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Reaction to fire tests for products — Non-combustibility test

Essais de réaction au feu de produits — Essai d'incombustibilité

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Foreword

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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 1182 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 1, *Fire initiation and growth*.

This fifth edition cancels and replaces the fourth edition (ISO 1182:2002), which has been technically revised.

Introduction

This fire test has been developed for use by those responsible for the selection of construction products which, whilst not completely inert, produce only a very limited amount of heat and flame when exposed to temperatures of approximately 750 °C.

The limitation of the field of application to testing homogeneous products and substantial components of non-homogeneous products was introduced because of problems in defining specifications for the specimens. The design of the specimen of non-homogeneous products strongly influences the test results, which is the reason non-homogeneous products cannot be tested to this International Standard.

Reaction to fire tests for products — Non-combustibility test

SAFETY PRECAUTIONS — The attention of all persons concerned with managing and carrying out this test is drawn to the fact that fire testing can be hazardous and that there is a possibility that toxic, harmful smoke and gases can be evolved during the test. Operational hazards can also arise during the testing of specimens and the disposal of test residues.

An assessment of all potential hazards and risks to health should be made and safety precautions should be identified and provided. Written safety instructions should be issued. Appropriate training should be given to relevant personnel. Laboratory personnel should ensure that they follow written safety instructions at all times.

1 Scope

This International Standard specifies a method of test for determining the non-combustibility performance, under specified conditions, of homogeneous products and substantial components of non-homogeneous products.

Information on the precision of the test method is given in Annex A.

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 13943, *Fire safety — Vocabulary*

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

EN 13238, *Reaction to fire tests for building products — Conditioning procedures and general rules for selection of substrates*

3 Terms and definitions

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

3.1
product
material, element or component about which information is required

3.2
material
single basic substance or uniformly dispersed mixture of substances

NOTE Examples of materials are metal, stone, timber, concrete, mineral wool with uniformly dispersed binder and polymers.

3.3
loose fill material
material without any physical shape

3.4
homogeneous product
product, consisting of a single material, having uniform density and composition throughout

3.5
non-homogeneous product
product, composed of more than one component, substantial or non-substantial, not having uniform density and composition throughout

3.6
substantial component
material that constitutes a significant part of a non-homogeneous product and that has a mass/unit area $> 1{,}0 \text{ kg/m}^2$ or a thickness $\geqslant 1{,}0$ mm

3.7
non-substantial component
material that does not constitute a significant part of a non-homogeneous product and that has a mass/unit area $< 1{,}0 \text{ kg/m}^2$ and a thickness $< 1{,}0$ mm

3.8
sustained flaming
persistence of flame at any part of the visible part of the specimen lasting 5 s or longer

NOTE Steady blue-coloured luminous gas zones should not be regarded as flaming. Such gas zones should only be noted under "observations during test" in the test report.

4 Apparatus

4.1 General

The test apparatus shall be capable of creating the conditions specified in 7.1. A typical design of furnace is given in Annex B; other designs of furnace may be used.

NOTE 1 All dimensions given in the description of the test apparatus are nominal values, unless tolerances are specified.

The apparatus shall consist of a furnace comprising essentially a refractory tube surrounded by a heating coil and enclosed in an insulated surround. A cone-shaped airflow stabilizer shall be attached to the base of the furnace and a draught shield to its top.

The furnace shall be mounted on a stand and shall be equipped with a specimen holder and a device for inserting the specimen-holder into the furnace tube.

Thermocouples, as specified in 4.4, shall be provided for measuring the furnace temperature and the furnace wall temperature. The thermal sensor, as specified in 4.5, shall be provided for measuring the furnace temperature along its central axis.

NOTE 2 Annex C gives details of additional thermocouples to be used if the specimen surface temperature and the specimen centre temperature are required.

4.2 Furnace, draught shield and stand

4.2.1 Furnace tube, made of an alumina refractory material as specified in Table 1, of density (2 800 ± 300) kg/m^3. It shall be (150 ± 1) mm high with an internal diameter of (75 ± 1) mm and a wall thickness of (10 ± 1) mm.

Table 1 — Composition of the furnace tube refractory material

Material	Composition % (kg/kg mass)
Alumina (Al_2O_3)	> 89
Silica and alumina (SiO_2, Al_2O_3)	> 98
Ferric oxide (Fe_2O)	< 0,45
Titanium dioxide (TiO_2)	< 0,25
Manganese oxide (Mn_3O_4)	< 0,1
Other trace oxides (sodium, potassium, calcium and magnesium oxides)	The balance

The furnace tube shall be fitted in the centre of a surround made of insulating material 150 mm in height and of 10 mm wall thickness, and fitted with top and bottom plates recessed internally to locate the ends of the furnace tube. The annular space between the tubes shall be filled with a suitable insulating material.

NOTE 1 An example of a typical furnace tube design is given in B.2.

An open-ended cone-shaped airflow stabilizer shall be attached to the underside of the furnace. The stabilizer shall be 500 mm in length, and reduce uniformly from 75 ± 1 mm internal diameter at the top to 10 ± 0,5 mm at the bottom. The stabilizer shall be manufactured from 1 mm-thick sheet steel, with a smooth finish on the inside. The joint between the stabilizer and the furnace shall be a close, airtight fit, with a smooth finish internally. The upper half of the stabilizer shall be insulated externally with a suitable insulating material.

NOTE 2 An example of suitable insulating material is given in B.3.

4.2.2 Draught shield, made of the same material as the stabilizer cone, and provided at the top of the furnace. It shall be 50 mm high and have an internal diameter of (75 ± 1) mm. The draught shield and its joint with the top of the furnace shall have a smooth finish internally, and the exterior shall be insulated with a suitable insulating material.

