INTERNATIONAL
STANDARD

ISO
10351

First edition
1992-12-01

Plastics — Determination of the combustibility of specimens using a 125 mm flame source

Plastiques — Détermination de la combustibilité d'éprouvettes soumises à une flamme de 125 mm comme source d'allumage

Reference number
ISO 10351:1992(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 10351 was prepared by Technical Committee ISO/TC 61, *Plastics*, Sub-Committee SC 4, *Burning behaviour*.

Annex A forms an integral part of this International Standard. Annex B is for information only.

International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland

Printed in Switzerland

Plastics — Determination of the combustibility of specimens using a 125 mm flame source

1 Scope

1.1 This International Standard specifies a small-scale laboratory screening procedure for comparing the relative burning behaviour of small specimens of plastics and also their resistance to burn-through when exposed to an ignition source of medium energy level (500 W flame). This method is applicable to both solid materials and cellular plastics materials with a density of 250 kg/m^3 or greater when determined in accordance with ISO 845.

1.2 This method of test is intended to characterize material performance, for example for quality-control purposes, and is not intended to assess the behaviour to fire of building materials or furnishings. The test method described may be used for the preselection acceptance of a material, provided that positive results are obtained at a thickness which equals the smallest thickness used in the application. The results obtained provide some information about the behaviour of plastics materials in service, but can never by themselves assure safe performance in service.

NOTE 1 Test results are influenced by material components, e.g. pigments, fillers, fire-retardant concentrates.

1.3 This test method subjects small specimens of plastics to a flame source approximately 10 times more severe than the flame source used in ISO 1210.

1.4 The classification system described in annex B is intended to provide guidance for preferred levels of performance when this method is used for quality assurance and the preselection of component materials for products.

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 291:1977, *Plastics — Standard atmospheres for conditioning and testing.*

ISO 293:1986, *Plastics — Compression moulding test specimens of thermoplastic materials.*

ISO 294:1975, *Plastics — Injection moulding test specimens of thermoplastic materials.*

ISO 295:1991, *Plastics — Compression moulding of test specimens of thermosetting materials.*

ISO 845:1988, *Cellular plastics and rubbers — Determination of apparent (bulk) density.*

ISO 1210:1992, *Plastics — Determination of the burning behaviour of horizontal and vertical specimens in contact with a small-flame ignition source.*

ISO 5725:1986, *Precision of test methods — Determination of repeatability and reproducibility for a standard test method by inter-laboratory tests.*

ISO 10093:—[1], *Plastics — Fire tests — Standard ignition sources.*

---

[1] To be published.

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 afterflame: Persistence of flaming of a material after the ignition source has been removed.

3.2 *afterflame time:* The length of time for which a material continues to flame, under specified test conditions, after the ignition source has been removed.

3.3 afterglow: Persistence of glowing of a material after cessation of flaming or, if no flaming occurs, after the ignition source has been removed.

3.4 afterglow time: The length of time for which a material continues to glow, under specified test conditions, after the ignition source has been removed and/or cessation of flaming.

4 Significance of test

4.1 Tests made on a material under the conditions specified in this International Standard can be of considerable value when comparing the relative burning behaviour of different materials, controlling manufacturing processes, or assessing any change in burning characteristics prior to, or during, use. The results obtained from this method are dependent on the shape, orientation and environment surrounding the specimen and on the conditions of ignition. Correlation with performance under actual service conditions is not implied.

4.2 Assessment for fire hazard requires consideration of such factors as fuel contribution, intensity of burning (rate of heat release), products of combustion, and environmental factors such as the intensity of the flame source, orientation of the exposed material and ventilation conditions.

4.3 Burning behaviour, as measured by this test method, is affected by such factors as the density, colour and anisotropy of the material and the thickness of the specimen.

4.4 Certain materials may shrink from the applied flame without igniting. In this event, test results are not valid, therefore additional bar specimens are required to obtain five valid test results for each conditioning. If all test specimens shrink from the applied flame without igniting, these materials are not suitable for evaluation by this test method.

4.5 The burning behaviour of some plastics materials may change with time. It is accordingly advisable to make tests before and after oven conditioning by an appropriate procedure that shall be described in the test report. The preferred oven conditioning conditions shall be 7 days at 70 °C. However, other oven conditioning times and temperatures may be used if agreeable to all parties and shall be noted in the test report.

