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Plastics — Determination of ignition temperature using a hot-air furnace

Plastiques — Détermination de la température d'allumage au moyen d'un four à air chaud

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 871 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 4, *Burning behaviour*.

This third edition cancels and replaces the second edition (ISO 871:1996), which has been technically revised.

Plastics — Determination of ignition temperature using a hot-air furnace

1 Scope

1.1 This International Standard specifies a laboratory method for determining the flash-ignition temperature and spontaneous-ignition temperature of plastics using a hot-air furnace. It is one of a number of methods in use for evaluating the reaction of plastics to the effects of ignition sources.

1.2 This method does not give a direct measure of the combustibility or rate of burning of a material or any definition of the safe upper limit of temperature for the plastics in use, and it should not be used alone 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 hazard or fire risk assessment which takes into account all of the factors pertinent to an assessment of the fire hazard of a particular end use.

1.3 Tests made under conditions of this method 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.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 291, *Plastics — Standard atmospheres for conditioning and testing*

ISO 13943, *Fire safety — Vocabulary*

IEC 60584-2:1982, *Thermocouples — Part 2: Tolerances*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply in addition to those given in ISO 13943.

3.1
flash-ignition temperature
FIT
minimum temperature at which, under specified test conditions, sufficient flammable gases are emitted to ignite momentarily on application of a pilot flame

3.2
spontaneous-ignition temperature
SIT
minimum temperature at which, under specified test conditions, ignition is obtained by heating in the absence of any additional ignition source

3.3
glowing combustion
combustion of a material in the solid phase without flame but with emission of light from the combustion zone

4 Principle

A specimen of the material is heated in a hot-air ignition furnace using various temperatures within the heated chamber, and the flash-ignition temperature is determined with a small pilot flame directed at the opening in the top of the furnace to ignite evolved gases.

The spontaneous-ignition temperature is determined in the same manner as the flash-ignition temperature, but without the pilot flame.

5 Apparatus

5.1 Hot-air ignition furnace, similar to that shown in Figure 1, consisting primarily of an electrical heating unit and a specimen holder.

5.2 Furnace tube, with an inside diameter of 100 mm $\pm$ 5 mm and a length of 240 mm $\pm$ 20 mm, made of a ceramic that will withstand at least 750 °C. The tube shall be positioned vertically so that it stands on the furnace floor above a plug for the removal of accumulated residue.

5.3 Inner ceramic tube, capable of withstanding at least 750 °C, with an inside diameter of 75 mm $\pm$ 2 mm, a length of 240 mm $\pm$ 20 mm and a thickness of approximately 3 mm, placed centrally inside the furnace tube and positioned 20 mm $\pm$ 2 mm above the furnace floor on three small refractory spacer blocks. The top shall be covered by a disc of heat-resistant material with a 25 mm $\pm$ 2 mm diameter opening in the centre which is used for observations and allows the passage of smoke and gases. The pilot flame shall be located immediately above the opening.

5.4 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. The air shall be heated and circulated in the space between the two tubes and enter the inner ceramic tube at the bottom. The air flow shall be metered by a rotameter or other suitable device.

5.5 Electrical heating unit, made of 50 turns of 1,3 mm $\pm$ 0,1 mm nichrome wire or equivalent. The wires, contained within a mineral-fibre sleeve, shall be wound around the furnace tube and shall be embedded in heat-resistant cement.

5.6 Insulation, consisting of a layer of mineral-fibre wool approximately 60 mm thick, and covered by a sheet-iron jacket.

5.7 Pilot igniter, consisting of a copper tube of nominal inside diameter 2,0 mm attached to a supply of 94 % minimum purity propane and placed horizontally 5 mm $\pm$ 1 mm above the top surface of the disc cover. The pilot flame shall be adjusted to 20 mm $\pm$ 2 mm in length and centred above the opening in the disc cover.

