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Standard Test Method for Temperature Limit of Flammability of Chemicals¹

This standard is issued under the fixed designation E1232; 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.

INTRODUCTION

The temperature limit of flammability test measures the minimum temperature at which liquid (or solid) chemicals evolve sufficient vapors to form a flammable mixture with air under equilibrium conditions. This temperature is applicable for assessing flammability in large process vessels and similar equipment ([Appendix X1](#) and [Appendix X2](#)).

1. Scope

1.1 This test method covers the determination of the minimum temperature at which vapors in equilibrium with a liquid (or solid) chemical will be sufficiently concentrated to form flammable mixtures in air at atmospheric pressure. This test method is written specifically for determination of the temperature limit of flammability of systems using air as the source of oxidant and diluent. It may also be used for other oxidant/diluent combinations, including air plus diluent mixtures; however, no oxidant/diluent combination stronger than air should be used. Also, no unstable chemical capable of explosive decomposition reactions should be tested (see [8.3](#)).

1.2 This test method is designed and written to be run at local ambient pressure and is limited to a maximum initial pressure of 1 atm abs. It may also be used for reduced pressures with the practical lower pressure limit being approximately 13.3 kPa (100 mm Hg). The maximum practical operating temperature of this equipment is approximately 150°C (302°F) ([Note A1.2](#)).

1.3 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units are provided for information only and are not considered standard.

1.4 This standard should be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions, and should not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as

elements of a fire risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use.

1.5 *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 safety precautions are given in [Section 8](#).

1.6 *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

- [D3278 Test Methods for Flash Point of Liquids by Small Scale Closed-Cup Apparatus](#)
- [D3828 Test Methods for Flash Point by Small Scale Closed Cup Tester](#)
- [D3941 Test Method for Flash Point by the Equilibrium Method With a Closed-Cup Apparatus](#)
- [E220 Test Method for Calibration of Thermocouples By Comparison Techniques](#)
- [E230 Specification and Temperature-Electromotive Force \(EMF\) Tables for Standardized Thermocouples](#)
- [E502 Test Method for Selection and Use of ASTM Standards for the Determination of Flash Point of Chemicals by Closed Cup Methods](#)

¹ This test method is under the jurisdiction of ASTM Committee [E27](#) on Hazard Potential of Chemicals and is the direct responsibility of Subcommittee [E27.04](#) on Flammability and Ignitability of Chemicals.

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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.

E537 Test Method for The Thermal Stability of Chemicals by Differential Scanning Calorimetry

E681 Test Method for Concentration Limits of Flammability of Chemicals (Vapors and Gases)

E698 Test Method for Kinetic Parameters for Thermally Unstable Materials Using Differential Scanning Calorimetry and the Flynn/Wall/Ozawa Method

2.2 *ANSI Standard*.³

ANSI-MC96.1 Temperature Measurement Thermocouples

2.3 *NFPA Standard*.⁴

NFPA 325 Fire Hazardous Properties Liquids

3. Terminology

3.1 Definitions:

3.1.1 *flash point*—the lowest temperature, corrected to a pressure of 101.3 kPa (760 mm Hg, 1013 mbar), at which application of an ignition source causes the vapors of the specimen to ignite under specified conditions of test.

3.1.2 *lower limit of flammability or lower flammable limit, (LFL)*—the minimum concentration of a combustible substance that is capable of propagating a flame through a homogeneous mixture of the combustible and a gaseous oxidizer under the specified conditions of test.

3.1.3 *lower temperature limit of flammability, (LTL)*—the lowest temperature, corrected to a pressure of 101.3 kPa (760 mm Hg, 1013 mbar), at which application of an ignition source causes a homogeneous mixture of a gaseous oxidizer and vapors in equilibrium with a liquid (or solid) specimen to ignite and propagate a flame away from the ignition source under the specified conditions of test.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *propagation of flame*—the upward and outward movement of the flame front from the ignition source to the vessel walls, that is determined by visual observation.

4. Summary of Test Method

4.1 A pool of liquid is stirred in a closed vessel in an air atmosphere. The vapor-air mixture above this liquid is exposed to an ignition source and the upward and outward propagation of flame away from the ignition source is noted by visual observation. Temperature in the test vessel is varied between trials until the minimum temperature at which flame will propagate away from the ignition source is determined.