5 Principle

5.1 This method requires the use of two specimen configurations to characterize material performance. Bars (clause 9) are used to assess burning behaviour, while plates (clause 10) are used to assess the resistance of the material to burn-through (penetration of the flame through the surface of the specimen on the side opposite the ignition source).

5.2 The effects on the burning behaviour of additives, deterioration and possible loss of volatile components are measurable using this method. Results obtained using this method may serve to compare the relative performance of materials and can be helpful in material assessment.

6 Apparatus and materials

6.1 Laboratory fume hood (cupboard), having an internal volume of at least 0,5 m^3, with a door that can be completely closed. The enclosure shall permit observation and shall be draught-free while permitting normal thermal circulation of air past the specimen during burning. For safety and convenience, it is desirable that this enclosure be fitted with an evacuation device, such as an exhaust fan, to remove products of combustion which may be toxic. However, it is important to be able to turn off the device during the actual test and to start it again immediately after the test to remove the products of combustion.

NOTE 2 The amount of oxygen available to support combustion is obviously important for the conduct of these flame tests. For tests conducted by this method when burning times are protracted, enclosure sizes less than 1 m^3 may not provide accurate results.

6.2 Laboratory burner, as specified in ISO 10093 as ignition source P/PF2, having a barrel length of 90 mm to 100 mm and an inside diameter (9,5 ± 0,3) mm. The barrel shall not be equipped with an end-attachment, such as a stabilizer.

NOTES

3 The burner is specified in more detail in ASTM D 5025:1989, *Standard specifications for a laboratory burner used for small-scale burning tests on plastics materials*.

4 The 500 W premixed test flame burner specified in IEC 695-2-4/2:—²⁾, *Fire hazard testing — Part 2: Test methods — Part 2-4, sheet 2: 500 W nominal pre-mixed test flame and guidance*, will provide similar results when adjusted to produce the confirmatory time indicated in A.5.1 of the calibration procedure given in annex A.

However, in case of dispute, use the ignition source P/PF2 as described in ISO 10093.

6.3 Ring stand, with clamps or the equivalent, adjustable for positioning the specimen.

6.4 Burner mounting block, capable of positioning the burner at an angle of 20° from the vertical axis.

6.5 Timing device, accurate to 1 s.

6.6 Measuring scale, graduated in millimetres.

6.7 Methane gas, of technical-grade, with regulator and meter for uniform gas flow.

NOTES

5 Other gas mixtures having a heat content of approximately 37 MJ/m^3 have been found to provide similar results.

6 Propane having a heat content of approximately 94 MJ/m^3 and butane having a heat content of approximately 120 MJ/m^3 provide similar results when using the procedure given in clause 9.

In cases of dispute, use technical-grade methane.

6.8 Dry, absorbent surgical cotton.

6.9 Desiccator, containing anhydrous calcium chloride or another drying agent.

6.10 Conditioning room or chamber, capable of being maintained at (23 ± 2) °C and a relative humidity of (50 ± 5) %.

6.11 Air-circulating oven (minimum of five air-changes per hour), capable of being maintained at (70 ± 1) °C or another agreed-upon temperature.

6.12 Micrometer, accurate to 0,01 mm.

6.13 Manometer and gas-flow meter, calibrated for the gas being used, capable of being read to the values given in table 1.

Table 1 — Gas sources

Gas	Heat content MJ/m^3	Flow rate ml/min	Pressure mmH$_2$O
Methane[1]	37	965	100
Propane	94	380	450
Butane	120	300	500

[1] Natural gas having a heat content of 37 MJ/m^3 has been found to provide similar results.

7 Specimens

7.1 All specimens shall be cut from a representative sample of the material (sheets or from end-products), or shall be cast, injection-moulded (see ISO 294), compression-moulded (see ISO 293 or ISO 295), or transfer-moulded to the necessary form. After any cutting operation, care shall be taken to remove all dust and any particles from the surface; cut edges shall have a smooth finish.

7.2 Bars shall be (125 ± 5) mm long, (13,0 ± 0,3) mm wide and (3,0 ± 0,2) mm thick.

7.3 Plates shall have sides of at least 150 mm and a thickness of at least (3,0 ± 0,2) mm.

7.4 Other thicknesses may be used if agreeable to all parties, but the maximum thickness of a specimen shall not exceed 13 mm.

NOTE 7 Tests made on specimens of different thicknesses or density may not be comparable. Tests made in different directions of anisotropy or on different colours may also not be comparable.

