



# Standard Test Method for Determining Ignition Temperature of Plastics<sup>1</sup>

This standard is issued under the fixed designation D1929; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope\*

1.1 This fire test response test method<sup>2</sup> covers a laboratory determination of the flash ignition temperature and spontaneous ignition temperature of plastics using a hot-air furnace.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *Caution*—During the course of combustion, gases or vapors, or both, are evolved that have the potential to be hazardous to personnel.

1.4 *This standard is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire-hazard or fire-risk assessment of the materials, products, or assemblies under actual fire conditions.*

1.5 *Fire testing is inherently hazardous. Adequate safeguards for personnel and property shall be employed in conducting these tests.*

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.* Specific precautionary statements are given in 1.3 and 1.4.

NOTE 1—This test method and ISO 871-1996 are identical in all technical details.

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.30 on Thermal Properties.30.03).

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In 1996, this test method was totally revised to be technically equal to ISO 871-1996, and a specific air velocity is specified, which eliminates the need for approximations.

<sup>2</sup> The following reference may be of interest in connection with this test method: Stetchkin, N. P., "A Method and Apparatus for Determining the Ignition Characteristics of Plastics," *Journal of Research*, National Institute of Standards and Technology, Vol 43, No. 6, December 1949 (RP 2052), p. 591.

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>3</sup>

D618 Practice for Conditioning Plastics for Testing

E176 Terminology of Fire Standards

### 2.2 International Standards:<sup>4</sup>

ISO 871-1996 Plastics—Determination of Ignition Temperature Using a Hot-Air Furnace

ISO 5725 Precision of Test Methods—Determination of Repeatability and Reproducibility for Standard Test Methods by Interlaboratory Tests

IEC 584-2 Thermocouples—Part 2: Tolerances

## 3. Terminology

3.1 For definitions of terms relating to fire, see Terminology E176.

### 3.2 Definitions of Terms Specific to This Standard:

3.2.1 *flash ignition temperature (FIT)*—the minimum temperature at which, under specified test conditions, sufficient flammable gases are emitted to ignite momentarily upon application of a small external pilot flame.

3.2.2 *glowing combustion*—combustion of a material in the solid phase without flame but with emission of light from the combustion zone, caused by slow decomposition and carbonization at various points in the specimen, without general ignition occurring.

3.2.3 *spontaneous ignition temperature or self-ignition temperature (SIT)*—the minimum temperature at which the self-heating properties of the specimen lead to ignition or ignition occurs of itself, under specified test conditions, in the absence of any additional flame ignition source.

## 4. Significance and Use

4.1 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

<sup>3</sup> 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.

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

\*A Summary of Changes section appears at the end of this standard

material under the conditions of this test. Test values are expected to rank materials according to ignition susceptibility under actual use conditions.

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

5. Apparatus

5.1 Hot-Air Ignition Furnace—A furnace similar to that shown in Fig. 1, consisting primarily of an electrical heating

unit and specimen holder.

5.2 Furnace Tube—A vertical tube with an inside diameter of  $100 \pm 5$  mm and a length of  $230 \pm 20$  mm, made of a ceramic that will withstand at least  $750^{\circ}\text{C}$ . The vertical tube stands on the furnace floor, fitted with a plug for the removal of accumulated residue.

5.3 Inner Ceramic Tube—A ceramic tube that will withstand at least  $750^{\circ}\text{C}$ , with an inside diameter of  $75 \pm 5$  mm, length of  $230 \pm 20$  mm, and thickness of approximately 3 mm, placed inside the furnace tube and positioned  $20 \pm 2$  mm above the furnace floor on three small spacer blocks. The top is covered

