.11 *standard rod test sample*, *n*—a 3.2 mm (0.125 in.) diameter rod with a minimum length of 101.6 mm (4 in.).

3.1.12 *threshold pressure*, *n*—This term is historically used to represent the definitions of either the lowest burn pressure or the highest no-burn pressure.

3.1.12.1 *Discussion*—In this standard, it represents the lowest burn pressure, which is used as the new term throughout.

3.1.13 *valid test*, *n*—a test in which the igniter and/or promoter combination has melted the bottom section of the test sample where the igniter and/or promoter is located.

4. Summary of Test Method

4.1 A standard rod sample of the material to be tested is vertically suspended in a chamber filled with pressurized test gas. The chamber contains sufficient oxygen so that not more than 10 % of the oxygen will be consumed if the sample completely burns. A promoter (aluminum is most common, however titanium, carbon steel and magnesium are also used) may be applied to the bottom of the rod to start burning of the material in conjunction with the igniter (typically Pyrofuse or Nichrome wire)[4]. The test chamber is pressurized to the required test pressure and the sample is heated to the required test temperature (if elevated temperature is one of the parameters).

4.2 The test is initiated by ignition of the igniter wire/promoter (typically through resistive heating) so that the end of the test sample is melted away to produce a valid test with relevant data collected, as specified.

NOTE 1—In 4.3 as subsequent samples are tested, only one parameter of temperature or pressure is varied and the other held constant within the tolerance allowed by this test method. It is up to the user to determine if the purpose of the test is to determine burn/no-burn pressure or burn/no-burn temperature. Only one of these variables should be changed during a series of tests.

4.3 If the sample is flammable, another standard sample rod is tested at a reduced test pressure or temperature. If the sample is not flammable, testing continues until the sample is not flammable in a minimum of fivetests at one set of conditions. It has been shown, for a burn probability of less than 10 %, 5 no burn results provides a 41 % confidence level in the (no burn) result, whereas twenty-two no burn results provides a 90 % confidence level (for the same burn probability of 10 %). A thorough discussion of the burn probabilities and associated confidence levels is given in Ref (**3**).

NOTE 2—Increasing the number of samples will always give a higher level of confidence and is recommended when possible. This method defines the highest no-burn pressure or temperature and the lowest burn pressure or temperature. The maximum no-burn (and burn) temperature and pressure and regression rate of the melting interface can be determined from the test data.

[4] The trade name for aluminum-palladium wire is Pyrofuze. It is a registered trademark of the Pyrofuze Corp., 121 S. Columbus Ave., Mt. Vernon, NY 10553, and is available from them.

5. Significance and Use

5.1 This test method will allow comparisons of the burning characteristics of various metallic materials. The burning characteristics that can be evaluated include (*1*) burn and no-burn pressure, (*2*) burn and no-burn temperature, (*3*) regression rate of the melting interface, and (*4*) visual evaluation of the burning process of the test sample.

6. Interferences

6.1 Any materials inside the test chamber that may bake out, ignite/burn, or vaporize during the burning process at test temperature/pressure may interfere with the chemistry of the fire propagation and subsequently affect burning.

6.2 The specific atmosphere in the test chamber can have a severe chemical or thermodynamic effect, or both. Therefore, test gas contamination or diluents (such as argon, nitrogen, carbon dioxide, water vapor, and others) can be important factors, so the oxygen gas purity and quantities and types of diluents should be specified in the data sheet.

6.3 The standard test is conducted under non-flowing conditions. Depending on the final gas velocity, tests conducted under flowing oxygen conditions may dramatically affect the test results.

7. Apparatus

7.1 *System*—A schematic of a typical system is shown in Fig. 1. Other designs may also be used if they fulfill the following requirements.