7.5 A minimum of 20 bars and 12 plates shall be prepared. It is advisable to prepare additional specimens in case the situation described in 4.4 is encountered where the specimens shrink from the flame without igniting.

8 Conditioning

8.1 Unless otherwise required by the specifications for the material being tested, condition two sets of 5 bars and 3 plates for at least 48 h at (23 ± 2) °C and (50 ± 5) % relative humidity, in accordance with ISO 291.

Additional bars may also need to be conditioned in case the material shrinks from the applied flame, as described in 4.4.

---

[2] To be published

8.2 Condition two sets of 5 bars and 3 plates for (168 ± 2) h at (70 ± 1) °C or another agreed-upon temperature. Then cool the specimens in a desiccator (6.9) over anhydrous calcium chloride for at least 4 h at room temperature.

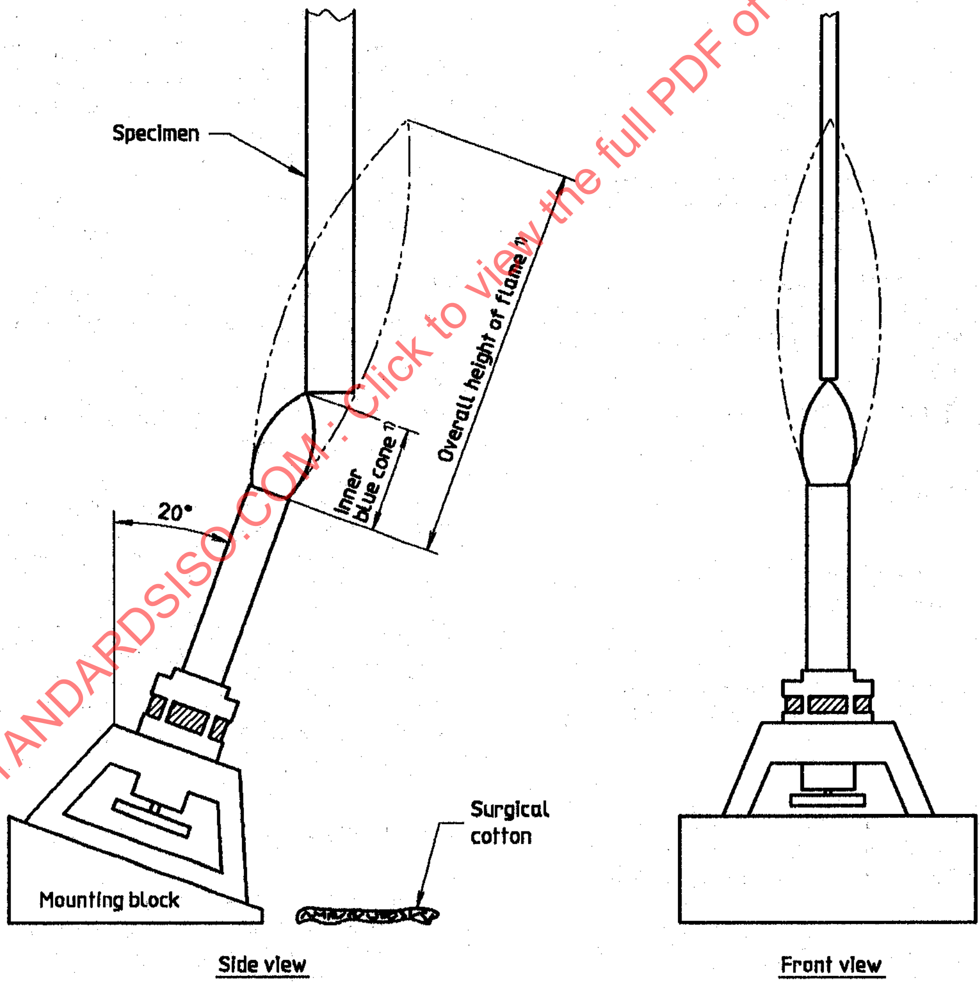
Additional bars may also need to be conditioned in case the material shrinks from the applied flame, as described in 4.4.

8.3 Conduct the tests in a laboratory atmosphere at (23 ± 3) °C and (50 ± 10) % relative humidity.

9 Test procedure for bars

9.1 Clamp a test specimen on the ring stand (6.3) from the upper 6 mm of its length, with the longitudinal axis vertical, so that the lower end of the specimen is 300 mm above a 50 mm × 50 mm horizontal layer of dry, absorbent surgical cotton (6.8), approximately 6 mm thick. (See figure 1.)