5. Significance and Use

5.1 The lower temperature limit of flammability is the minimum temperature at which a liquid (or solid) chemical will evolve sufficient vapors to form a flammable mixture with air under equilibrium conditions. Knowledge of this temperature is important in determining guidelines for the safe handling of chemicals, particularly in closed process and storage vessels.

NOTE 1—As a result of physical factors inherent in flash point apparatus

³ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁴ Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, <http://www.nfpa.org>.

and procedures, closed-cup flash point temperatures are not necessarily the minimum temperature at which a chemical will evolve flammable vapors (see **Appendix X2** and **Appendix X3**, taken in part from Test Method **E502**). The temperature limit of flammability test is designed to supplement limitations inherent in flash point tests (**Appendix X2**). It yields a result closely approaching the minimum temperature of flammable vapor formation for equilibrium situations in the chemical processing industry such as in closed process and storage vessels.

NOTE 2—As a result of flame quenching effects existing when testing in standard closed-cup flash point apparatus, there are certain chemicals that exhibit no flash point but do evolve vapors that will propagate a flame in vessels of adequate size (**X3.2**). The temperature limit of flammability test chamber is sufficiently large to overcome flame quenching effects in most cases of practical importance, thus, usually indicating the presence of vapor-phase flammability if it does exist (**6.2**).

NOTE 3—The lower temperature limit of flammability (LTL) is only one of several characteristics that should be evaluated to determine the safety of a specific material for a specific application. For example, some materials are found to have an LTL by this test method when, in fact, other characteristics such as minimum ignition energy and heat of combustion should also be considered in an overall flammability evaluation.

5.2 The vapor concentration present at the lower temperature limit of flammability equals the lower flammable limit concentration as measured by Test Method **E681** and extrapolated back to the same temperature. (This permits estimation of lower temperature limits of flammability if vapor pressure and concentration limit of flammability data are available (**A2.3**). A comparison of results of the tests, thus, affords a check on test reliability, the reliability of vapor pressure data, or both.)

6. Interferences

6.1 This test method is not applicable to materials that undergo chemical changes when mixed with air. Examples include, but are not limited to, oxidation and polymerization.

6.2 Measured temperature limits are influenced by flame quenching effects of the test vessel walls. The test vessel employed in this test method is of sufficient size to eliminate these effects for most materials. For certain amines, halogenated materials, etc., that have large ignition-quenching distances, tests should be conducted in vessels with larger diameters than the one listed in this test method (**A1.1**). Quenching effects become increasingly significant as the test pressure decreases.

6.3 Measured temperature limits of flammability of chemicals can be greatly influenced, as are flash points, by the presence of various impurities or known mixture components. Small quantities of volatile flammable impurities can reduce temperature limit values, and volatile inert diluents can raise temperature limit values or produce complete inerting. (See **8.2.3** and **Annex A3** for a discussion of mixture testing.)

7. Apparatus

7.1 **Fig. 1** is a schematic diagram of the apparatus; details and dimensions are presented in **Annex A1**. The apparatus consists of the following:

