Designation: D 1929 – 68ε

AMERICAN SOCIETY FOR TESTING AND MATERIALS

1916 Race St., Philadelphia, Pa., 19103

Standard Method of Test for IGNITION PROPERTIES OF PLASTICS[1]

This Standard is issued under the fixed designation D 1929; 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.

ε NOTE 1—Editorial changes were made in Fig. 2 in February 1971.

1. Scope

1.1 This method[2] covers a laboratory determination of the self-ignition and flash-ignition temperatures of plastics using a hot-air ignition furnace.

NOTE 1—The values stated in U.S. customary units are to be regarded as the standard. The metric equivalents of U.S. customary units may be approximate.

2. Significance

2.1 Tests made under conditions herein prescribed can be of considerable value in comparing the relative ignition characteristics of different materials. Values obtained represent the lowest ambient air temperature that will cause ignition of the material under the conditions of this test. Test values are expected to rank materials according to ignition susceptibility under actual use conditions.

NOTE 2—Round-robin results from three laboratories indicate an ignition temperature range of 5 to 20 C (9 to 36 F) at the 250 to 350 C (482 to 662 F) level and 20 to 45 C (38 to 81 F) at the 350 to 500 C (662 to 932 F) level.

2.2 This test is not intended to be the sole criterion for fire hazard. In addition to ignition temperatures, fire hazard includes such other factors as burning rate or flame spread, intensity of burning, fuel contribution, products of combustion, and others.

3. Definitions

3.1 *flash-ignition temperature*—the lowest initial temperature of air passing around the specimen at which a sufficient amount of combustible gas is evolved to be ignited by a small external pilot flame.

3.2 *self-ignition temperature*—the lowest initial temperature of air passing around the specimen at which, in the absence of an ignition source, the self-heating properties of the specimen lead to ignition or ignition occurs of itself, as indicated by an explosion, flame, or sustained glow.

3.3 *self-ignition by temporary glow*—In some cases slow decomposition and carbonization of the plastic results only in glow of short duration at various points in the specimen without general ignition actually taking place. This is a special case of self-ignition temperature, defined as "self-ignition by temporary glow."

4. Apparatus

4.1 The apparatus[3] shall be a hot-air ignition furnace as shown in Fig. 1 and shall consist primarily of the following parts:

4.1.1 *Furnace Tube*—A vertical tube with an inside diameter of 100 mm (4 in.) and a length of 210 to 250 mm ($8^1/_2$ to 10 in.), made of a ceramic that will withstand 750 C (1382 F), and with an opening at the bottom fitted with a plug for the removal of accumulated residue.

4.1.2 *Inner Ceramic Tube*—A ceramic tube with inside diameter of 76 mm (3 in.), length

[1] This method is under the jurisdication of ASTM Committee D-20 on Plastics. A list of committee members may be found in the ASTM Yearbook. This standard is the direct responsibility of Subcommittee D-20.30 on Thermal Properties.

Current edition effective Sept. 9, 1968. Originally issued 1962. Replaces D 1929 – 62 T.

[2] The following reference may be of interest in connection with this method:

Setchkin, N. P., "A Method and Apparatus for Determining the Ignition Characteristics of Plastics," *Journal of Research*, Nat. Bureau Standards, Vol 43, No. 6, Dec., 1949, (RP 2052) p. 591.

[3] The apparatus described is commercially available as Model CS-88 from Custom Scientific Instruments, Inc., 13 Wing Drive, Whippany, N. J.

of 210 to 250 mm ($8^1/_2$ to 10 in.), and thickness of about 3.2 mm (0.125 in.); placed inside the furnace tube and positioned 20 mm ($^3/_4$ in.) above the furnace floor on three small spacer blocks. The top shall be covered by a disk of heat-resistant material with a 25.4-mm (1-in.) diameter opening which is used to insert thermocouple leads, for observation, and for passage of smoke and gases. The pilot flame shall be located immediately above the opening.

4.1.3 *Air Source*—An outside air source to admit clean air tangentially near the top of the annular space between the ceramic tubes through a copper tube at a steady and controllable rate. Air shall be heated and circulated in the space between the two tubes and enter the inner furnace tube at the bottom. Air shall be metered by a rotameter or other suitable device; refer to air calibration curves (Fig. 2) for proper furnace air velocities.