9.2 Adjust the gas flow and pressure to the values shown in table 1 for the corresponding gas source, using the general arrangement shown in figure 2. Place the burner (6.2) away from the specimen, ignite the flame and, in a darkened room with the burner in a vertical position, regulate the flame. Adjust the gas flow, while maintaining the values given in table 1, until the overall height of the flame is (125 ± 10) mm and the height of the inner blue cone is (40 ± 2) mm. Support the burner on the burner mounting block (6.4) so that the burner tube is positioned at 20° from the vertical. The narrow edge of the specimen shall face the burner. (See figure 1.)



1) For flame dimensions, see 9.2.

Figure 1 — Test assembly for bars

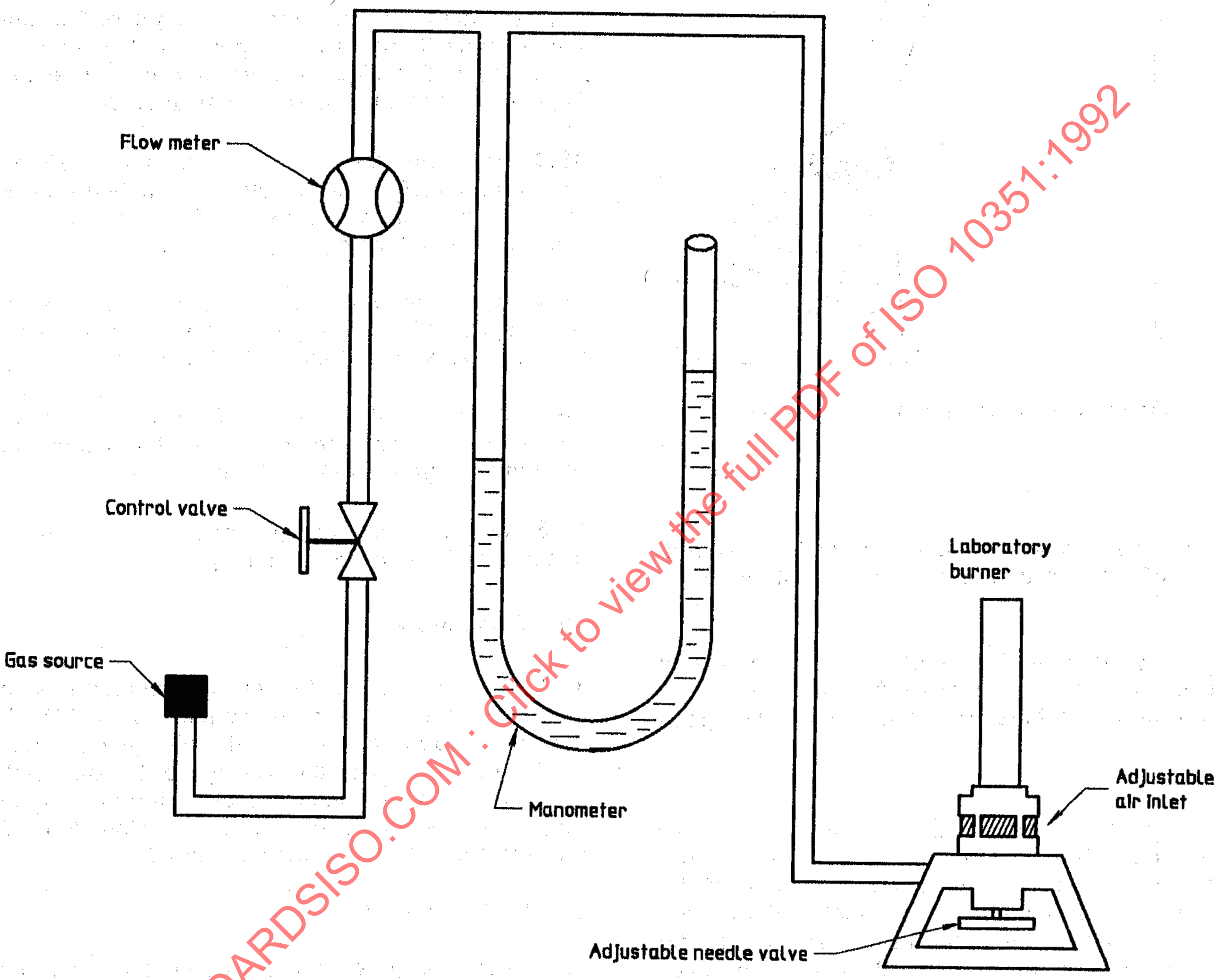


Figure 2 — Burner supply arrangement

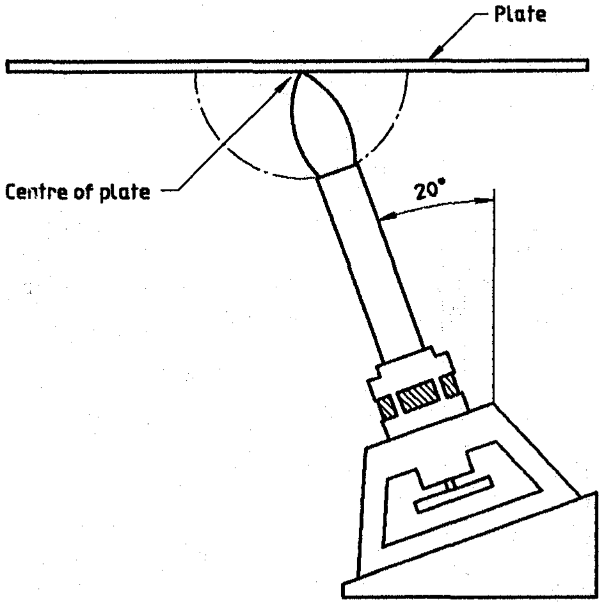


Figure 3 — Test assembly for plates

9.3 In case of dispute, use the procedure given in annex A for calibration of the applied test flame.

9.4 Apply the flame to one of the lower corners of the specimen at an angle of 20° from the vertical, so that the tip of the blue cone just touches the specimen.

9.5 Apply the flame for 5 s and then remove it for 5 s. Repeat this until the specimen has been subjected to five applications of the test flame. If the specimen drips particles or elongates during the test, adjust the height of the burner so that the tip of the inner blue cone is in contact with the major remaining portion of the specimen corner.

9.6 After the fifth removal of the test flame, observe and record the following:

a) afterflame time;

b) afterglow time;

c) whether or not during the test the specimen dripped particles that ignited the cotton indicator.

9.7 Conduct this test procedure on at least 5 specimens for each conditioning and record the average value.

10 Test procedure for plates

10.1 Support a plate in the horizontal plane by using a clamp on the ring stand (6.3). (See figure 3.)