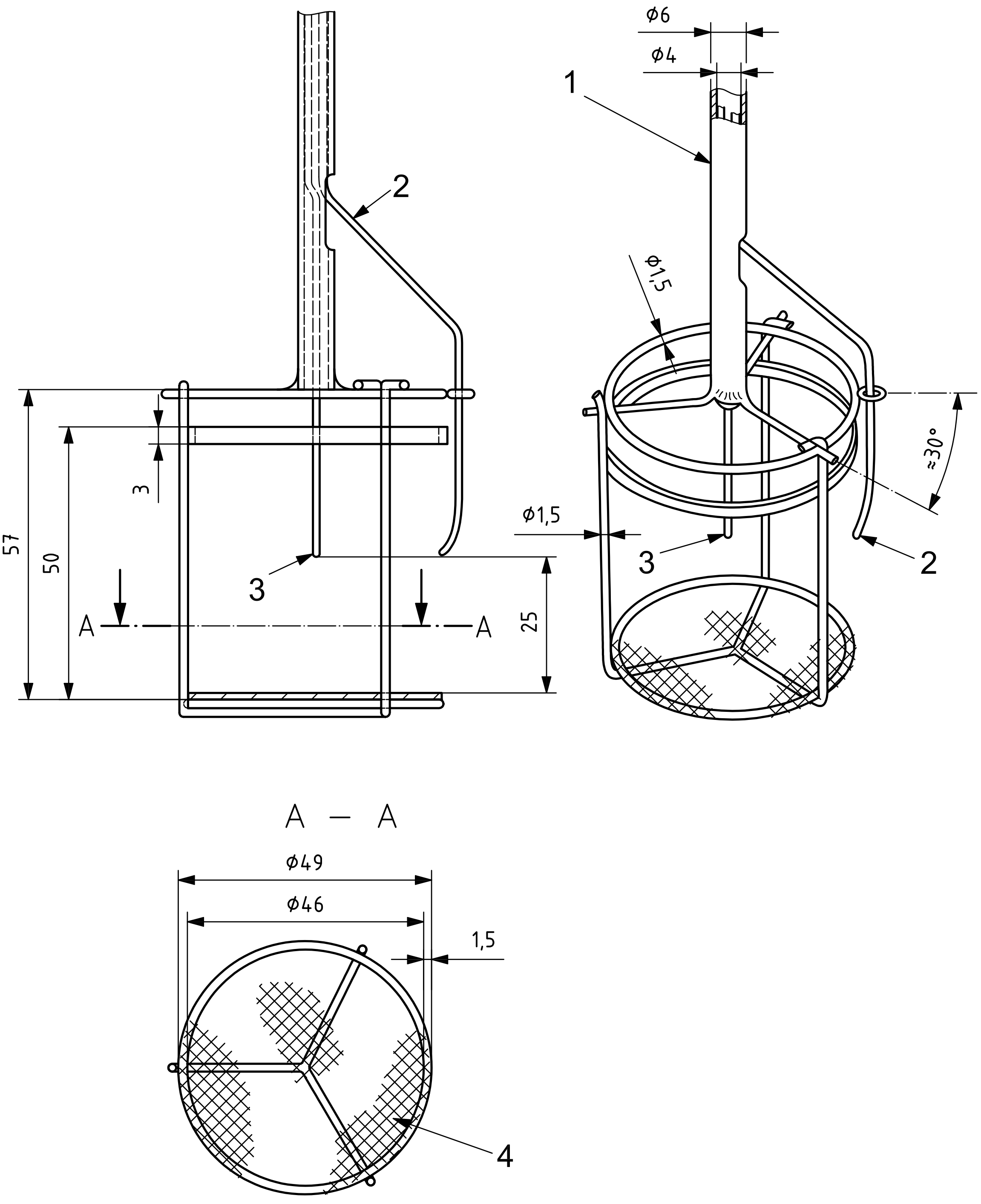
NOTE An example of suitable insulating material is given in B.4.

4.2.3 Stand, firm and horizontal, on which the assembly of the furnace, stabilizer cone and draught shield are mounted. There shall be a base and draught screen attached to the stand to reduce draughts around the bottom of the stabilizer cone. The draught screen shall be 550 mm high and the bottom of the stabilizer cone shall be 250 mm above the base plate.

4.3 Specimen holder and insertion device

4.3.1 Specimen holder, as specified in Figure 1 and made of nickel/chromium or heat-resisting steel wire. A fine metal gauze tray of heat-resisting steel shall be placed in the bottom of the holder. The mass of the holder shall be (15 ± 2) g.

Dimensions in millimetres



Key

1 stainless steel tube

2 specimen surface thermocouple

3 specimen centre thermocouple

4 aperture mesh 0,9 mm diameter of wire 0,4 mm

Figure 1 — Specimen holder

The specimen holder shall be capable of being suspended from the lower end of a tube of stainless steel having an outside diameter of 6 mm and a bore of 4 mm.

4.3.2 Insertion device, suitable for lowering the specimen holder precisely down the axis of the furnace tube smoothly and carefully, such that the geometric centre of the specimen is located rigidly at the geometric centre of the furnace during the test. The insertion device shall consist of a metallic sliding rod moving freely within a vertical guide fitted to the side of the furnace.

The specimen holder for loose fill materials shall be cylindrical and of the same outer dimensions as the specimen (see 5.1), and made of a fine metal wire gauze of heat-resisting steel similar to the wire gauze used at the bottom of the normal holder specified in 4.3.1. The specimen holder shall have an open end at the top. The mass of the holder shall not exceed 30 g.

4.4 Thermocouples, with a wire diameter of 0,3 mm and an outer diameter of 1,5 mm. The hot junction shall be insulated and not earthed. The thermocouples shall be of either type K or type N. They shall be of tolerance class 1 in accordance with IEC 60584-2. The sheathing material shall be either stainless steel or a nickel based alloy. All new thermocouples shall be artificially aged before use to reduce reflectivity.

NOTE A suitable method of ageing is to run a test without any test specimen inserted for 1 h.

The furnace thermocouple shall be located with its hot junction (10 ± 0,5) mm from the tube wall and at a height corresponding to the geometric centre of the furnace tube (see Figure 2). The correct position of the thermocouple shall be maintained with the help of a guide attached to the draught shield.

The position of the thermocouple shall be set using the locating guide illustrated in Figure 3. The length of the furnace thermocouple outside the guide shall be 40 ± 5 mm.

The furnace thermocouple shall be initially calibrated at 750 °C. Any correction term received at the calibration shall be added to the output.

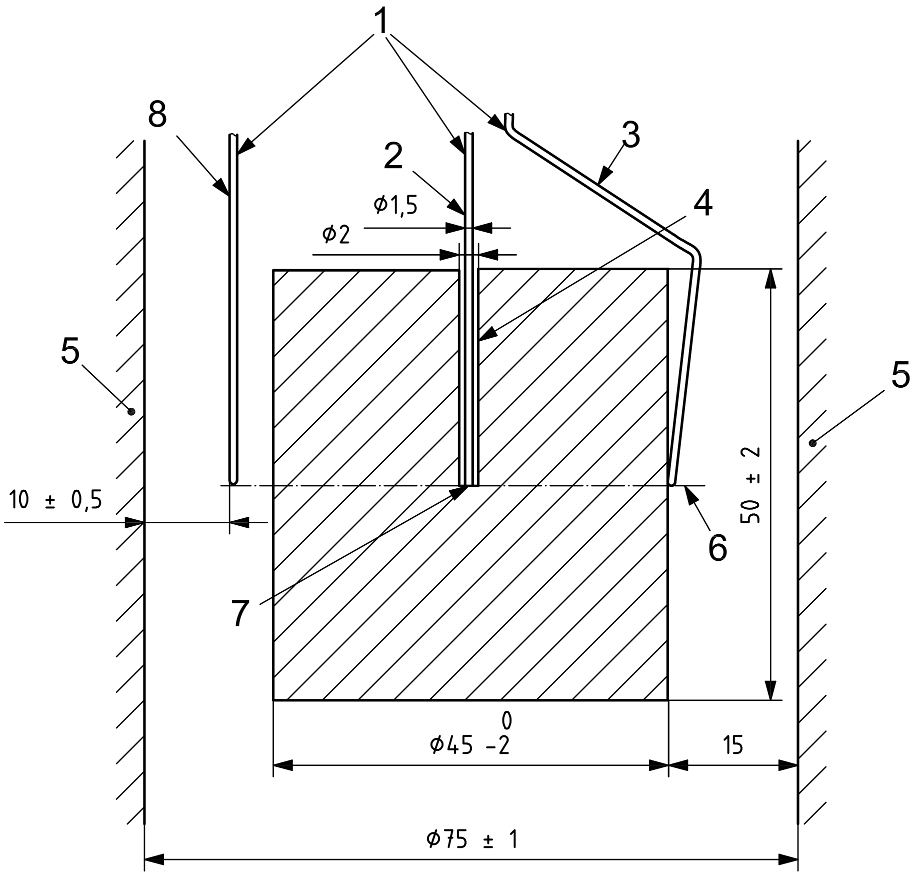
The furnace thermocouple shall be replaced after 200 test runs.