7.2 *Test Chamber*—A cross-section of a typical test chamber is shown in Fig. 2. Appendix X1 provides criteria for establishing the lowest test pressures that meet the stated criterion of using no more than 10 % of the available oxidizer for various vessel volumes. If the chamber cannot be made sufficiently large, an accumulator can be attached between the test chamber and the chamber isolation valve that contains more test gas. The test chamber (and accumulator if used) shall not contribute any chemical interference to testing.

7.3 *Sample Holder*—capable of securing the sample at the top and supporting it in a vertical position.

7.4 *Temperature Sensor*—used to measure gas or sample temperatures in the chamber, accurate to within ±1 % of reading or accuracy otherwise noted.

7.5 *Pressure Transducer*—used to measure gas pressure in the chamber, accurate to within ±1 % of reading or accuracy otherwise noted.

7.6 *Liner (optional)*—a burn-resistant (for example, copper or ceramic) liner is recommended in the test chamber to serve as an internal shield to protect the chamber and components from the burning, molten slag, and other reaction products produced during sample burning.

7.7 *Sight Glass*—(optional for tests not determining either the regression rate of the melting interface or visual evaluation of the burning process), capable of withstanding the maximum test pressure anticipated (initial pressure plus pressure rise due to heating during burning). Other methods of observing the test may be possible, though direct observation is most common.

7.8 *Igniter Power Supply*—electrically isolated and capable of providing adequate current to initiate the ignition within 3 s of the application of power.