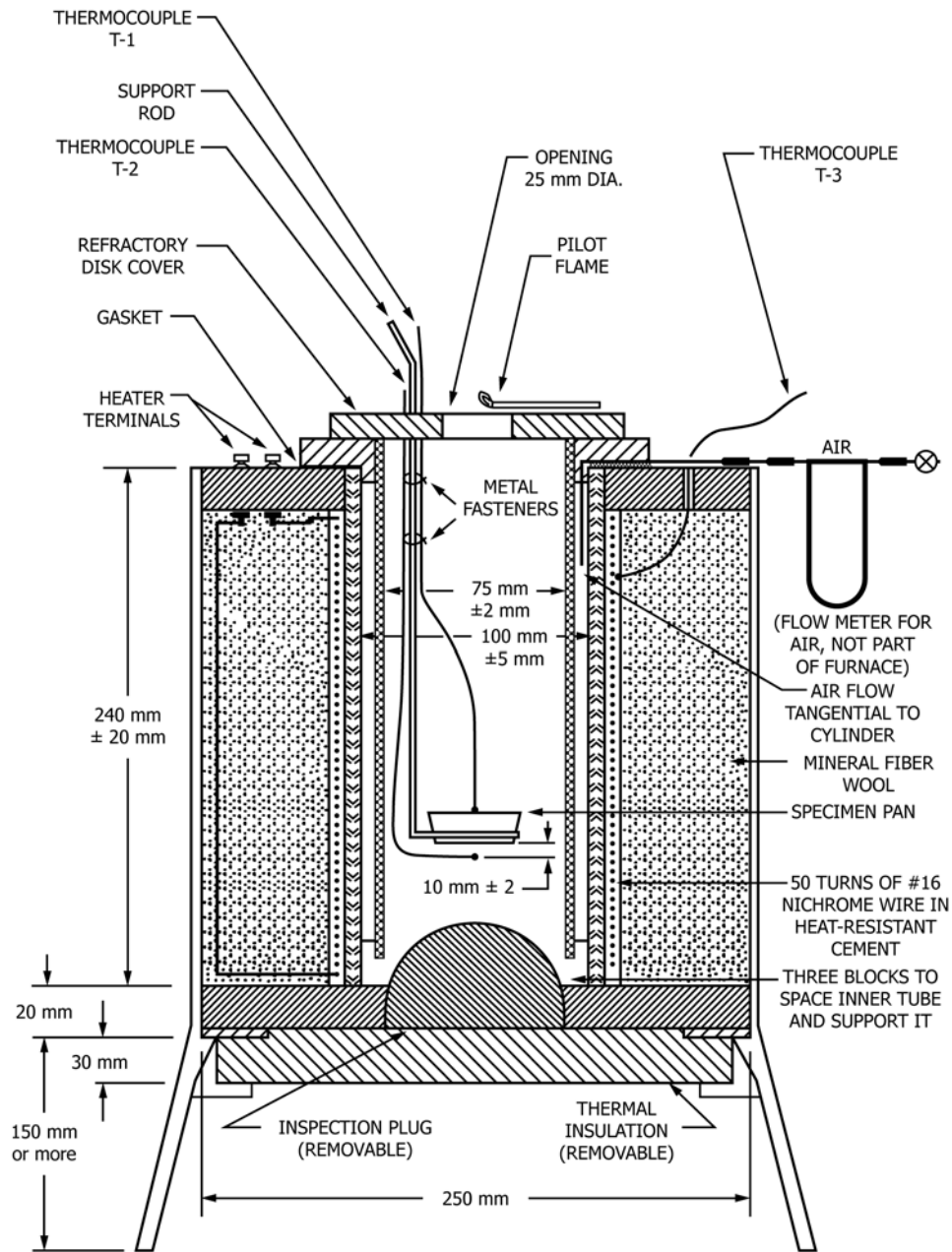


FIG. 1 Cross Section of Hot-Air Ignition Furnace

by a disk of heat-resistant material with a  $25 \pm 2$ -mm diameter opening in the center that is used for observation and passage of smoke and gases. The pilot flame is located immediately above the opening.

NOTE 2—Fire resistant materials such as silica glass and stainless steel have also been found suitable for this application.

5.4 *Air Source*—An outside air source to supply clean air 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.

5.5 *Electrical Heating Unit*, contained within the mineral fiber sleeve and constructed of 50 turns of  $1.3 \pm 0.1$  mm Nichrome V alloy wire, wound around the furnace tube and embedded in heat-resistant cement.

NOTE 3—Other constructions such as finely coiled wire embedded in molded ceramic fiber have also been found to be acceptable.

5.6 *Insulation*, consisting of a layer of mineral fiber, approximately 60-mm thick, and covered by a metal jacket.