4.1.4 *Heating Unit*—An electrical heating unit made of 50 turns of No. 16 B & S wire.[4] The wires, contained within an asbestos sleeve, shall be wound around the furnace tube, and shall be embedded in cement.[5]

4.1.5 *Insulation*, consisting of a layer of asbestos wool approximately 64 mm ($2^1/_2$ in.) thick, and covered by a sheet iron jacket.

4.1.6 *Pilot Flame*, consisting of 1.6-mm ($^1/_{16}$-in.) inside diameter copper tubing attached to a gas supply and placed horizontally 6.4 mm ($^1/_4$ in.) above the top surface of the divided disk. The pilot flame shall be adjusted to 19 mm ($^3/_4$ in.) in length and centered above the opening in the disk.

4.1.7 *Specimen Support and Holder*—A convenient specimen holder, measuring 38 mm ($1^1/_2$ in.) in diameter by 13 mm ($^1/_2$ in.) in depth, is a $^1/_2$-oz metal container of approximately 0.2-mm (5-mil) thick steel.[6] One half of the container shall be used as a specimen holder and shall be held in a ring of 1.6-mm ($^1/_{16}$-in.) stainless steel welding rod. The ring shall be welded to a length of the same type rod extending through the cover of the furnace as shown in Fig. 1. The specimen holder shall be located 180 to 190 mm (7 to $7^1/_2$ in.) down from the top of the furnace.

4.1.8 *Thermocouples*—Chromel-alumel or iron-constantan (0.5-mm or 0.020-in.) thermocouples for temperature measurement. These shall be conveniently connected to a multiple-point recorder and each thermocouple temperature shall be recorded at least every 15 s. Thermocouple No. 1 (T_1) measures the temperature of the specimen. It should be located as near the center of the specimen as possible when the specimen is in place in the furnace. Thermocouple No. 2 (T_2) measures the temperature of the air traveling past the specimen. It shall be located slightly below and to the side of the specimen holder. Thermocouple No. 3 (T_3) measures the temperature of the heating coil. Thermocouple No. 1 is also used for measuring initial air temperature in constant-temperature runs before insertion of the specimen.

NOTE 3—The desired air temperature in the inner tube may be maintained by controlling the electric current supplied to the heating coils through an autotransformer, variable transformer, or equivalent, connected in series with the heating coils. Current adjustment may be made by reference to thermocouple T_3 in the furnace heating coil. This thermocouple is used in preference to the inner-tube thermocouples because of faster response. Constant furnace temperature may also be maintained conveniently by use of an automatic controller.

5. Test Specimens

5.1 Thermoplastic materials may be tested in pellet form normally supplied for molding. Where only sheet samples are available for thermosetting materials, 20 by 20-mm ($^3/_4$ by $^3/_4$-in.) squares of the available sheet or film shall be bound together with fine wire. A specimen weight of 3 ± 0.5 g is required.

6. Conditioning

6.1 *Conditioning*—Condition the test specimens at 23 ± 2 C (73.4 ± 3.6 F) and 50 ± 5 percent relative humidity for not less than 40 h prior to test in accordance with Procedure A of ASTM Methods D 618, Conditioning Plastics and Electrical Insulating Materials for Testing,[7] for those tests where conditioning is required. In cases of disagreement, the tolerances shall be ±1 C (±1.8 F) and ±2 percent

[4] Nichrome V alloy wire made by the Driver Harris Co., Harrison, N. J., or equivalent, has been found satisfactory for the purpose.

[5] Alundum cement made by the Norton Co., Worchester, Mass., or equivalent, has been found satisfactory for this purpose.

[6] A metal salve container, Style 100, made by the Buckeye Stamping Co., Columbus, Ohio, or equivalent, has been found satisfactory for this purpose.

[7] *Annual Book of ASTM Standards*, Part 27.

relative humidity.

6.2 *Test Conditions*—Conduct tests in the Standard Laboratory Atmosphere of 23 ± 2 C (73.4 ± 3.6 F) and 50 ± 5 percent relative humidity, unless otherwise specified in the test methods or in this specification. In cases of disagreement, the tolerances shall be ±1 C (±1.8 F) and ±2 percent relative humidity.