10.2 Using the procedure described in 9.2, place the burner (6.2) away from the specimen, ignite the flame and adjust it so that when the burner is in a vertical position the overall height of the flame is approximately 125 mm and the height of the inner blue cone is 40 mm. Then, support the burner on the burner mounting block (6.4) so that the burner tube is positioned at 20° from the vertical axis.

10.3 Apply the flame to the approximate centre of the bottom surface of the plate at an angle of 20° from the vertical so that the tip of the blue cone just touches the surface of the plate.

10.4 Apply the flame for 5 s and then remove it for 5 s. Repeat this until the plate has been subjected to five applications of the test flame.

10.5 After the fifth removal of the test flame, observe and record whether or not the flame penetrated through the material (burn-through).

10.6 Conduct this test procedure on at least 3 specimens for each conditioning.

11 Precision

11.1 The precision data were determined from an inter-laboratory experiment conducted in 1988 involving 10 laboratories, 6 materials (levels) and 3 replicates each using the average of 5 data points. The analysis was conducted on 3-mm-thick specimens. The results were analysed using ISO 5725 and are summarized in tables 2 and 3.

11.1.1 Repeatability

The difference between two independent averages, determined from 5 specimens, should exceed the repeatability shown in tables 2 and 3 not more than once in 20 cases on average.

11.1.2 Reproducibility

The difference between two independent averages, determined from 5 specimens, should exceed the reproducibility shown in tables 2 and 3 not more than once in 20 cases on average.

11.2 The two averages determined from 5 specimens are to be considered suspect and not equivalent if they differ by more than the repeatability and reproducibility shown in tables 2 and 3. Any judgement per 11.1.1 or 11.1.2 would have an approximately 95 % (0,95) probability of being correct.

Tables 2 and 3 are only intended to present a meaningful way of considering the approximate precision of this test method for a range of materials. These data should not be rigorously applied for the acceptance or rejection of material, as they are specific to the inter-laboratory test and may not be representative of other lots, conditions, materials or laboratories.