The additional two thermocouples for measurements of specimen centre and surface temperature should be controlled at 100 °C. Details of any additional thermocouples required and their positioning are given in Annex C. The use of these two thermocouples is optional.

4.5 Thermal sensor, made of a thermocouple of the type specified in 4.4, brazed to a copper cylinder of diameter (10 ± 0,2) mm and height (15 ± 0,2) mm. The hot junction shall be at the geometrical centre of the copper cylinder

4.6 Contact thermocouple, made of a thermocouple of the type specified in 4.4. The thermocouple shall be curved according to Figure 4.

Dimensions in millimetres



Key

1 sheathed thermocouples

2 specimen centre thermocouple

3 specimen surface thermocouple

4 2 mm diameter hole

5 furnace wall

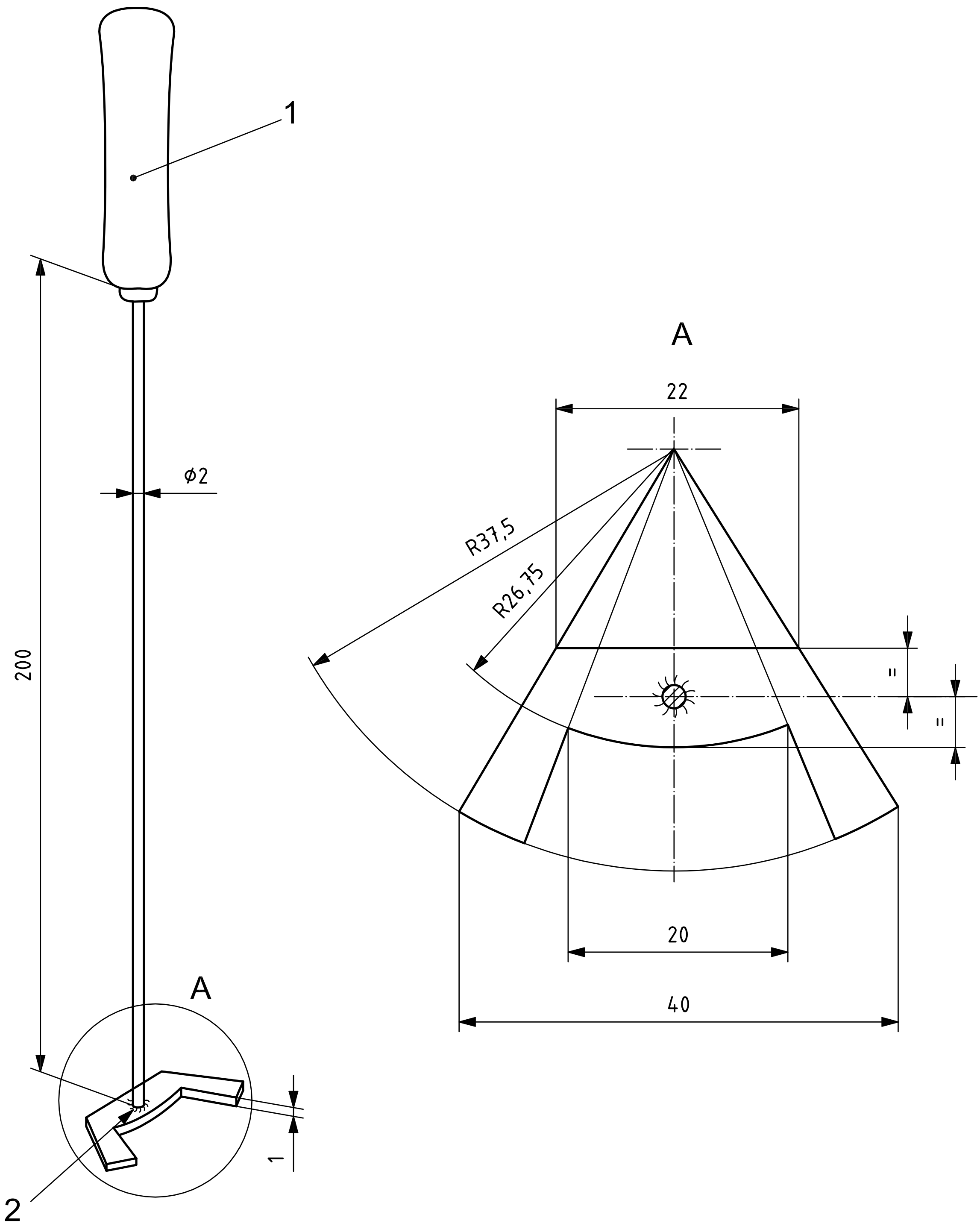
6 mid-height of constant temperature zone