5.7 *Pilot Igniter*, consisting of a nominal  $1.8 \pm 0.3$ -mm inside diameter (ID) copper tubing attached to a gas supply of 94 % minimum purity propane and placed horizontally  $5 \pm 1$  mm above the top surface of the disk cover. The pilot flame shall be adjusted to  $20 \pm 2$  mm in length and centered above the opening in the disk cover.

5.8 *Specimen Support and Holder*—The specimen pan consists of a metal container of approximately 0.5-mm thick steel measuring  $40 \pm 2$  mm in diameter by  $15 \pm 2$  mm in depth. It is held in a ring of approximately 2.0-mm diameter stainless steel welding rod. The ring is welded to a length of the same type of rod extending through the cover of the furnace, as shown in Fig. 1. The bottom of the specimen pan shall be located  $185 \pm 5$  mm down from the top of the inner furnace tube.

5.9 *Thermocouples*, 0.5-mm diameter, Chromel-Alumel (Type K) or Iron-Constantan (Type J), for temperature measurement connected to a calibrated recording instrument with a tolerance not exceeding  $\pm 2^\circ\text{C}$ . The thermocouple tolerance shall be in accordance with IEC 584-2, Table 1, Class 2 or better.

5.10 *Heating Control*—A suitable variable transformer or an automatic controller connected in series with the heating coils.

5.11 *Timing Device*, having an accuracy of at least 1 s.

## 6. Location of Thermocouples

6.1 Thermocouple  $TC_1$  measures the temperature,  $T_1$ , of the specimen. It is located as close as possible to the center of the upper surface of the specimen when the specimen is in place within the furnace. The thermocouple wire is attached to the specimen support rod.

6.2 Thermocouple  $TC_2$  gives some indication of the temperature,  $T_2$ , of the air traveling past the specimen. It is located  $10 \pm 2$  mm below the center of the specimen pan. The thermocouple wire is attached to the specimen support rod.

6.2.1 It is acceptable to install thermocouple  $TC_2$  through a hole drilled adjacent to the inspection plug below the specimen pan, instead of introducing it from the top, as shown in Fig. 1.

6.3 Thermocouple  $TC_3$  measures the temperature,  $T_3$ , of the heating coil. It is located adjacent to the furnace heating coil and is used as a reference for temperature adjustment purposes. A metallic sheathed thermocouple with a diameter not greater than 1.7 mm is permitted to be used for thermocouple  $TC_3$ . The limit on thermocouple thickness in 5.9 does not apply to thermocouple  $TC_3$ .

## 7. Test Specimens

7.1 It is acceptable to use as test specimens materials, or products, supplied in any form, with some examples being pellets, powders and films. It is also acceptable to use composites as test specimens. The test report shall include full details of the form in which the test specimens have been tested.

NOTE 4—Specimens containing high levels of inorganic fillers are difficult to evaluate.

NOTE 5—In some cases the same material will give different results if tested in different forms.

7.2 A specimen mass of  $3.0 \pm 0.2$  g shall be used for materials having a density greater than  $100 \text{ kg/m}^3$ .

7.2.1 *Instructions for Specific Types of Test Specimens:*

7.2.1.1 For sheet materials, cut the sheet into squares of  $20 \pm 2$  by  $20 \pm 2$  mm maximum size, and stack these to a height that gives the required specimen mass.

7.2.1.2 For film materials, roll a strip  $20 \pm 2$  mm wide and of length sufficient to give the required specimen mass.

7.2.1.3 For cellular materials having a density less than  $100 \text{ kg/m}^3$ , remove any outer skin and cut the specimens in the form of a block measuring  $20 \pm 2$  by  $20 \pm 2$  by  $50 \pm 5$  mm.

7.3 Sufficient material is required for at least two determinations.

7.4 The test specimens shall be conditioned at  $23 \pm 2^\circ\text{C}$  and  $50 \pm 10$  % relative humidity for not less than 40 h prior to test, in accordance with Practice D618.

## 8. Procedure

8.1 *Flash Ignition Temperature (FIT):*

8.1.1 Set the air velocity to 25 mm/s by adjusting the actual air flow rate through the full section of the inner tube at the furnace temperature, using the following formula:

$$Q_v = 6.62 \times \frac{293}{T}$$

where:

$Q_v$  = air flow rate, L/min, and  
 $T$  = temperature, K, at  $T_2$ .

Ensure that the air flow rate is maintained at  $\pm 10$  % of the calculated value.