7.1.1 *Glass Test Vessel*,

7.1.2 *Insulated Chamber*, equipped with a source of controlled-temperature air,

7.1.3 *Ignition Device*, with an appropriate power supply, and

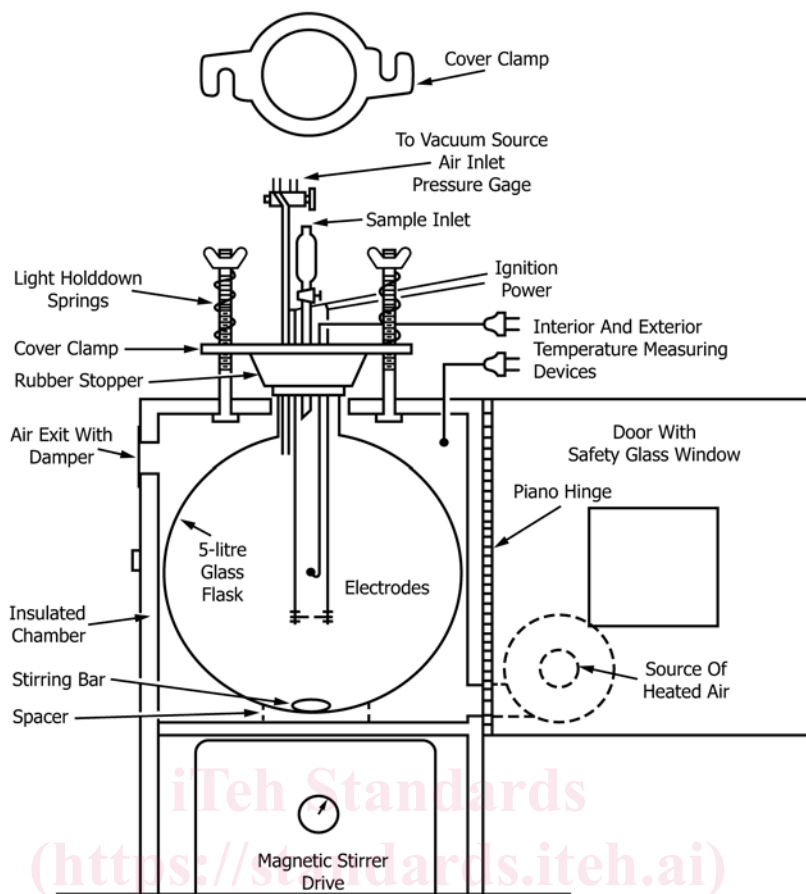


FIG. 1 Schematic Diagram of Test Apparatus

7.1.4 *Magnetic Stirrer and Cover*, equipped with the necessary operating connections and components.

8. Hazards

8.1 *Tests should not be conducted in this apparatus with gaseous oxidants stronger than air* since explosive violence increases as oxidizer strength increases. Do not use oxygen, nitrous oxide, nitrogen dioxide, chlorine, etc. in this glass apparatus.

8.2 *Adequate shielding must be provided* to prevent injury in the event of equipment rupture, due to both implosions and explosions. A metal enclosure such as that recommended in A1.2 is one method suitable for this purpose.

8.2.1 Implosion of the test vessel at high vacuum levels is possible and, therefore, all evacuations must be made with the required shielding to protect against flying fragments.

8.2.2 Energetic explosions may be produced if tests are made at temperatures above the LTL. The determination of the LTL should always be initiated at a temperature below the estimated LTL, and successive ignition trials made at intervals of not more than a 2°C temperature increase. Methods for estimating initial test temperatures, discussed in Annex A2, should be employed to ensure that initial trials are conducted at temperatures less than the LTL (Note 4). The glass test vessel,

equipped with a lightly held or loose cover, vents most explosions adequately. Nevertheless, shielding is required to protect against any possibility of test vessel rupture.

8.2.3 The testing of materials that are reactive with the metal parts of the apparatus can effect results, and may cause energetic explosions. For example, acids and alkaline materials can generate hydrogen gas. When testing such materials, variable results due to the generation of hydrogen may be detected by varying the holding time of several trials at a specific temperature. If corrosion occurs, materials of construction should be changed to corrosion resistant types.

8.2.4 Testing should be carried out in a manner that prevents accidental activation of the ignition source at incorrect stages of the procedure.

8.3 Tests should not be conducted on peroxides, monopropellants, or other thermally unstable materials that might undergo explosive gas or liquid phase decomposition reactions. For example, some monomers may undergo energetic vapor phase polymerization reactions. For information on evaluating the thermal stability of proposed test materials, see DS-51A, and Test Methods E537 and E698.

8.4 Tests should be conducted in a fume hood or other ventilated area to prevent exposure of personnel to toxic chemicals or combustion products.

8.5 Precautions must be taken to ensure that the high voltage spark ignition source is always adequately insulated from other electrical circuits and metal parts of the apparatus, fume hood, etc. to prevent electrical hazards to personnel and instrumentation. Careful attention to electrical insulation integrity plus the use of disconnection procedures are required to achieve a satisfactory protection against electrical hazards.

9. Calibration

9.1 System temperature and pressure and barometric pressure measuring devices must be calibrated against adequate standards. For information on calibration of thermocouples, see Test Method E220, Specification E230, and ANSI-MC96.1. The pressure sensing devices should be calibrated against a traceable standard such as a primary standard piston gage, commonly called a dead weight gage.

10. Procedures

10.1 Lower Temperature Limit of Flammability Test:

10.1.1 Assemble the equipment, as shown in Fig. 1, within an appropriate fume hood or other ventilated area and secure the door of the metal enclosure. Clean and dry the test vessel and all components. Evacuate the system and flush with air, or other specified test gas, sufficiently to ensure removal of residual volatile materials that may be present as a result of cleaning or prior tests.

10.1.2 Based on methods given in Annex A2, adjust the flask to the desired test temperature below the anticipated lower temperature limit of flammability.