5.8 Specimen support and holder, consisting of a metal specimen pan made of 0,7 mm $\pm$ 0,2 mm thick stainless steel and measuring 40 mm $\pm$ 2 mm in diameter by 15 mm $\pm$ 2 mm in depth, having a rounded bottom and held in a ring of approximately 2 mm diameter stainless-steel welding rod. The ring shall be welded to a length of the same type of rod extending through the cover of the furnace, as shown in Figure 1. The bottom of the specimen pan shall be located 185 mm $\pm$ 2 mm down from the lower edge of the pilot igniter.

5.9 Thermocouples, 0,5 mm in 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 °C. The thermocouple tolerance shall be in accordance with IEC 60584-2:1982, Table A.1, class 2, or better.

5.10 Heating control, consisting of a suitable variable transformer or an automatic controller connected in series with the heating coils.

5.11 **Timing device**, having an accuracy of 1 s or better.

6 Location of thermocouples

6.1 Thermocouple TC_1 (see Figure 1) measures the temperature T_1 of the specimen. It is located as close as possible to the centre 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 travelling past the specimen. It is located 10 mm $\pm$ 2 mm below the centre of the specimen pan. The thermocouple wire is conveniently attached to the specimen support rod.

NOTE Thermocouple TC_2 may also be installed through a hole drilled in the centre of the inspection plug below the specimen pan.

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 in preference to the inner-tube thermocouples because of its faster response.

7 Test specimens

7.1 Materials supplied in any form, including composites, may be used, but it is essential that the form is fully described in the test report.

NOTE 1 Specimens containing flame retardants and high levels of inorganic fillers may be difficult to evaluate.

NOTE 2 The same material tested in different forms may give different results.

7.2 For materials having a density greater than 100 kg/m^3, a specimen mass of 3,0 g $\pm$ 0,2 g shall be used. Materials may be tested in the form of pellets or powder, as normally supplied for moulding. For sheet materials, cut the sheet into squares of maximum size (20 mm $\pm$ 2 mm) $\times$ (20 mm $\pm$ 2 mm) and stack these to a height which gives the required specimen mass. For film materials, roll up a strip 20 mm $\pm$ 2 mm wide and of length sufficient to give the required specimen mass.

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

NOTE If the specimen is bulky and light and easily affected by the air flow in the furnace so that it may fall out of the tray, the specimen may be bound by a thin wire.

7.4 Sufficient material is required for at least two determinations.

7.5 Condition the test specimens at 23 °C $\pm$ 2 °C and (50 $\pm$ 5) % relative humidity for not less than 40 h prior to test, in accordance with ISO 291.