12 Test report

The test report shall include the following information:

a) full identification of the tested product, including the manufacturer's name, number or code;

b) reference to this International Standard;

c) individual specimen thickness, to the nearest 0,1 mm;

d) nominal apparent density (rigid cellular materials only);

e) direction of any anisotropy relative to the test specimen dimensions;

f) colour of the specimen;

g) conditioning treatment;

h) any prior treatment before testing, other than cutting, trimming and conditioning;

i) gas source, flow rate and pressure used;

j) individual test values, including:

   1) afterflame time for each specimen after the fifth removal of the flame;

   2) afterglow time for each specimen after the fifth removal of the flame;

   3) whether the cotton indicator pad was ignited;

   4) average afterflame time of the 5 specimens;

   5) average afterglow time of the 5 specimens;

   6) whether the flame penetrated through the plate specimens.

Table 2 — Precision data on the afterflame time after the fifth flame application

Values in seconds

Parameter	Material					
	PBT(1)	PBT(2)	PA	PPO	PC	UP
Average	1,0	1,2	1,5	10,3	2,1	6,7
Repeatability	1,1	1,6	0,8	11,6	1,9	5,4
Reproducibility	1,7	3,0	2,6	16,8	2,9	15,1

Table 3 — Precision data on the afterflame or afterglow time after the fifth flame application

Values in seconds

Parameter	Material					
	PBT(1)	PBT(2)	PA	PPO	PC	UP
Average	9,1	9,4	1,5	10,3	2,2	8,3
Repeatability	5,2	2,7	0,9	11,6	1,8	5,0
Reproducibility	16,5	17,0	2,5	16,6	2,8	14,4

Annex A
(normative)

Procedure for calibration of a 125 mm test flame

A.1 Principle

A 125-mm-high test flame with a 40-mm-high inner blue cone is obtained with a gas supplied at a given pressure and flow rate. A thermal sensor is then positioned over the flame, and the time required for the temperature of the sensor to increase from 100 °C to 700 °C is determined. This time is used to confirm the heat evolution profile of the test flame.

A.2 Significance of the test

A.2.1 The flame height and colour (indicative of the air-to-gas ratio) for a test flame have traditionally been specified in the individual test method.

The energy content of the flame is known by reference to a specific supply gas. It has been shown that the supply gas pressure and flow rate can be varied without affecting the height and colour of the flame, however, they do affect the energy content of the flame. This procedure specifies the pressure and flow rate of the supply gas and provides a calibration procedure for confirming the heat flux profile of the test flame.

A.2.2 Information is provided for the test flame using methane, propane or butane. Using this information, these supply gases can be used interchangeably with a standardized burner to produce essentially the same flame.

A.3 Apparatus

A.3.1 Laboratory fume hood (cupboard), having an inside volume of at least 0,5 m^3, with a door that can be completely closed. The enclosure shall permit observation and shall be draught-free while permitting normal thermal circulation of air past the thermal sensor.

A.3.2 Laboratory burner, as specified in ISO 10093 as ignition source P/PF2, having a barrel length of 90 mm to 100 mm and an inside diameter of (9,5 ± 0,3) mm. The barrel shall not be equipped with an end-attachment, such as a stabilizer. (See also notes 3 and 4 in 6.2.)

In case of dispute, use the ignition source P/PF2 as described in ISO 10093.

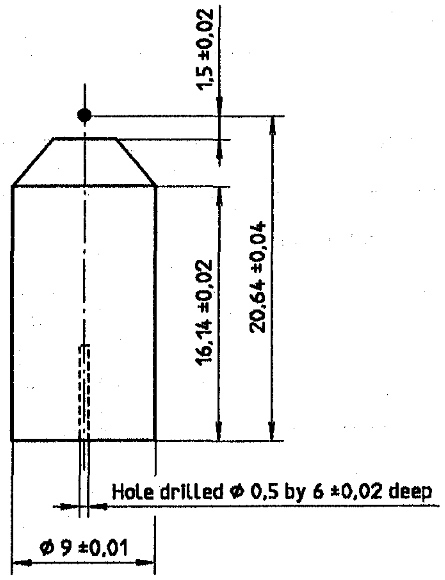
A.3.3 Manometer and gas flow meter, calibrated for the gas being used, and capable of being read to the values given in table A.1.

Table A.1 — Gas sources

Gas	Heat content MJ/m^3	Flow rate ml/min	Pressure mmH_2O
Methane[1]	37	965	100
Propane	94	380	450
Butane	120	300	500

[1] Natural gas having a heat content of 37 MJ/m^3 has been found to provide similar results.