7 contact between thermocouple and material

8 furnace thermocouple

Figure 2 — Relative position of furnace, specimen and thermocouple

Dimensions in millimetres



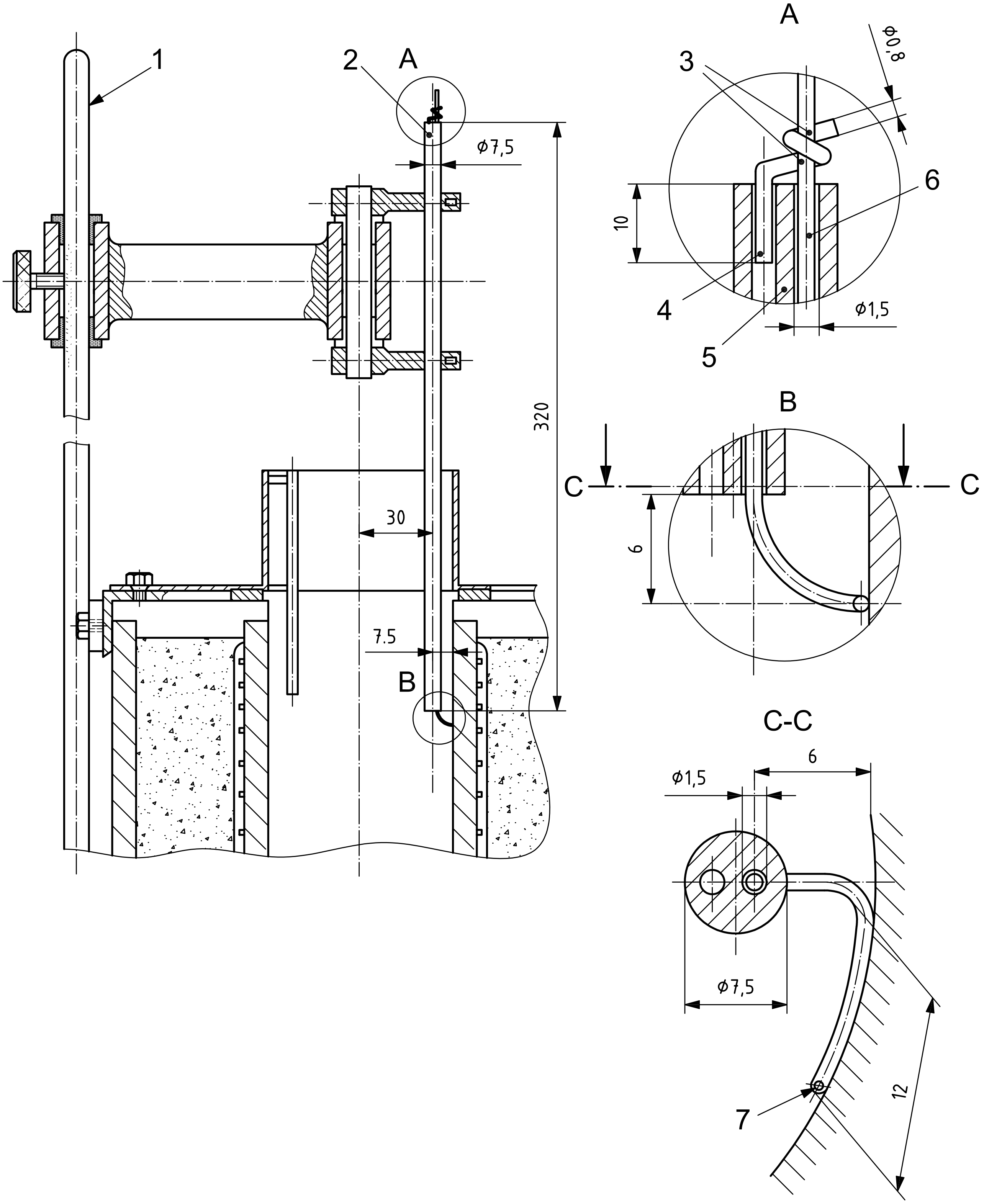
Key

1 wooden handle

2 weld

Figure 3 — A typical locating guide

Dimensions in millimetres



Key

1 heat resisting steel rod
2 thermocouple sheath porcelain alumina
3 silver soldered
4 steel wire
5 ceramic tube
6 shielded thermocouple
7 hot junction

Figure 4 — Typical contact thermocouple and support

4.7 Mirror, provided above the apparatus, positioned such that it does not affect the test, to facilitate observation of sustained flaming and for the safety of the operator.

NOTE A mirror 300 mm square at an angle of 30° to the horizontal, 1 m above the furnace, has been found suitable.

4.8 Balance, with an accuracy of 0,01 g.

4.9 Voltage stabilizer, single-phase automatic, with a rating of not less than 1,5 kVA.

It shall be capable of maintaining the accuracy of the output voltage within ±1 % of the rated value from zero to full load.

4.10 Variable transformer, capable of handling at least 1,5 kVA and of regulating the voltage output from zero to a maximum value equal to that of the input voltage.

4.11 Electrical input monitor, consisting of an ammeter and voltmeter or wattmeter, to enable rapid setting of the furnace to approximately the operating temperature. Any of these instruments shall be capable of measuring the levels of electrical power specified in 7.2.3.

4.12 Power controller, for use as an alternative to the voltage stabilizer, variable transformer and electrical input monitor specified in 4.9, 4.10 and 4.11. It shall be of the type which incorporates phase-angle firing and shall be linked to a thyristor unit capable of supplying 1,5 kVA. The maximum voltage shall not be greater than 100 V and the current limit shall be adjusted to give “100 % power” equivalent to the maximum rating of the heater coil. The stability of the power controller shall be approximately 1,0 % and the set point repeatability shall be ± 1,0 %. The power output shall be linear over the set point range.

4.13 Temperature indicator and recorder, capable of measuring the output from the thermocouple to the nearest 1 °C or the millivolt equivalent. It shall be capable of producing a permanent record of this at intervals of not greater than 1 s.

NOTE A suitable instrument is either a digital device or a multirange chart recorder with an operating range of 10 mV full-scale deflection with a “zero” of approximately 700 °C.

4.14 Timing device, capable of recording elapsed time to the nearest second and accurate to within 1 s in 1 h.

4.15 Desiccator, for storing the conditioned specimens (see Clause 6).

5 Test specimen

5.1 General

The test specimen shall be taken from a sample which is sufficiently large to be representative of the product.

The test specimens shall be cylindrical and each shall have a volume of (76 ± 8) cm^3, a diameter of (45^{+0}_{-2}) mm and a height of (50 ± 3) mm.

5.2 Preparation

5.2.1 If the thickness of the material is different from (50 ± 3) mm, specimens of the height of (50 ± 3) mm shall be made by using a sufficient number of layers of the material or by adjustment of the material thickness.

5.2.2 The layers shall occupy a horizontal position in the specimen holder and shall be held together firmly, without significant compression, by means of two fine steel wires, of maximum diameter 0,5 mm, to prevent air gaps between layers. The specimens of loose fill materials shall be representative in appearance, density, etc. as in use.

5.2.2.1 When a specimen is composed of a number of layers, the overall density should be as close as possible to that of the product provided by the manufacturer.

5.2.2.2 Where it is possible for the component being tested to fray, any loose fibres shall be removed prior to test. However, the final dimensions of the test specimen shall be in accordance with this International Standard.

5.2.3 Where adhesives or other liquid-applied products are used in thicknesses where they can be classified as substantial components, the following procedure shall be used.

5.2.3.1 An initial single solid test specimen shall be cast in a plastic tube of the correct or appropriate diameter. This initial specimen shall be tested.

NOTE Some corrections for shrinkage can be required to give the required test specimen diameter (trial and error determines this).

5.2.3.2 If this initial test specimen behaves normally in the test, the remaining test specimens shall be made by this method and tested.