Dimensions in millimetres

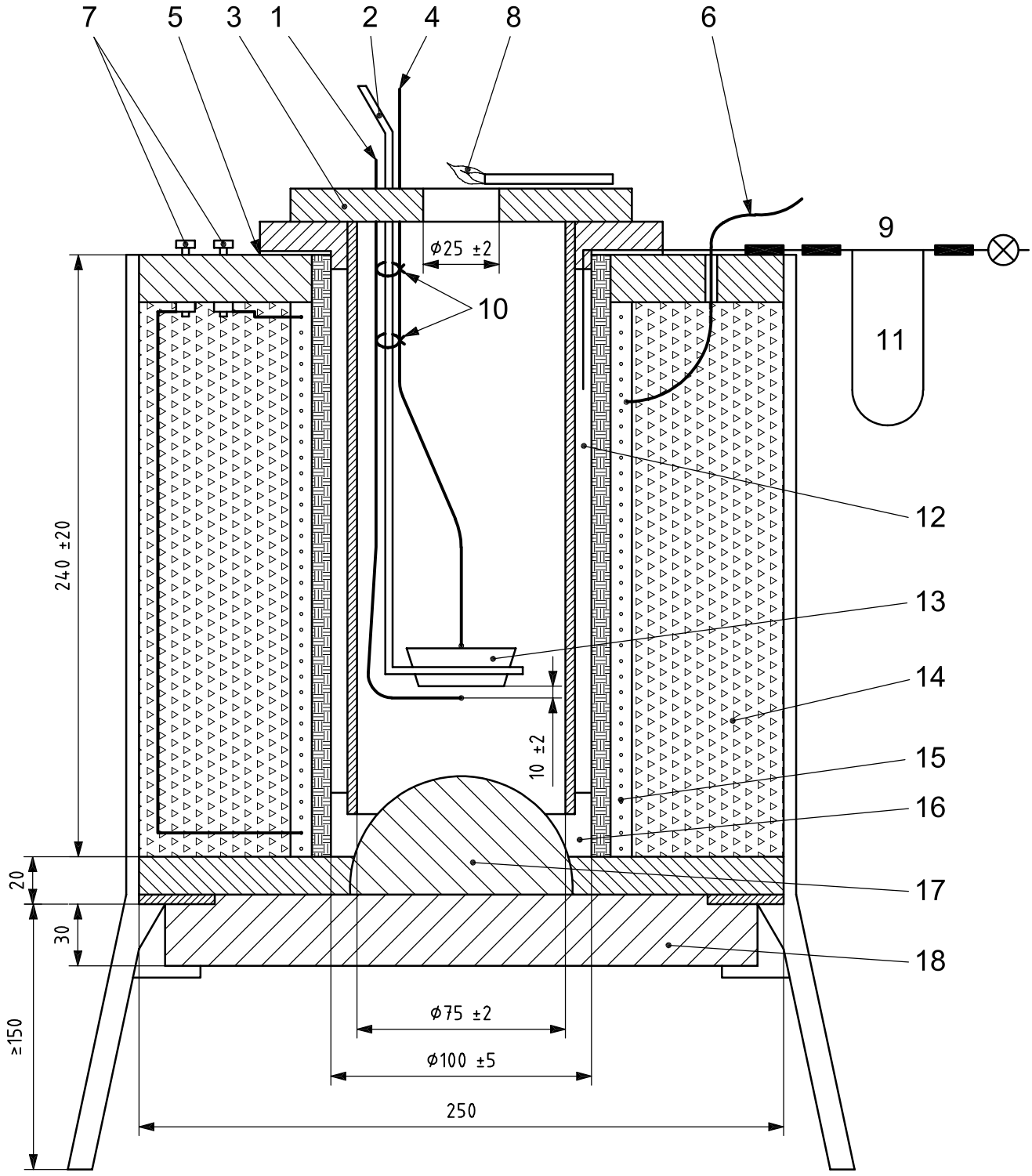

Figure 1 — Cross section of hot-air ignition furnace

Key

1 thermocouple TC_2
2 support rod
3 refractory disc cover
4 thermocouple TC_1
5 gasket
6 thermocouple TC_3
7 heater terminals
8 pilot flame
9 air supply
10 metal fasteners
11 air-flow meter (not part of furnace)
12 air flow tangential to cylinder
13 specimen pan
14 mineral fibre wool
15 50 turns of No. 16 nichrome wire in heat-resistant cement
16 three refractory blocks to space inner tube and support it
17 inspection plug (removable)
18 thermal insulation (removable)

Figure 1 — Cross section of hot-air ignition furnace (*continued*)

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 q_V through the full section of the inner tube (5.3) at the furnace temperature to a value calculated in litres per minute from the following equation:

$$q_V = 6{,}62 \times \frac{293}{T}$$

where T is the temperature in K.

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 (5.5) by means of the variable transformer or automatic controller (5.10), by reference to temperature T_3, until the air temperature T_2 remains constant at the desired initial test temperature.

NOTE A temperature of 400 °C is used when no prior knowledge of the probable flash-ignition temperature range is available. Other starting temperatures may be selected if information about the material indicates a better choice.

8.1.3 Raise the specimen holder (see 5.8) to the cover opening and place the pan with the specimen into the ring of the holder. Ensure that thermocouples TC_1 and TC_2 are in their correct position (see 6.1 and 6.2) and lower the pan into the furnace. Start the timer (5.11), ignite the pilot flame and watch for evidence of a flash or mild explosion of combustible gases which may be followed by burning of the specimen.