NOTE 4—A prudent operator will use a wide safety factor in choosing initial test temperatures (6.3). This may necessitate a few additional trials but will provide increased safety for the operation.

10.1.3 It may be necessary to separately heat, insulate, or heat and insulate cover components and lines, to prevent vapor condensation at cool sites within the vapor space. The liquid, mist, or both, that may otherwise be formed can cause erroneous results.

10.1.4 Make certain that all safety precautions have been taken.

10.2 Sample Introduction of Liquids:

10.2.1 Introduce 50 cm³ of liquid to the flask using a separatory funnel or other inlet device.

NOTE 5—The 50 cm³ of liquid provide substantially more than theoretically required. Smaller sample sizes are adequate for pure chemicals and larger sample sizes may be required for mixtures (Annex A3).

10.2.2 Turn on the stirrer at a speed of approximately 400 rpm.

10.2.3 Close the hood door. (Cover hold-down devices should be loose).

10.2.4 Stir for at least 5 min after attainment of thermal equilibrium. Slower stirrer speeds, longer mix times, or both, may be required for viscous materials. Observe results obtained with different mixing times and speeds, at constant temperature, as a check to ensure that complete mixing and thermal equilibrium are being achieved without generation of mist. If a visible mist is generated, decrease stirring speed until it is eliminated.

NOTE 6—If mixing is inadequate, vapor concentrations can vary throughout the flask, and inconsistent results will be obtained. Some regions may contain insufficient fuel to propagate a flame at temperatures above the true equilibrium flammable limit temperature.

10.2.5 Turn off the stirrer.

10.2.6 Record the test temperature and system pressure (usually barometric pressure unless system is being operated at sub-ambient pressure).

10.2.7 Disconnect instrumentation lines as required and connect the ignition wires.

10.2.8 Check for liquid condensation or mist in the vapor regions of the flask. Heat, insulate, or both, to prevent condensation and then repeat the test (10.3).

NOTE 7—Although this test method is intended to be applied to vapor situations only, it is theoretically possible to generate mist in some situations. Any mist tends to give a more conservative (lower) temperature limit.

10.2.9 Darken the viewing area. Activate the ignition source. Observe for ignition and flame propagation away from the ignition source. At each test temperature record any occurrence of flame propagation.

NOTE 8—It is recommended that the ignition source not be activated until 30 s after the stirrer is turned off to allow the mixture to become quiescent. However, to prevent stratification activate the ignition source within 60 s.

NOTE 9—At concentrations just outside the flammable range a small cap of flame will be visible above the arc position. Absence of a flame cap may be an indication of insufficient ignition energy. The onset of spherical, upward, and partial outward flame propagation signifies a limit or near-limit temperature. It is suggested that detailed observations of flame behavior be recorded on all trials. Include such notes as flame cap, no flame cap, upward and outward propagation, downward propagation, etc. These observations can serve as a guide to narrowing the region of uncertainty between go and no-go trials.

10.2.10 Flush the test vessel sufficiently with air, or other specified test gas, to remove possible decomposition, combustion products, or both.

10.2.11 Raise the vessel temperature in steps no greater than 2°C to find the minimum temperature, T_1 , that gives flame propagation and the maximum temperature, T_2 , below T_1 , that does not give flame propagation. (The difference between T_1 and T_2 is a measure of the variability of the procedure for the material being studied (Note 14.))

10.2.12 Conduct several preliminary trials on a given liquid charge. It is necessary to remove the vessel for periodic cleaning and recharging with liquid.

10.2.13 Each final trial should be in a clean vessel using a fresh sample.

NOTE 10—Ignition failures and inconsistent performance are occasionally encountered when, for example, electrically highly conductive or insulating materials, or materials having a very high ignition energy, are tested using the spark ignition source. Activate the spark ignition source in air to determine whether the equipment or material under test is causing performance problems. Limits for materials causing inconsistent spark performance should be determined using a fuse wire ignition source. Fuse wire ignition should also be used to confirm results if temperature limits are conducted at reduced pressure.

10.2.14 Record the values of the test temperatures, T_1 and T_2 , and the test pressure (barometric pressure in most situations) in the vessel.

10.3 Sample Introduction of a Solid:

10.3.1 As with liquids, place 50 cm³ of the solid in the flask.

NOTE 11—This technique is only suitable for powdered or small crystalline solids.

10.3.2 Add chemicals having melting points above room temperature to the test vessel as solids. If the chemical melts at the test temperature, the procedure is identical to that given in 10.5.