7. Procedure A

7.1 *First Approximation of Flash-Ignition Temperature* (*Effect of Air Flow Rate*):

7.1.1 *Low Air Flow Determination*—Raise the cup to the cover opening and place the specimen in the furance (Note 4). Set the air flow at 152.4 cm/s (5 ft/min) (Note 5). Adjust the transformer controlling current to the furnace coils to provide a rise in temperature T_2 of approximately 600 C (1080 F)/h (±10 percent). Light the gas pilot flame and place it across the hole in the top of the furnace. Note the air temperature (T_2) at which the combustible gases are ignited. This point is evidenced by a rapid rise in the specimen temperature (T_1). This is an approximation of the flash-ignition temperature.

NOTE 4—The furnace must be cooled to 50 C (122 F) or lower before each rising-temperature run is started.

NOTE 5—At all times the air flow shall be adjusted to the actual rate through the full section of the inner furnace tube. (The actual velocity past the specimen surface is unknown, but the effect of variable air supply through the furnace is resolved by controlling the rate through the unrestricted, and thus measurable, portion of the tube.) Refer to the air calibration curves in Fig. 2 for proper settings at various furnace temperatures. An air flow rate within ±10 percent of the nominal value is suitable.

7.1.2 *Medium Air Flow Determination*—Repeat 7.1.1 but with an air setting of 50.8 mm/s (10 ft/min) (Notes 4 and 5).

7.1.3 *High Air Flow Determination*—Repeat 7.1.1 but with an air setting at 101.6 mm/s (20 ft/min) (Notes 4 and 5).

7.2 *First Approximation of Self-Ignition Temperature* (*Effect of Air Flow Rate*):

7.2.1 Repeat 6.1.1 but without the pilot flame. Note the recorded air temperature (T_2) at which the specimen flames, explodes, or glows.

7.2.2 Repeat 7.1.2 but without the pilot flame. Note the recorded air temperature (T_2) at which the specimen flames, explodes, or glows.

7.2.3 Repeat 7.1.3 but without the pilot flame. Note the recorded air temperature (T_2) at which the specimen flames, explodes, or glows.

7.3 *Second Approximation of Flash-Ignition Temperature*—Choose the air setting from 7.1 that gives the lowest flash temperature, and repeat the appropriate determination, 7.1.1, 7.1.2, or 7.1.3, using a temperature rise of 300 C (540 F)/h (±10 percent).

7.4 *Second Approximation of Self-Ignition Temperature*—Choose the air setting from 7.2 that gives the lowest self-ignition temperature, and repeat the appropriate determination, 7.1.1, 7.1.2, or 7.1.3, using a temperature rise of 300 C (540 F)/h (±10 percent).

7.5 *Constant-Temperature Tests to Determine Minimum Ignition Temperatures:*

NOTE 6—The air temperature of ignition in the constant-temperature determinations is taken with the specimen thermocouple (T_1) before the specimen is inserted. The air temperature thermocouple (T_2) in these runs simply records whether the furnace is running under constant conditions during the time of the test.

7.5.1 *Minimum Flash-Ignition Temperature*—Start the furnace with the air setting used in 7.3. Adjust the transformer setting until the initial air temperature (T_1) stays constant as indicated by the recorded temperature readings for a 15-min period. The initial temperature should be maintained not more than 10 C (18 F) below the flash temperature found in 7.3. Place the specimen in the furnace, ignite the pilot flame, and watch for ignition of gases from the specimen. If ignition occurs, repeat this run with temperature T_1 maintained at a 10 C (18 F) lower setting. Repeat at successively lower temperatures until there is no ignition in 30 min. When temperature T_1 is reached at which no ignition occurs, it is suggested that a second run be made to ensure that this is truly below the self-ignition temperature. Report the lowest air temperature (T_1) setting at which ignition occurred as the minimum flash-ignition temperature.

7.5.2 *Minimum Self-Ignition Temperature* (Notes 7 and 8)—Repeat 7.1 but without the pilot flame. Start with an air temperature 10 C lower than the ignition temperature found in 7.4.

NOTE 7—If no ignition point was found in 7.2 or 7.4, this procedure for minimum self-ignition temperature should be started with a constant air temperature of about 100 C (180 F) above the flash-ignition temperature found in 7.3. This is because some plastics, for example, polystyrene, boil away before self-ignition takes place during the rising-temperature test. However, a self-ignition point can be found in the constant-temperature test if the initial temperature is started high enough. The air flow rate selected for this test should be the same as used in 7.3.

NOTE 8—If a sample does not ignite at 750 C (1382 F) at an air-flow rate of 10 ft/min, reference should be made to ASTM Method E 136, for Determining Noncombustibility of Elementary Materials[8] for the purpose of obtaining a "noncombustible" rating for the test material.