5.2.3.3 If the initial test specimen shows abnormal behaviour (such as spalling or explosive releases due to air pockets), the method of specimen preparation, as described in 5.2.3.4, shall be applied.

5.2.3.4 If the method of casting solid test specimens is not applicable, all five test specimens shall be built up from discs cut from sheets of the liquid-based adhesive (or other liquid applied product) cast at the maximum expected in-use thickness.

5.2.3.5 When the test specimens of this type are prepared with a hole on the central axis for measuring the temperature inside the test specimen (see Annex C), flammable gas can develop inside the hole and result in flaming. When testing liquid-based adhesives or other liquid-applied products, the tests in accordance with this International Standard should be performed without any additional optional temperature measurement.

5.3 Number

Five specimens shall be tested following the procedure given in 7.4.

NOTE Additional specimens can be tested as required for any classification system.

6 Conditioning

The test specimens shall be conditioned as specified in EN 13238. Afterwards, they shall be dried in a ventilated oven maintained at (60 ± 5) °C, for between 20 h and 24 h, and cooled to ambient temperature in a desiccator prior to testing. The mass of each specimen shall be determined to an accuracy of 0,01 g prior to test.

7 Test procedure

7.1 Test environment

The apparatus shall not be exposed to draughts, any form of strong direct sunlight or artificial illumination, which would adversely affect the observation of flaming inside the furnace. Surrounding areas should be prepared in such a way that they do not interfere with the observation.

The room temperature shall not change by more than 5 °C during a test.

7.2 Set-up procedure

7.2.1 Specimen holder

Remove the specimen holder (see 4.3) and its support from the furnace.

7.2.2 Thermocouple

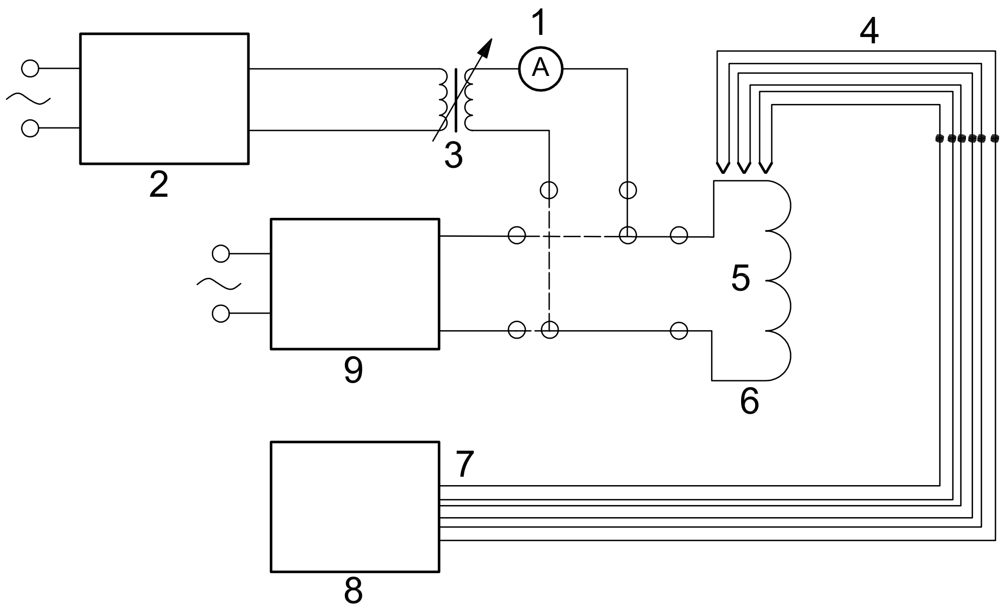
Position the furnace thermocouple as specified in 4.4, and position additional thermocouples, if required, as specified in 4.4 and Annex C. Connect all thermocouples to the temperature indicator (see 4.13) using compensating cables.

7.2.3 Electricity supply

Connect the heating element of the furnace either to the voltage stabilizer (see 4.9), variable transformer (see 4.10) and the electrical input monitor (see 4.11) or the power controller (see 4.12) as shown in Figure 5. Automatic thermostatic control of the furnace shall not be used during testing.

The heating element normally draws a current of between 9 A and 10 A at approximately 100 V under steady state conditions. In order not to overload the winding, it is recommended that the maximum current not exceed 11 A.

It is recommended that a new furnace tube be subjected to slow heating initially. A suitable procedure has been found to increase the furnace temperature in steps of approximately 200 °C, allowing 2 h heating at each temperature.



Key

1	ammeter	6	furnace winding
2	voltage stabilizer	7	compensating cable
3	variable transformer	8	temperature indicator
4	thermocouples	9	power controller
5	terminal blocks		

Figure 5 — Layout of apparatus and additional equipment

7.2.4 Furnace stabilization

Adjust the power input to the furnace such that the average furnace temperature, as indicated by the furnace thermocouple (see 4.4), is stabilized for at least 10 min at (750 ± 5) °C. The drift (linear regression) shall be not more than 2 °C during these 10 min and there shall be a maximum deviation from the average temperature of not more than 10 °C in 10 min (see Annex D).

Take a continuous record of the temperature.

7.3 Calibration procedure

7.3.1 Furnace wall temperature

7.3.1.1 When the furnace temperature is stabilized as given in 7.2.4, measure the temperature of the furnace wall using a contact thermocouple of the type specified in 4.6 and the temperature indicator specified in 4.13. Make measurements on three vertical axes of the furnace wall, such that the distances separating each of the axes are the same. Record the temperatures on each axis at a position corresponding to the mid-height point of the furnace tube and at positions both 30 mm above and 30 mm below the mid-height point.

Use the thermocouple scanning device with the thermocouple and insulating tubes described in Figure 4. Particular attention should be paid to the contact between thermocouple and furnace wall which, if poor, can lead to low temperature readings. At each measurement point the temperature recorded by the thermocouple shall be stable before a temperature reading is taken.

Nine temperature readings are obtained, $T_{i,j}$ (i = axis 1 to 3; j = level a to c for +30 mm, 0 mm and –30 mm), as indicated in Table 2.