8.1.2 Adjust the electric current supplied to the heating coil by means of the variable transformer or automatic controller, by reference to temperature  $T_3$  until the air temperature,  $T_2$ , remains constant at the desired initial test temperature.

8.1.2.1 The default initial test temperature shall be 400°C when no prior knowledge of the probable ignition temperature of the material or product to be tested is available.

8.1.2.2 If the approximate ignition temperature of the material or product to be tested is known, set the initial test temperature to 50°C below the expected ignition temperature.

8.1.3 Proceed as shown in 8.1.3.1 through 8.1.3.4 to assess the flash ignition temperature. Ignition is likely to be followed by continuous burning of the specimen.

8.1.3.1 Raise the specimen pan to the cover opening, and place the specimen on the pan.

8.1.3.2 Lower the pan into the furnace, while ensuring that thermocouples  $TC_1$  and  $TC_2$  are in their correct position, as per 6.1 and 6.2.

8.1.3.3 Start the timer and ignite the pilot flame.

8.1.3.4 Watch for the occurrence of the following events, any one of which represents evidence of ignition:

- (1) flaming combustion of the specimen,
- (2) glowing combustion of the specimen,
- (3) flash,
- (4) explosion,
- (5) rapid rise in temperature  $T_1$  above that of  $T_2$ .

NOTE 6— $T_2$  is essentially the temperature of the air surrounding the test specimen.  $T_1$  is essentially the temperature of the top surface of the test specimen. For a non-combustible test specimen, it would be expected that the temperature of  $T_1$ , the test specimen surface, would not significantly exceed the actual temperature  $T_2$  of the air flowing past it. If  $T_1$  were to significantly rise above  $T_2$ , the only source for this heat energy would be the test specimen itself. Because of this relationship, an instantaneous change in the heating rate of  $T_1$ , where  $T_1$  becomes greater than  $T_2$ , may be taken as an indication of ignition (burning) of the test specimen

8.1.4 At the end of 10 min, depending on whether ignition has or has not occurred, lower or raise the temperature  $T_2$  by 50°C accordingly, and repeat the test with a fresh specimen.

8.1.5 When the range within which the flash ignition temperature lies has been determined, begin the test 10°C below the highest temperature within this range, and continue by dropping the temperature in 10°C steps until the temperature is reached at which there is no ignition during a 10 min period.

8.1.6 Record the lowest air temperature,  $T_2$ , at which a flash is observed, during the 10 min period, as the flash ignition temperature.

8.2 *Spontaneous Ignition Temperature (SIT):*

8.2.1 Follow the same procedure as described in 8.1 with two exceptions:

- (1) do not use pilot flame;
- (2) use the evidences of ignition listed in 8.2.2 instead of those listed in 8.1.3.4.

8.2.2 The occurrence of any one of the following events is considered evidence of spontaneous ignition:

- (1) flaming combustion of the specimen;
- (2) glowing combustion of the specimen;
- (3) rapid rise in temperature of  $T_1$  above that of  $T_2$ .

NOTE 7—With some materials, it is difficult to detect spontaneous ignition visually when burning is by glowing combustion rather than

flaming combustion. In such cases, a rapid rise in temperature,  $T_1$  above  $T_2$ , is a more reliable reference.

8.2.3 Record the lowest air temperature,  $T_2$ , at which the specimen burns, during the 10 min period, as the spontaneous ignition temperature.

9. Test Report

9.1 Report the following information:

- 9.1.1 Reference to this test method;
- 9.1.2 Designation of the material, including the name of the manufacturer and composition;
- 9.1.3 Form of the material (granules, sheet, etc.);
- 9.1.4 Mass of the test specimen, g;
- 9.1.5 Density of the cellular test specimens, kg/m<sup>3</sup> ;
- 9.1.6 Flash ignition temperature (FIT), °C;
- 9.1.7 Spontaneous ignition temperature (SIT), °C;
- 9.1.8 Whether the combustion observed was flaming or glowing;
- 9.1.9 Observations regarding the behavior of the specimen during the test (how ignition occurred, the formation of soot or smoke, excessive foaming, melting, bubbling, smoking, etc.); and
- 9.1.10 The following statement:

“These test results relate only to the behavior of test specimens under the particular conditions of the test. They are not intended to be used, and shall not be used, to assess the potential fire hazards of a material in use.”