8. Procedure B (Short Method)

8.1 *Minimum Flash-Ignition Temperature:*

8.1.1 Set the air flow rate to provide a velocity of 5 ft/min at 400 C in the test chamber of the furnace. Adjust the current to the heating coil until the initial air temperature, T_2, remains constant at 400 C for 15 min.

NOTE 9—The temperature of 400 C is used where no prior knowledge of the probable ignition temperature range is available. Other starting temperatures may be selected if information about the material indicates a better choice.

8.1.2 Locate thermocouple T_1 centrally in the specimen holder intimately surrounded by the test material and lower the unit into the furnace. Start a timer, ignite the gas pilot flame and watch for ignition. Flash-ignition will be evidenced by a flash or mild explosion of combustible gases which may be followed by continuous burning of the specimen. If the specimen burns, by flaming or glowing, a rapid rise will be observed in the temperature at thermocouple T_1 above that at T_2.

8.1.3 If at the end of 5 min ignition has or has not occurred, lower or raise the temperature (T_2) 50 C as required and repeat the test with a fresh specimen. When the minimum ignition temperature has been bracketed, tests are begun 10 C below the lowest ignition temperature observed and repeated, dropping the temperature in 10 C intervals until the temperature is reached at which there is no ignition during 13 min. A repeat run may be desirable at this temperature using an air velocity of 10 ft/min to verify the use of 5 ft/min as optimum.

NOTE 10—Ordinarily, increasing the air velocity above 5 ft/min does not reduce the minimum ignition temperature in this test. However, if a repeat run at the next higher velocity results in ignition, it will be necessary to determine, by repeat tests at lower temperatures, the optimum air velocity for the material.

8.1.4 The lowest air temperature (T_2) at which a flash is observed is recorded as the minimum flash-ignition temperature.

8.2 *Minimum Self-Ignition Temperature:*

8.2.1 Follow the same procedure as in 8.1 but *without* the gas pilot flame.

8.2.2 Self-ignition will be evidenced by flaming or glowing of the specimen. It may be difficult, with some materials, to detect self-ignition visually when burning is by glowing rather than flaming. In such cases, the rapid rise in temperature at thermocouple T_1 above that at T_2 is the more reliable reference.

8.2.3 The lowest air temperature (T_2) at which the specimen burns is recorded as the minimum self-ignition temperature.

9. Report

9.1 The report shall include the following:

9.1.1 Designation of material, including name of manufacturer, composition, and state of subdivision (granules, sheet, etc.),

9.1.2 Air velocities used. If air velocity is not critical, this should be noted,

9.1.3 Flash-ignition temperature,

9.1.4 Self-ignition temperature, and

9.1.5 Visual observations (melting, bubbling, smoking, etc.).

[8] *Annual Book of ASTM Standards*, Part 14.