Dimensions in millimetres



Material: High-conductivity copper
Mass (10 ± 0,05) g
Polished all over

Figure A.1 — Thermal sensor

A.3.4 Thermal sensor, comprising a copper slug, 9 mm in diameter, with an overall length of 20 mm, having a 4-mm-long conical section at the tip so that the diameter is reduced from 9 mm to 3 mm (see figure A.1). A Type K 0,089-mm-diameter thermocouple with protective 38 AWG stainless-steel sheathing of 0,5 mm diameter should be peened into the top of the block to a depth of 6 mm (see figure A.2).

A.3.5 Temperature indicator, to determine the temperature of Type K thermocouples.

A.3.6 Ring stand, with clamps or the equivalent, adjustable for positioning the specimen.

A.3.7 Stop-watch, accurate to 1 s.

A.3.8 Gas supply, of methane, propane or butane.

A.3.8.1 Methane, technical-grade, 98 % minimum purity, having a heat content of 37 MJ/m^3.

NOTE 8 Natural gas having a heat content of 37 MJ/m^3 has been found to provide similar results.

A.3.8.2 Propane, natural grade, 96 % minimum purity, having a heat content of 94 MJ/m^3.

A.3.8.3 Butane, chemically pure grade, 99 % minimum purity, having a heat content of 120 MJ/m^3.