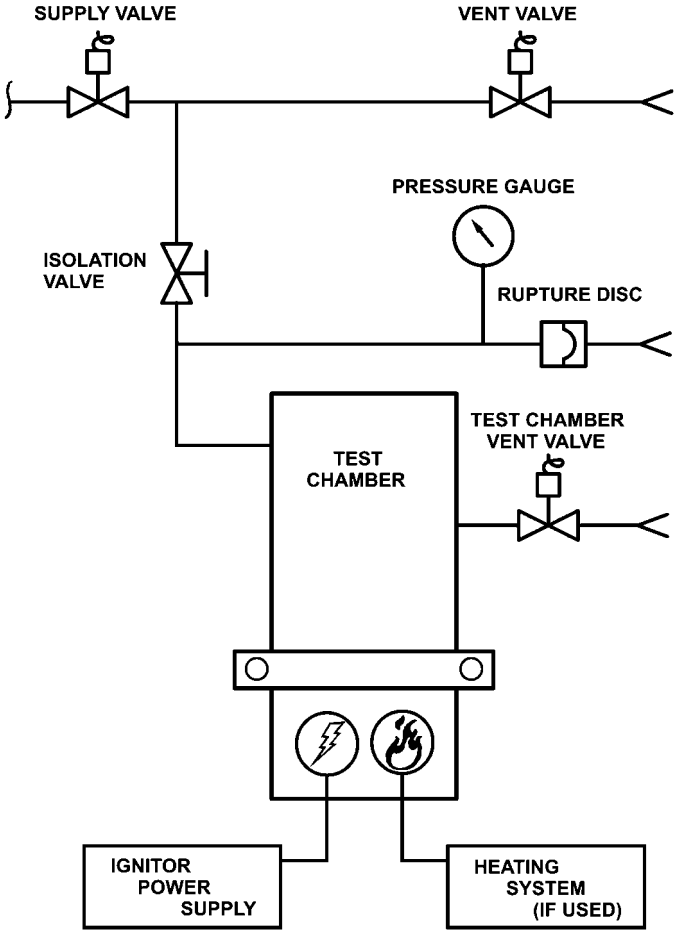

FIG. 1 Schematic of Typical System

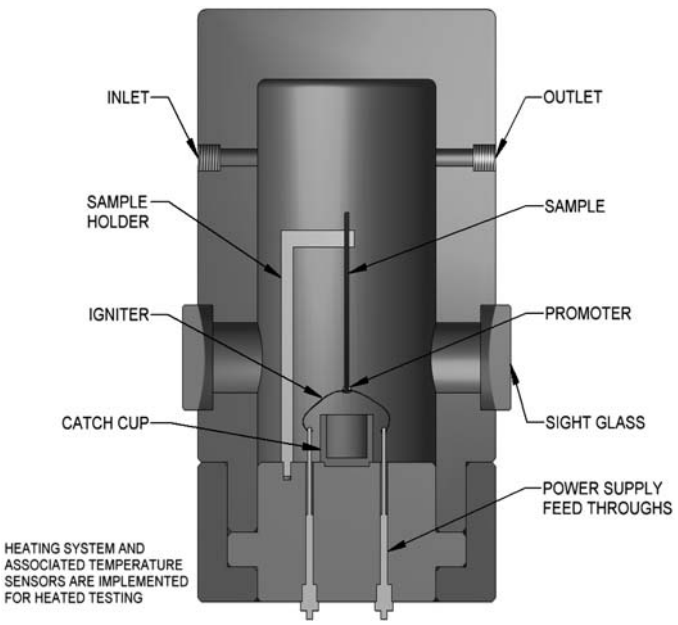

FIG. 2 Typical Stainless Steel Test Chamber Cross-Section

7.9 *Test Cell*—a room to house the test chamber, constructed of non-flammable material (such as concrete or metal) with sufficient strength to provide protection from explosion, pneumatic release or fire hazards. A continuous ventilation system shall circulate fresh air in the test cell. The test cell shall be cleaned periodically to avoid contamination of the sample and equipment and minimize fire hazards.

7.10 *Piping System*— which purges, pressurizes, and vents the test chamber. The piping system shall be designed to permit remote test chamber purge, pressurization, and venting without unsafe exposure of personnel. It is recommended the test chamber be purged and pressurized through one line and vented through a separate line to minimize the chances of a contaminant migrating into the pressurization line, which might influence subsequent tests. It is also recommended that a pressure relief device with an appropriate setting be fitted to the piping system and be able to communicate to the test chamber.

NOTE 3—Although the use of separate lines is preferred it is not a requirement. Periodic inspection and cleaning of lines and valves should be done to decrease the risk of cross contamination. A typical piping system for this test is shown in Fig. 1.

7.11 *Control Area*—which will isolate test personnel from the test cell during tests. This control area shall be provided with the necessary control and instrumentation features to perform test chamber purge, pressurization and venting operations, and monitoring of the test chamber instrumentation during the test.

7.12 *Data Acquisition System*—capable of recording, storing, and accessing the pressure, temperature and regression rate data at a rate of ten samples per second (minimum). It may also include a video recording device that displays the "real-time" burn phenomenon. The video recording with embedded timer, thermocouple sensor arrays, and ultrasonic rod length measurements are some of the methods available for determination of the regression rate of the melting interface (see Annex A1).

7.13 *Heating System (for elevated temperature testing only)*—which will heat the sample to the required initial test sample temperature range, without interfering with the other functions of the test system or the test chamber integrity. The heating system is required to evaluate burning characteristics at elevated temperatures above ambient. (No heating system is required if testing is to be done at ambient temperature only.) The method used can include, but is not limited to, localized heating methods including induction heating, resistive heating, and radiant heating. Heating of the entire system has also been successfully used, however the vessel pressure rating must be considered due to the temperature dependency of the chamber material strength (see 9.4) and any non-metallic materials exposed to elevated temperatures should be used in accordance with Guide G63.

8. Reagents and Materials

8.1 *Gaseous Oxygen*—Oxygen purity equal to or greater than that of practical systems is preferred for the standard test, and an analysis of the test oxidant is required. Other oxygen/diluents mixtures may be used and it is recommended that the exact oxygen purity used be specified with the test results. **(4)**

NOTE 4—Oxygen purity has been shown, for certain materials to significantly affect the results. Extremely high purity or low purity oxygen (with diluents present) should be avoided unless conducting special studies using gas mixtures **(5)** and in all cases the purity should be