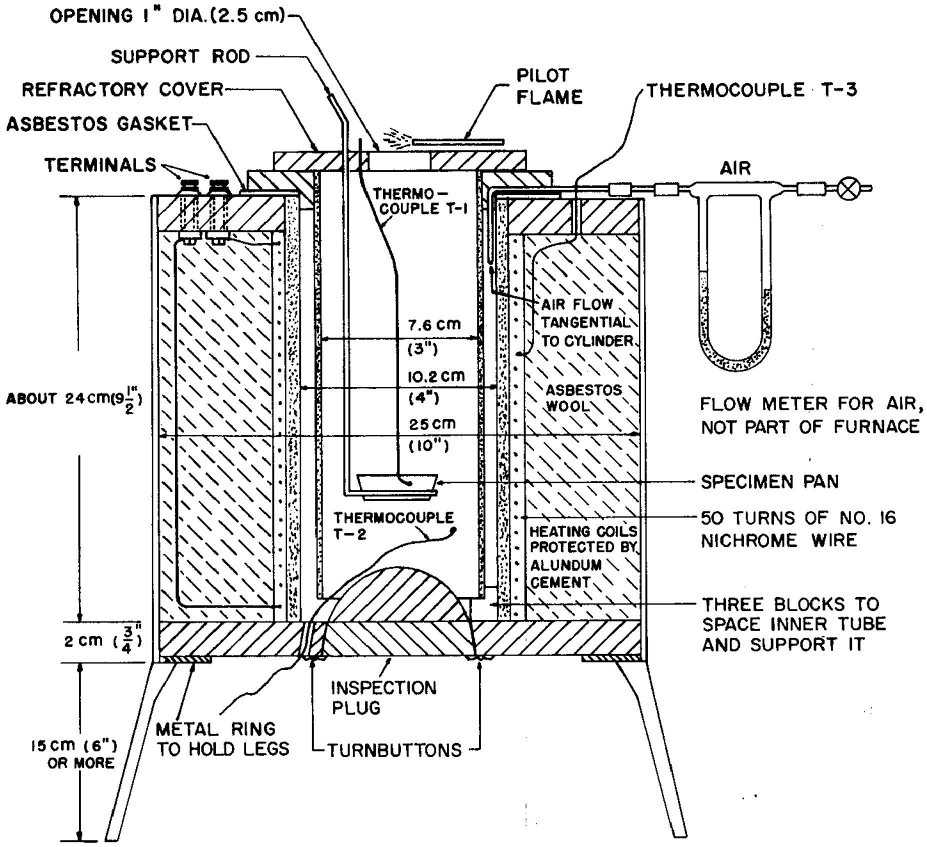

FIG. 1 Cross Section of Hot-Air Ignition Furnace Assembly.

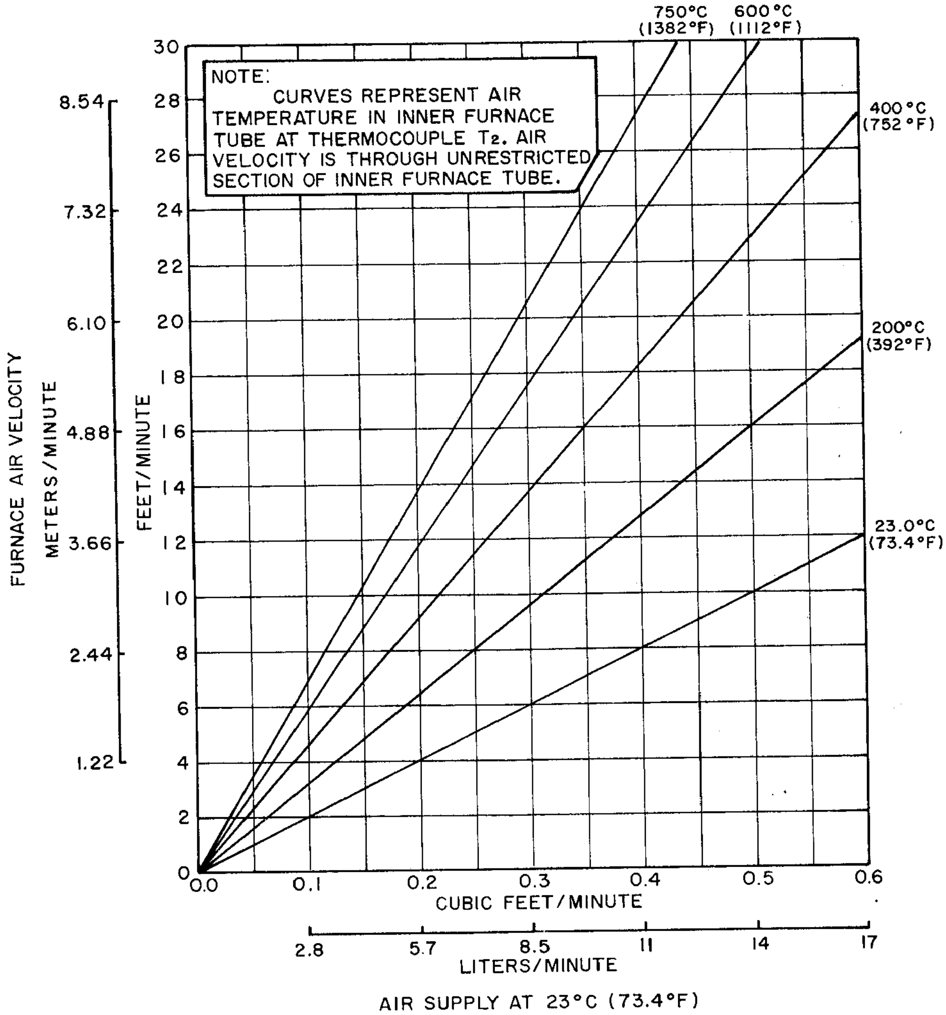

FIG. 2 Air Calibration Curves for Hot-Air Ignition Furnace.