Table 2 — Position of furnace wall temperature readings

Vertical axis	Level		
	a at 30 mm	b at 0 mm	c at –30 mm
1 (at 0°)	$T_{1,a}$	$T_{1,b}$	$T_{1,c}$
2 (at 120°)	$T_{2,a}$	$T_{2,b}$	$T_{2,c}$
3 (at 240°)	$T_{3,a}$	$T_{3,b}$	$T_{3,c}$

7.3.1.2 Calculate and record the arithmetic mean of the nine temperature readings recorded in 7.3.1.1 as the average furnace wall temperature, T_{avg}.

$$T_{avg} = \frac{T_{1,a} + T_{1,b} + T_{1,c} + T_{2,a} + T_{2,b} + T_{2,c} + T_{3,a} + T_{3,b} + T_{3,c}}{9} \quad (1)$$

Calculate the arithmetic means of the temperature readings on the three axes recorded in 7.3.1.1 as the three vertical axes average furnace wall temperatures.

$$T_{avg,axis1} = \frac{T_{1,a} + t_{1,b} + t_{1,c}}{3} \quad (2a)$$

$$T_{avg,axis2} = \frac{T_{2,a} + t_{2,b} + t_{2,c}}{3} \quad (2b)$$

$$T_{avg,axis3} = \frac{T_{3,a} + t_{3,b} + t_{3,c}}{3} \quad (2c)$$

Calculate the absolute percentage value of the deviations of the temperature on the three axes from the average furnace wall temperature.

$$T_{\text{dev,axis1}} = 100 \times \frac{\left|T_{\text{avg}} - T_{\text{avg,axis1}}\right|}{T_{\text{avg}}} \qquad (3a)$$

$$T_{\text{dev,axis2}} = 100 \times \frac{\left|T_{\text{avg}} - T_{\text{avg,axis2}}\right|}{T_{\text{avg}}} \qquad (3b)$$

$$T_{\text{dev,axis3}} = 100 \times \frac{\left|T_{\text{avg}} - T_{\text{avg,axis3}}\right|}{T_{\text{avg}}} \qquad (3c)$$

Calculate and record the average deviation (arithmetic mean) of the average temperature on each the three axes and the average furnace wall temperature.

$$T_{\text{avg,dev,axis}} = \frac{T_{\text{dev,axis1}} + T_{\text{dev,axis2}} + T_{\text{dev,axis3}}}{3} \qquad (4)$$

Calculate the arithmetic means of the temperature readings on the three levels recorded in 7.3.1 as the three level average furnace wall temperatures.

$$T_{\text{avg,levela}} = \frac{T_{1,\text{a}} + t_{2,\text{a}} + t_{3,\text{a}}}{3} \qquad (5a)$$

$$T_{\text{avg,levelb}} = \frac{T_{1,\text{b}} + t_{2,\text{b}} + t_{3,\text{b}}}{3} \qquad (5b)$$

$$T_{\text{avg,levelc}} = \frac{T_{1,\text{c}} + t_{2,\text{c}} + t_{3,\text{c}}}{3} \qquad (5c)$$

Calculate the absolute percentage value of the deviations of the temperature on the three levels from the average furnace wall temperature.

$$T_{\text{dev,levela}} = 100 \times \left|\frac{T_{\text{avg}} - T_{\text{avg,levela}}}{T_{\text{avg}}}\right| \qquad (6a)$$

$$T_{\text{dev,levelb}} = 100 \times \left|\frac{T_{\text{avg}} - T_{\text{avg,levelb}}}{T_{\text{avg}}}\right| \qquad (6b)$$

$$T_{\text{dev,levelc}} = 100 \times \left|\frac{T_{\text{avg}} - T_{\text{avg,levelc}}}{T_{\text{avg}}}\right| \qquad (6c)$$

Calculate and record the average deviation (arithmetic mean) of the average temperature on each of the three levels and the average furnace wall temperature.

$$T_{\text{avg,dev,level}} = \frac{T_{\text{dev,levela}} + T_{\text{dev,levelb}} + T_{\text{dev,levelc}}}{3} \qquad (7)$$

The average deviation of the temperature on the three vertical axes from the average furnace wall temperature $T_{\text{avg,dev,axis}}$ (4) shall be less than 0,5 %.

The average deviation of the temperature on the three levels from the average furnace wall temperature $T_{avg,dev,level}$ (7) shall be less than 1,5 %.

7.3.1.3 The average wall temperature at level (+30 mm) $T_{avg,levela}$ (5a) shall be less than the average wall temperature at level (–30 mm), $T_{avg,levelc}$ (5c).

7.3.2 Furnace temperature

7.3.2.1 When the furnace temperature is stabilized, as given in 7.2.4, and when the furnace wall temperature is as given in 7.3.1, measure the temperature of the furnace along its central axis using the thermal sensor specified in 4.5 and the temperature indicator specified in 4.13. The following procedure shall be achieved using a suitable positioning device to locate precisely the thermal sensor. The reference for the vertical positioning shall be the top surface of the copper cylinder of the thermal sensor when mounted in the furnace.

Record the temperature of the furnace along its central axis at a position corresponding to the mid-height point of the furnace tube.

From this position, move the thermal sensor downwards in steps of maximum 10 mm until the bottom of the furnace tube is reached and record the temperature at each position once it has stabilized.

Move the thermal sensor from the lowest position upwards in steps of maximum 10 mm until the top of the furnace is reached and record the temperature in each position once it has stabilized.

From the top of the furnace move the thermal sensor downwards in 10 mm steps until the midpoint of the furnace is reached and record the temperature in each position once it has stabilized.

The temperature should be allowed to stabilize for 5 min at each measuring point.

For each position, two temperatures are recorded, one going upwards and one downwards. Report the arithmetic mean of these temperature records with distance.

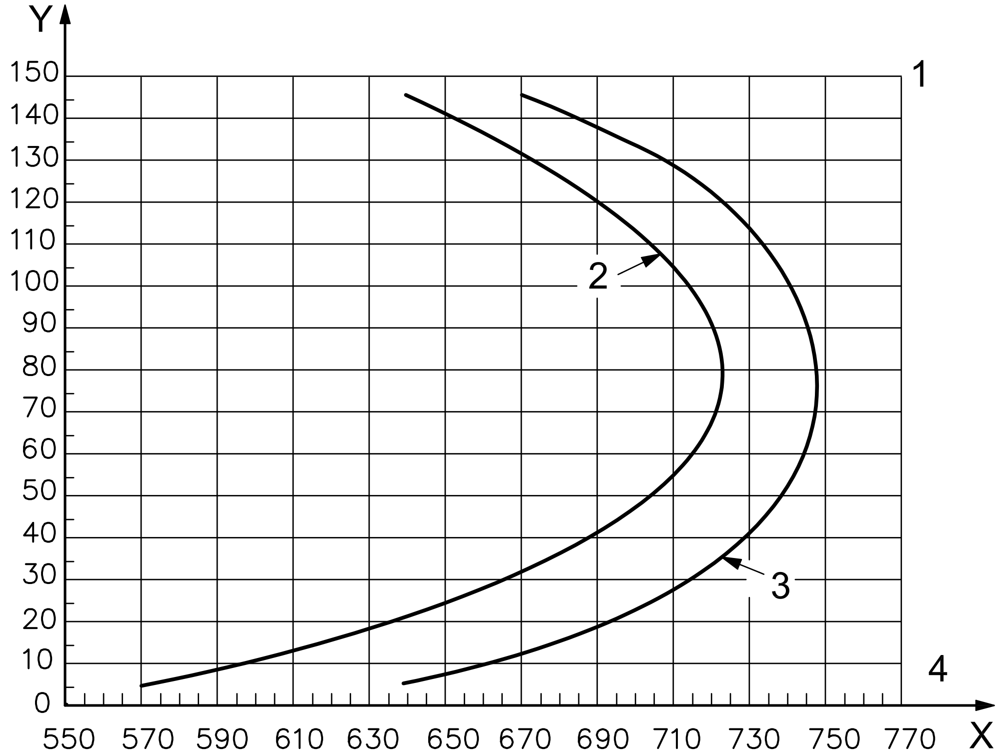
7.3.2.2 The calculated mean temperature at each level used shall be inside the limits specified as follows (see Figure 6):