Dimensions in millimetres

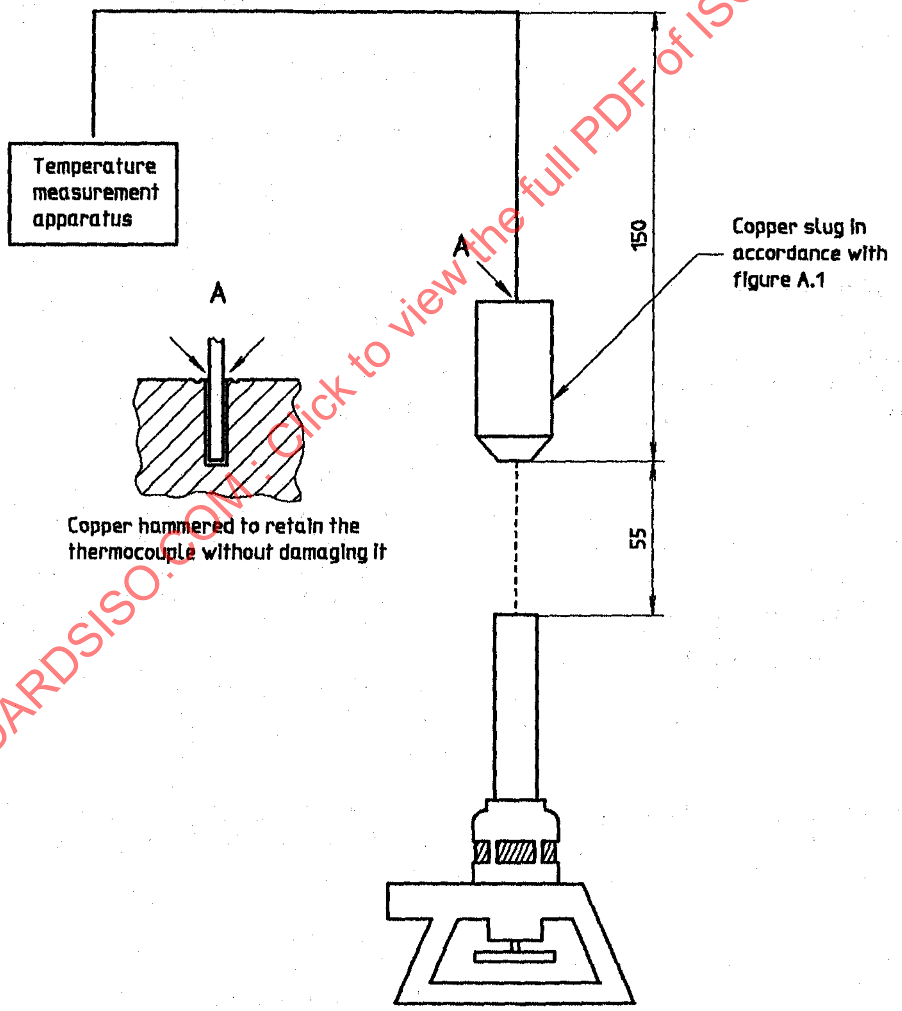


Figure A.2 — Arrangement to check the temperature of the flame

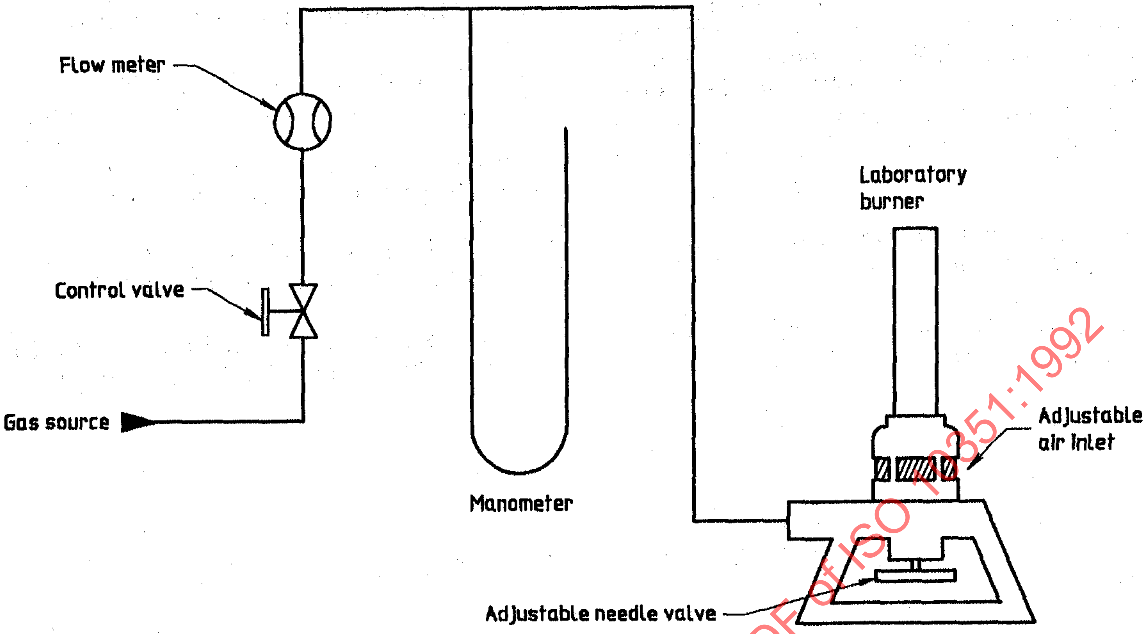


Figure A.3 — Burner supply arrangement

A.4 Calibration procedure

A.4.1 Place the burner (A.3.2) in the laboratory fume hood (A.3.1). Connect the burner to the gas supply (A.3.8), in line with a control valve, flow meter and manometer (A.3.3). (See figure A.3.)

A.4.2 Connect the leads of the Type K thermocouple (see A.3.4) to the temperature indicator (A.3.5).

A.4.3 Clamp the thermocouple sheath above the burner, along its central axis, so that the copper slug (A.3.4) is suspended 75 mm from the clamp. Position the slug 55 mm from the top of the burner (see figure A.2).

A.4.4 Move the burner away from the copper slug to ensure there is no influence of the flame on the slug during preliminary adjustment of gas and air flows.

A.4.5 Ignite the flame and adjust the gas flow rate and pressure as specified in table A.1. Adjust the needle valve and air ports of the burner until the overall height of the flame is 125 mm and the height of the inner blue cone is 40 mm, when viewed in subdued light.

A.4.6 Allow the burner to operate for 5 min to stabilize the working temperature.

A.4.7 The initial temperature of the copper slug shall be (23 ± 2) °C.

A.4.8 Reposition the burner under the thermal sensor. Start the stop-watch (A.3.7) when the temperature of the copper slug reaches 100 °C, and stop it when the temperature reaches 700 °C. Record this time. Remove the burner and allow the copper slug to cool naturally in air to (23 ± 2) °C.

A.4.9 If the thermal sensor has not been used before, conduct a preliminary run to condition the surface of the copper slug. Discard this first result.

A.4.10 Repeat the heating procedure (A.4.8) two additional times, and report the average of the three determinations.

A.5 Calibration

A.5.1 The time to raise the temperature of the thermal sensor from 100 °C to 700 °C by the 500 W flame shall be (54 ± 2) s.