8.1.4 At the end of 10 min, lower or raise the temperature T_2 by 50 °C, depending on whether ignition has or has not occurred, 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 tests 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 as the flash-ignition temperature the lowest air temperature T_2 at which a flash is observed during the 10 min period.

8.2 Spontaneous-ignition temperature (SIT)

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

8.2.2 Ignition will be evidenced by flaming or glowing combustion of the specimen. It may be difficult, with some materials, to detect spontaneous ignition visually when burning is by glowing combustion rather than flaming. In such cases, a rapid rise in temperature T_1 above temperature T_2 accompanied by a visual observation is the more reliable reference.

8.2.3 Record as the spontaneous-ignition temperature the lowest air temperature T_2 at which flaming or glowing combustion of the specimen is observed within the 10 min period.

NOTE Determination of ignition temperatures is a process which is very sensitive to outer conditions. It is therefore necessary to keep strictly to the test conditions and procedures specified in this International Standard.

9 Precision

Precision data based on interlaboratory trials are given in Annex A.

10 Test report

The test report shall include the following:

a) a reference to this International Standard;

b) the designation of the material, including name of manufacturer and composition;

c) the mass of the test specimen, in grams;

d) the form of the material (granules, sheet, etc.);

e) the density of cellular materials, in kilograms per cubic metre;

f) the flash-ignition temperature (FIT), in degrees Celsius;

g) the spontaneous-ignition temperature (SIT), in degrees Celsius;

h) whether the combustion observed was flaming or glowing;

i) observations about the behaviour of the specimen during the test (how ignition occurred, formation of soot or smoke, excessive foaming, melting, bubbling, smoking, etc.);

j) the following statement:

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

Annex A
(informative)

Results obtained by interlaboratory trials

A.1 These precision data were determined from interlaboratory tests, involving seven laboratories, on five polymeric materials, with three replicates of each material. The resulting data were analysed in accordance with ISO 5725-2:1994, *Accuracy (trueness and precision) of measurement methods and results — Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method* and are summarized in Tables A.1 and A.2. Whilst the repeatability of the method for all materials tested was good, the reproducibility of the method for some materials was poor. For example, phenol-formaldehyde resin was an outlier in the tests and the data have been omitted from the analysis. The observations with phenol-formaldehyde resin may be attributed to the subjective nature of the ignition characteristics of this material (see 8.2.2).

Table A.1 — Flash-ignition temperature (FIT)

Values in degrees Celsius

	Physical form	Average FIT	Repeatability limit	Reproducibility limit
High-impact polystyrene	granulated	382	11	13
High-impact FR polystyrene	granulated	370	13	52
Polyamide 6	granulated	412	4	42
Poly(vinyl chloride) film	thickness 0,15 mm	325	11	45
Polyurethane foam, flexible	thickness 25 mm	346	12	66

Table A.2 — Spontaneous-ignition temperature (SIT)

Values in degrees Celsius

	Physical form	Average SIT	Repeatability limit	Reproducibility limit
High-impact polystyrene	granulated	458	12	59
High-impact FR polystyrene	granulated	422	14	47
Polyamide 6	granulated	439	6	59
Poly(vinyl chloride) film	thickness 0,15 mm	437	13	64
Polyurethane foam, flexible	thickness 25 mm	374	4	58

A.2 Repeatability limit — the value less than or equal to which the absolute difference between two test results obtained under repeatability conditions is expected to be with a probability of 95 %. The repeatability limits for this test method will normally not exceed those shown in Tables A.1 and A.2.

A.3 Reproducibility limit — the value less than or equal to which the absolute difference between two test results obtained under reproducibility conditions is expected to be with a probability of 95 %. The reproducibility limits for this test method will normally not exceed those shown in Tables A.1 and A.2.

A.4 Two averages (each determined from three specimens) are to be considered suspect and not equivalent if they differ by more than the repeatability or reproducibility limits shown in Tables A.1 or A.2.

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