10.3.3 An occasional solid will sublime sufficiently to have a temperature limit of flammability while still solid. These materials are tested by the same techniques as liquids. However, some difficulty can be encountered with stirring. Employ reduced stirring speeds and longer holding times for attainment of equilibrium.

11. Calculation

11.1 Calculate *l*_{tl}, the uncorrected temperature limit of flammability, using Eq 1. Correct this limit to LTL at standard atmospheric pressure, 101.3 kPa (760 mm Hg), using either Eq 2 or Eq 3.

$$l_{tl} = 1/2 (T_1 + T_2) \quad (1)$$

$$LTL = l_{tl} + 0.25 (101.3 - p) \quad (2)$$

where:

p = absolute initial pressure in the vessel in kPa.

$$LTL = l_{tl} + 0.03 (760 - P) \quad (3)$$

where:

P = absolute initial pressure in the vessel in mm Hg.

All temperatures are in degrees Celsius.

NOTE 12—The barometric pressure used in this calculation is the ambient pressure for the laboratory at the time of the test. Many aneroid barometers, such as those used at weather stations and airports, are precorrected to give sea level readings and would not give the correct reading for this test.

NOTE 13—The barometric correction in Eq 2 and Eq 3 is an approximation based on a material of average lower flammable limit, having a vapor pressure of average slope. Theoretically, a separate barometric adjustment would be required for each material; however, the approximation in Eq 2 and Eq 3 is adequate for most cases. For non-standard materials, for temperature limit measurements made at high altitudes (Denver, for example), or for data being used to evaluate hazards at high altitudes, corrections might better be based on the actual vapor pressure data of the material in question.

12. Report

12.1 The report shall include the following:

12.1.1 Temperature limit, LTL, to the nearest 1°C (2°F); report *T*₁, *T*₂, and the test pressure,

12.1.2 Ignition source used,

12.1.3 Date,

12.1.4 Purity of the material, if known, and any special sample preparation,

12.1.5 Type and concentration of oxidant and diluent if other than air,

12.1.6 Deviations made from the procedure as written in this method, for example, vessel size or ignition source, and

12.1.7 For those samples tested that do not exhibit the presence of sufficient vapors to form flammable mixtures with air, the report shall state either *no flame propagation to boiling* or *no flame propagation in tests from ___°C to ___°C by ASTM Test Method E1232*.

13. Precision and Bias

13.1 An interlaboratory study of the repeatability and reproducibility of this test method has not been carried out. However, a single laboratory repeatability study is available. Duplicate or triplicate test were performed over a 12 year period by different operators to determine the LTL of 14 substances and UTL of 13 substances. The maximum LTL deviation has been found to be bounded by the following formulae:

$$Abs[Max Dev (C)] = 2.2 \cdot 10^{-5} * [LTL (deg. R)]^2$$

NOTE 14—Generally a clear-cut change from no flame propagation to flame propagation occurs over a 3°C (5°F), or less, temperature range for lower limit tests at 38°C (100°F) and over a 6°C (10°F), or less, temperature range for tests at 93°C (200°F).

13.2 An analysis of a subset (LTL of 7 substances and UTL of 4 substances) of the data covering limit temperatures in the range from 42°F to 359°F indicates that there is no discernible bias between the test results and the theoretical predictions using the vapor pressure data and limit concentration.

13.3 A report including the data and analysis is available from ASTM Headquarters.⁵

⁵ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:E27-1004. Contact ASTM Customer Service at service@astm.org.

ANNEXES

(Mandatory Information)

A1. DIMENSIONS AND SPECIFICATIONS OF APPARATUS (Fig. 1)

A1.1 *Test Vessel*—The test vessel shall be a borosilicate glass boiling flask, short-ring neck, 5000 cm³ capacity, approximately 222 mm (8¾ in.) in diameter and 305 mm (12 in.) in height.

A1.2 *Insulated Chamber*—The dimensions shall be as follows:

Inside, 279 by 279 by 305 mm (11 by 11 by 12 in.) high,
Height, 483 mm (19 in.), adjust to accommodate stirrer unit,
Rear panel, >200 by 200-mm vent area,
Top hole, 70.0 mm (2¾ in.) diameter,
Air inlet hole, to fit air supply unit, and
Air exit hole, to accommodate a simple slide damper.

