INTERNATIONAL STANDARD

ISO 871

Second edition
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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

Reference number
ISO 871:1996(E)

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.

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.

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

This second edition cancels and replaces the first edition (ISO 871:1980), which has been technically revised.

Annex A of this International Standard is for information only.

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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 resistance of plastics to the effects of high temperatures.

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 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 standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 291:—[1], *Plastics — Standard atmospheres for conditioning and testing.*

ISO/IEC Guide 52:1990, *Glossary of fire terms and definitions.*

IEC 584-2:1982, *Thermocouples — Part 2: Tolerances.*

3 Definitions

For the purposes of this International Standard, the following definitions apply, in addition to those given in ISO/IEC Guide 52.

3.1 flash-ignition temperature (FIT): The 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): The minimum temperature at which ignition is obtained by heating, under specified test conditions, in the absence of any additional flame 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.

1) To be published. (Revision of ISO 291:1977)

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 ignition 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 ± 5 mm and a length of 240 mm ± 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 ± 2 mm, a length of 240 mm ± 20 mm and a thickness of approximately 3 mm, placed inside the furnace tube and positioned 20 mm ± 2 mm above the furnace floor on three small spacer blocks. The top shall be covered by a disc of heat-resistant material with a 25 mm ± 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.

NOTE 1 Fire-resistant materials such as silica glass and stainless steel have also been found suitable for this application.

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 shall be metered by a rotameter or other suitable device.

5.5 Electrical heating unit, made of 50 turns of 1,3 mm ± 0,1 mm nichrome V alloy 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 ± 1 mm above the top surface of the disc cover. The pilot flame shall be adjusted to 20 mm ± 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 approximately 0,5 mm thick steel and measuring 40 mm ± 2 mm in diameter by 15 mm ± 1 mm in depth 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 ± 2 mm down from the top of the inner ceramic tube.

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 ± 2 °C. The thermocouple tolerance shall be in accordance with IEC 584-2:1982, table 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

(see figure 1)

6.1 Thermocouple TC_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 ± 2 mm below the centre of the specimen pan. The thermocouple wire is conveniently attached to the specimen support rod.

NOTE 2 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.