$$T_{min} = 541,653 + (5,901 \times h_{furn}) - (0,067 \times h_{furn}^2) + (3,375 \times 10^{-4} \times h_{furn}^3) - (8,553 \times 10^{-7} \times h_{furn}^4) \quad (8)$$

$$T_{max} = 613,906 + (5,333 \times h_{furn}) - (0,081 \times h_{furn}^2) + (5,779 \times 10^{-4} \times h_{furn}^3) - (1,767 \times 10^{-6} \times h_{furn}^4) \quad (9)$$

where h_{furn} is the furnace height in mm and h_{furn} = 0 mm corresponds to the bottom of the furnace.

The values in Figure 6 are given in Table 3.



Key

X temperature, T (°C)

Y furnace height, h_{furn} (mm)

1 top of the furnace

2 lower limit, T_{min}

3 upper limit, T_{max}

4 bottom of the furnace

Figure 6 — Furnace temperature profile along its central axis measured with the thermal sensor

Table 3 — Furnace temperature profile values

Furnace height, h_{furn} mm	T_{min} °C	T_{max} °C
145	639	671
135	664	698
125	683	716
115	698	729
105	709	737
95	717	743
85	722	746
75	723	747
65	720	746
55	712	743
45	699	736
35	679	724
25	652	705
15	616	678
5	570	639

7.3.3 Procedure frequency

The procedures given in 7.3.1 and 7.3.2 shall be carried out for a new furnace and whenever the furnace tube, winding, insulation or power supply is replaced.

7.4 Standard test procedure

7.4.1 Stabilize the furnace as described in 7.2.4.

If the recorder used does not allow a real-time calculation, the temperature stabilization shall be checked afterwards. If the conditions specified in 7.2.4 are not satisfied, the test shall be repeated.

7.4.2 Before starting the test, ascertain that the whole equipment is in good working order, for example, that the stabilizer is clean, the specimen insertion device is working smoothly and the specimen holder exactly occupies the required position in the furnace.

7.4.3 Insert one specimen prepared and conditioned as specified in Clause 6 into the specimen holder (4.3) suspended on its support.

7.4.4 Place the specimen holder in the furnace in the position specified in 4.3.2, taking not more than 5 s for this operation.

7.4.5 Start the timing device (4.14) immediately following the insertion of the specimen into the furnace.

7.4.6 Record throughout the test the temperature measured by the furnace thermocouple (4.4) and, if required (see Annex C), the temperature measured by the surface thermocouple and centre thermocouple (4.4). The temperature measured by the furnace thermocouple shall be corrected according to the calibration (see 4.4).

7.4.7 Carry out the test for a period of 30 min.

If final temperature equilibrium, which is achieved when the temperature drift (linear regression) as measured by the furnace thermocouple does not exceed 2 °C over a period of 10 min, has been reached by the thermocouple at this time (30 min), the test shall be stopped. If final temperature equilibrium has not been reached by the thermocouple at 30 min, continue the test, checking for final temperature equilibrium at 5 min intervals thereafter. Stop the test once equilibrium is established by the thermocouple or after 60 min and note the duration of the test. Then remove the specimen from the furnace. The end of the test is the end of the final 5 min interval or 60 min (see Annex D).

If the recorder used does not allow for real-time calculation, the end recordings shall be checked after the test. If the requirements set out above are not satisfied, the test shall be repeated.

If additional thermocouples are used the test shall be stopped when final temperature equilibrium is achieved for all thermocouples used or after 60 min.

7.4.8 After cooling to ambient temperature in a desiccator, weigh the specimen. Recover any char, ash or other debris, which breaks off the specimen and falls down the tube, either during or following the test, and include this as a part of the unconsumed specimen.

7.4.9 Test all five specimens as given in 7.4.1 to 7.4.8.

7.5 Observations during test

7.5.1 Record the mass, in grams, before and after the test for each specimen tested according to 7.4, and note any observations relating to the behaviour of the specimen during the test.

7.5.2 Note the occurrence of any sustained flaming and record the duration of such flaming in seconds. Note the occurrence of any steady blue-coloured luminous gas zones.

7.5.3 Record the following temperatures, in degrees Celsius, as measured by the furnace thermocouple:

a) the initial temperature, T_i, which is the average temperature over the final 10 min of the stabilization period as defined in 7.2.4;

b) the maximum temperature, T_max, which is the discrete value at maximum temperature anywhere over the entire test period;

c) the final temperature, T_f, which is the average temperature over the final 1 min of the test period as defined in 7.4.7.

Examples of temperature recording are given in Annex D.

If additional thermocouples are used, record the temperatures as described in Annex C.

8 Expression of results

8.1 Mass loss

Calculate and record the mass loss, in per cent, for each of the five specimens, expressed as a percentage of the initial mass of the specimen, measured as specified in 7.5.1.

8.2 Flaming

Calculate and record the total duration of sustained flaming, in seconds, for each of the five specimens measured as specified in 7.5.2.

8.3 Temperature rise

Calculate and record the temperature rise, $\Delta T = T_{max} - T_f$, in degrees Celsius, for each of the five specimens recorded by the thermocouple as specified in 7.5.3.

9 Test report

The test report shall include, at a minimum, the following information. A clear distinction shall be made between the data provided by the sponsor and data determined by the test.

a) reference to this International Standard, i.e. ISO 1182 [see b)];

b) any deviation from the test method;

c) name and address of the testing laboratory;

d) date and identification number of the report;

e) name and address of the sponsor;

f) name and address of the manufacturer/supplier, if known;

g) date of sample arrival;

h) identification of the product;

i) description of the sampling procedure, where relevant;

j) general description of the product tested including density, mass per unit area and thickness, together with details of the construction of the product;

k) details of conditioning;

l) date of test;

m) calibration results, expressed in accordance with 7.3.1 and 7.3.2;

n) test results, expressed in accordance with Clause 8, also C.5, if additional thermocouples are used;

o) observations made during the test;

p) the statement: The test results relate to the behaviour of the test specimens of a product under the particular conditions of the test; they are not intended to be the sole criteria for assessing the potential fire hazard of the product in use.

Annex A
(informative)

Precision of test method

A round robin exercise was conducted by CEN/TC 127. The protocol used was functionally the same as described in this International Standard.

The products tested in this round robin were as described in Table A.1.