10. Precision and Bias

10.1 Relative precision data based on a preliminary interlaboratory study conducted in 1994, using ISO/DIS 871 as protocol, is indicated in Appendix X1. Findings from this interlaboratory study resulted in changes to the procedure; therefore, another interlaboratory study was initiated in 2012.

10.2 *Precision*<sup>5</sup>—The repeatability standard deviation from a single operator is shown in Table 1 and Table 2.

TABLE 1 FIT (°C)

Material ID	Average	Repeatability Standard Deviation
	$\bar{x}$	$s_r$
Polymethylmethacrylate (PMMA)	323.3	5.8
High Density Polyethylene (HDPE)	353.3	5.8
Polyamide 11 (PA11)	406.7	5.8
Polycarbonate (PC)	446.7	5.8
Polypropylene (PP)	313.3	5.8
Polyvinylidene Fluoride (PVDF)	510.0	0.0

<sup>5</sup> Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D20-1260. Contact ASTM Customer Service at service@astm.org.



**TABLE 2 SIT (°C)**

Material ID	Average	Repeatability Standard Deviation
	$\bar{x}$	$s_r$
Polymethylmethacrylate (PMMA)	450.0	0.0
High Density Polyethylene (HDPE)	370.0	0.0
Polyamide 11 (PA11)	423.3	5.8
Polycarbonate (PC)	550.0	0.0
Polypropylene (PP)	353.3	5.8
Polyvinylidene Fluoride (PVDF)	510.0	0.0

## 11. Keywords

11.1 flash ignition temperature; ignition temperature; spontaneous ignition temperature

## APPENDIX

### (Nonmandatory Information)

#### X1. RESULTS OBTAINED BY INTERLABORATORY TRIALS

X1.1 An interlaboratory study was conducted in 1994 using ISO/DIS 871.1 protocol for the testing criteria.

X1.2 These precision data were determined from interlaboratory tests involving seven laboratories, on six polymeric materials, with three replicates of each material. The resulting data were analyzed in accordance with ISO 5725 and are summarized in [Table X1.1](#) and [Table X1.2](#).

X1.3 Repeatability, in the normal and correct operation of the test method, is the difference between two averages (determined from three specimens) using identical test material and the same apparatus by one analyst within a short time interval. The values of repeatability will not exceed those given

in [Table X1.1](#) and [Table X1.2](#).

X1.4 Reproducibility, in the normal and correct operation of the test method, is the difference between two independent averages (determined from three specimens) found by two operators working in different laboratories on identical test material. The values of reproducibility will not exceed those given in [Table X1.1](#) and [Table X1.2](#).

X1.5 Two averages (determined from three specimens) are to be considered suspect and not equivalent if they differ by more than the repeatability and reproducibility given in [Table X1.1](#) or [Table X1.2](#). Any judgment per [X1.3](#) or [X1.4](#) would have an approximate 95 % (0.95) probability of being correct.

**TABLE X1.1 Flash Ignition Temperature (FIT)**

	Physical Form	Average FIT, ° C	Repeatability	Reproducibility
High-impact polystyrene	granulated	378	10	27
High-impact FR polystyrene	granulated	370	13	52
Polyamide 6	granulated	413	8	38
Polyvinyl chloride film	0.15 mm in thickness	327	11	45
Flexible polyurethane foam	25 mm thickness	349	12	66
Phenol-formaldehyde resin	solid bars	430	9	117

**TABLE X1.2 Spontaneous Ignition Temperature (SIT)**

	Physical Form	Average SIT, ° C	Repeatability	Reproducibility
High-impact polystyrene	granulated	458	12	59
High-impact FR polystyrene	granulated	422	14	47
Polyamide 6	granulated	439	31	56
Polyvinyl chloride film	0.15 mm in thickness	438	13	64
Flexible polyurethane foam	25 mm thickness	370	11	61
Phenol-formaldehyde resin	solid bars	482	14	103

**SUMMARY OF CHANGES**

Committee D20 has identified the location of selected changes to this standard since the last issue (D1929 – 14) that may impact the use of this standard. (April 1, 2016)

(1) Added **6.2.1**. Deleted old Note 4.

(2) Added **Note 6**.

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