Dimensions in millimetres

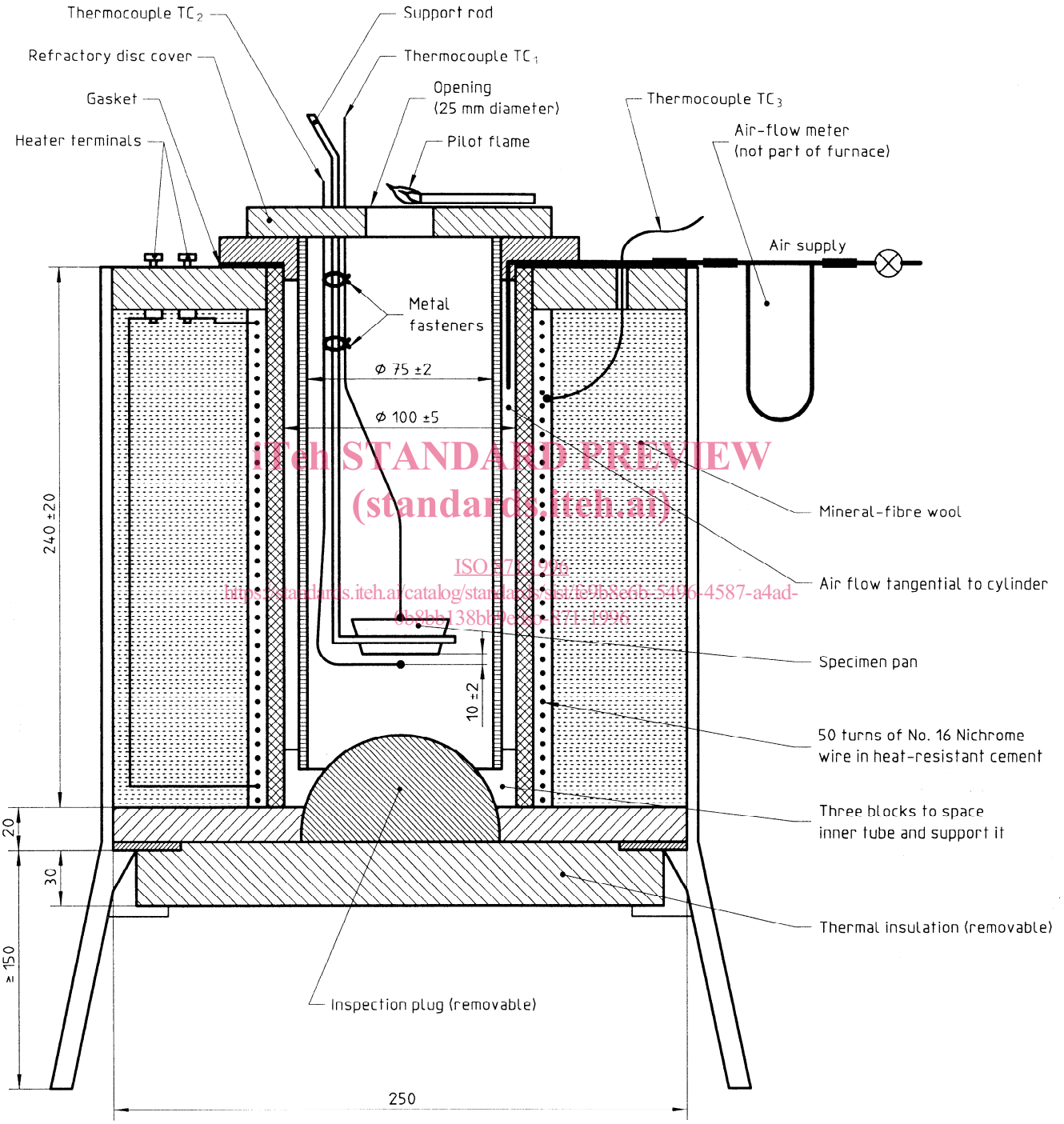

Figure 1 — Cross-section of hot-air ignition furnace

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.

NOTES

3 Specimens containing high levels of inorganic fillers are difficult to evaluate.

4 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 ± 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 ± 2 mm) × (20 mm ± 2 mm) and stack these to a height which gives the required specimen mass. For film materials, roll up a strip 20 mm ± 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 ± 2 mm) × (20 mm ± 2 mm) × (50 mm ± 5 mm).

7.4 Sufficient material is required for at least two determinations.

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

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 kelvins.

Ensure that the air-flow rate is maintained at ± 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 5 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 pan (see 5.8) to the cover opening and place the specimen on the pan. Lower the pan into the furnace, ensuring that thermocouples TC_1 and TC_2 are in their correct position (see 6.1 and 6.2). 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 continuous burning of the specimen. Flaming or glowing combustion can also be observed by a rapid rise in temperature T_1, as compared with temperature T_2.

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 that of 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 the specimen burns during the 10 min period.

9 Precision

The precision of this method is being developed. See annex A for relative precision data based on a preliminary interlaboratory study conducted in 1994 using ISO/DIS 871 as protocol. Findings from this interlaboratory study resulted in changes to the procedure which are now incorporated in the standard.

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, to assess the potential fire hazards of a material in use."

Annex A
(informative)

Results obtained by interlaboratory trials

A.1 An interlaboratory study was conducted in 1994 using the first DIS of 871 as protocol for the testing criteria.

A.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 analysed in accordance with ISO 5725:1986, *Precision of test methods — Determination of repeatability and reproducibility for a standard test method by inter-laboratory tests* (now withdrawn), and are summarized in tables A.1 and A.2.

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

Values in degrees Celsius

	Physical form	Average FIT	Repeatability	Reproducibility
High-impact polystyrene	granulated	378	10	27
High-impact FR polystyrene	granulated	370	13	52
Polyamide 6	granulated	413	8	38
Poly(vinyl chloride) film	thickness 0,15 mm	327	11	45
Flexible polyurethane foam	thickness 25 mm	349	12	66
Phenol-formaldehyde resin	solid bars	430	9	117

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

Values in degrees Celsius

	Physical form	Average SIT	Repeatability	Reproducibility
High-impact polystyrene	granulated	458	12	59
High-impact FR polystyrene	granulated	422	14	47
Polyamide 6	granulated	439	31	56
Poly(vinyl chloride) film	thickness 0,15 mm	438	13	64
Flexible polyurethane foam	thickness 25 mm	370	11	61
Phenol-formaldehyde resin	solid bars	482	14	103

A.3 Repeatability, in the normal and correct operation of the method, is the difference between two averages (each determined from three specimens) obtained using identical test material and the same apparatus by one analyst within a short time interval. The values of repeatability for this test method will normally not exceed those shown in tables A.1 and A.2.

A.4 Reproducibility, in the normal and correct operation of the method, is the difference between two independent averages (each determined from three specimens) obtained by two operators working in different laboratories on identical test material. The values of reproducibility for this test method will normally not exceed those shown in tables A.1 and A.2.

A.5 Two averages (each determined from three specimens) are to be considered suspect and not equivalent if they differ by more than the repeatability and reproducibility shown in tables A.1 or A.2. Any judgement per clause A.3 or A.4 would have an approximately 95 % (0,95) probability of being correct.