A1.2.1 *Materials*—Sheet metal of at least 16 gage covered with insulation. Generally a portion of the metal bottom must be partially removed and replaced with nonmagnetic material to permit operation of the magnetic stirrer. The rear panel should be equipped with a vent (>200 by 200 mm) providing explosion relief at low over-pressures: <6.9 kPa (1 psi). A lightly held panel of insulating board may be used.

A1.2.2 *Door, hinged and latched*—fitted with a 102 to 127 mm (4 to 5 in.) square safe viewing window made of polycarbonate and at least 12.7 mm (½ in.) thickness, or equivalent.

A1.2.3 *Bolts*—top-fitted with 2, ¼-20 bolts on 127 mm (5 in.) centers to secure test vessel cover.

A1.2.4 *Spacer*—A cylindrical spacer constructed of perforated, light-gage metal is placed under the test vessel. It is sized so as to position the top of the neck of the test vessel just above the top of the test chamber. This permits air circulation and facilitates insertion and removal of the test vessel.

NOTE A1.1—If heavy construction is employed for the front, top, and side walls of the chamber, and if the rear and bottom panels of the chamber are of lightweight materials, explosion venting will be to the rear, away from the operator, in the event of vessel rupture.

A1.2.5 *Alternatives*—Other thermostated chambers or ovens and heating means may be employed if they permit temperature control and proper test manipulation and observation with adequate safety.

A1.3 *Heater*—Heated air is supplied from a blower, at the rate of approximately 0.38 m³/min (13.5 ft³/min), feeding air through a variable electric heater of approximately 2400 W. Commercial blowers, heaters, and manual or automatic controls and combination, thereof, are available.

A1.4 *Ignition Device:*

A1.4.1 *Electrode rods*—3.175 to 4.76 mm (⅛ to ⅜ in.) diameter stainless steel, 317.5 mm (12½ in.) long. The upper ends are threaded for connection to a high-voltage source and the lower ends are threaded for attachment of spark gap points,

or fuse wire, or both. Electrode rods are spaced at least 32 mm (1¼ in.) apart. The spark gap points are suspended approximately 70.3 mm (2¾ in.) above the bottom of the flask. Other materials of construction may be used as needed.

A1.4.2 *Spark gap*—having 6.4 mm (¼ in.) electrode spacing. Gap electrode extensions may be fabricated of platinum or tungsten wire held in wire connector lugs.

A1.4.3 *Fuse wire*—A 19 mm (¾ in.) loop of 40-gage copper wire attached to threaded electrode rods in place of spark gaps.

A1.4.4 *Power*—approximately 30 mA at 15 kV, supplied by the secondary of a 120-V, 60 Hz luminous tube transformer, or by an equivalent device. Power for the fuse wire is 120 V, 60 Hz.

A1.4.5 *Timer*—to limit spark duration to 0.2 to 0.4 s. Commercial interval timers are available.

A1.5 *Stirring Devices:*

A1.5.1 *Stirring bar*—63.5 mm (2½ in.) egg-shaped, plastic-coated, magnet bar.

A1.5.2 *Drive*—Laboratory magnetic stirrer capable of functioning through the bottom of the test chamber and vessel.

A1.6 *Test Vessel Cover*—The cover can be constructed of a Number 14 rubber stopper with necessary holes for electrodes, sample inlet device, air inlet, and evacuation connection and temperature-measuring device (see Fig. 1). It is important to note that the stopper rests on top and not inside the neck of the flask in order to facilitate venting.

NOTE A1.2—It is possible to operate at temperatures greater than 150°C (302°F) and to obtain more positive vacuum sealing through the use of specially constructed metal covers. High temperature O-ring seals for the flask top and inlet separatory funnel, and ceramic feedthroughs for the spark ignition source may be employed.

A1.7 *Cover Retainer*—This device (see Fig. 1) held in place with wing nuts, light springs, and ¼-20 bolts can improve vacuum tightness of the test vessel when used to clamp down on the vessel cover.

A1.8 *Temperature Measurement:*

A1.8.1 Thermocouple, thermistor, resistance thermometer or other device with an accuracy of ±0.5°C may be used.

NOTE A1.3—Certain bare wire thermocouples may cause catalytic oxidation of test vapors, as evidenced by a persistent high-temperature excursion of the thermocouple junction. If this occurs, other thermocouple materials should be employed.

A1.8.2 A temperature measuring device outside the test vessel but in the heating chamber or inlet air stream can aid in controlling test temperature.

A1.8.3 Measurements of temperature uniformity within the test vessel should be conducted and recorded at a series of temperatures on the initial setup of an apparatus of this type.