Table A.1 — Products included in the round robin exercise

Product	Density kg/m^3	Thickness mm
Glass wool	10,9	100
Stone wool	145	50
Calcium silicate board with cellulose	460	50,8
Wood fibre board	50	25
Gypsum fibre board (10 wt % – paper fibre)	1 100	25
FR cellulose loose fill	30	—
Mineral wool loose fill	30	—
Vermiculux[1)]	190	50,1
Polystyrene concrete board	50	25

Values of statistical means (m), standard deviation (S_r and S_R), repeatability (r) and reproducibility (R) at 95 % confidence level were calculated according to ISO 5725-2 (see Table A.2) for the three parameters: temperature increase (ΔT in degrees Celsius), mass loss (Δm in per cent) and flaming time (t_f in seconds). Such values for r and R are equal to 2,8 times the appropriate standard deviation. The values include results identified as "stragglers", but exclude results identified as "outliers".

Table A.2 — Statistical results of the round robin exercise

Parameter	Statistical mean m	Standard deviation S_r	Standard deviation S_R	r	R	S_r/m %	S_R/m %
ΔT (°C)	from 1,60 to 144,17	from 1,13 to 20,17	from 1,13 to 54,26	from 3,15 to 56,47	from 3,15 to 151,94	from 9,37 to 70,36	from 0,64 to 0,36
Δm (%)	from 2,12 to 90,13	from 0,25 to 1,68	from 0,33 to 3,06	from 0,71 to 4,70	from 0,93 to 8,57	from 0,55 to 29,6	from 1,33 to 29,62
t_f (s)	from 0,00 to 251,22	from 0,00 to 37,05	from 0,00 to 61,75	from 0,00 to 103,73	from 0,00 to 172,90	from 9,19 to 43,37	from 23,94 to 136,19

1) Vermiculux is an example of a suitable product available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of this product.

NOTE Percentage values become very high due to division by very low mean values.

It was possible for all the parameters to obtain linear models for S_r, S_R, r and R. The coefficients are presented in Table A.3. The graphic for ΔT is presented as an example in Figure A.1. For mass loss in per cent and flaming time in seconds, the results lead to models which are more or less meaningless, even if they are statistically correct. More complicated models than simple linear models could better fit to these parameters, but this was not considered in the round robin exercise.

Table A.3 — Statistical models of the round robin exercise

Parameter	S_r	S_R	r	R
ΔT (°C)	$= 1{,}26 + 0{,}10 \times \Delta T$	$= 0{,}96 + 0{,}26 \times \Delta T$	$= 3{,}53 + 0{,}29 \times \Delta T$	$= 2{,}68 + 0{,}73 \times \Delta T$
Δm (%)	$= 0{,}00 + 0{,}09 \times \Delta m$	$= 0{,}00 + 0{,}11 \times \Delta m$	$= 0{,}00 + 0{,}24 \times \Delta m$	$= 0{,}00 + 0{,}30 \times \Delta m$
t_f (s)	$= 0{,}00 + 0{,}14 \times t_f$	$= 0{,}00 + 0{,}32 \times t_f$	$= 0{,}00 + 0{,}38 \times t_f$	$= 0{,}00 + 0{,}89 \times t_f$

When the models correctly fit to the parameters, they can be a tool to "predict" a result. This can be illustrated by means of an example. Suppose a laboratory tests a single specimen of a given product and determines that the temperature increase, ΔT, is 25 °C. If the same laboratory conducts a second test on the same product, the value of r is evaluated as:

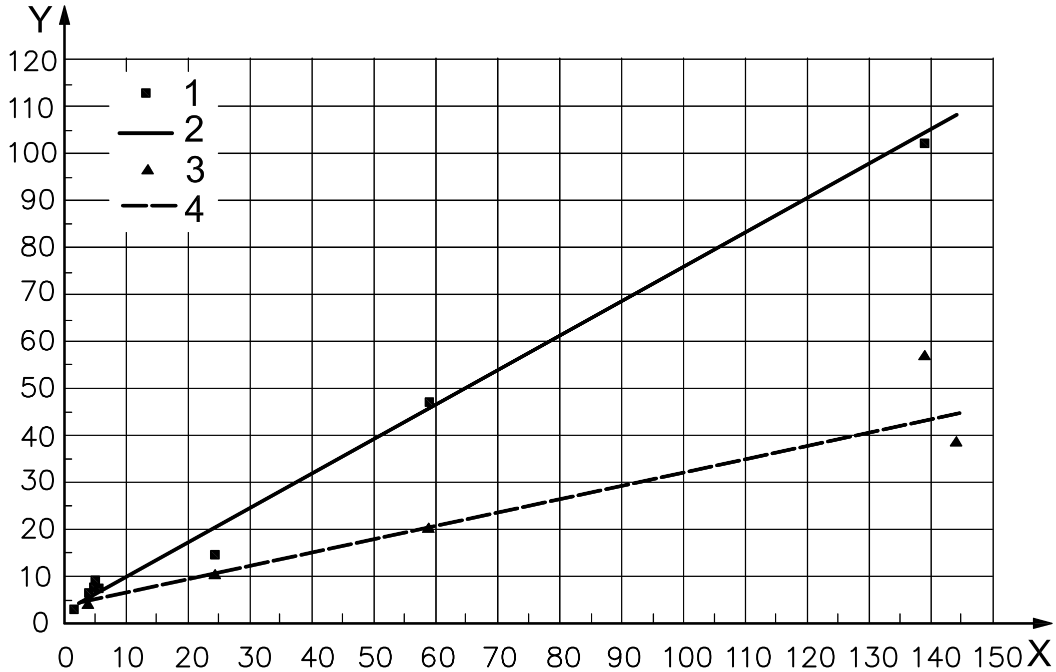
$$r = 3{,}53 + 0{,}29 \times 25 \approx 11\ °\text{C} \tag{A.1}$$

Then the probability is 95 % that the results of the second test fall between 14 °C and 36 °C.

Suppose that the same product is tested by a different laboratory. The value of R is evaluated as:

$$R = 2{,}68 + 0{,}73 \times 25 \approx 21\ °\text{C} \tag{A.2}$$

Then the probability is 95 % that the results from the test at that laboratory fall between 4 °C and 46 °C.



Key

Y ΔT

X estimated mean m

1 r

2 model r

3 R

4 model R

Figure A.1 — Statistical model for ΔT in degrees Celsius

Annex B
(informative)

Typical designs of test apparatus

B.1 General

A typical arrangement of the test apparatus is shown in Figure B.1.

B.2 Furnace tube

The furnace tube may be provided with a single winding of 80/20 nickel/chromium electrical resistance tape or wire, and may be wound as specified in Figure B.2. Grooves may be cut into the tube to allow accurate winding of the tape, at the discretion of the manufacturer.

The annular space between the tube and the external insulating wall may be filled with magnesium oxide powder of bulk density of (170 ± 30) kg/m^3.

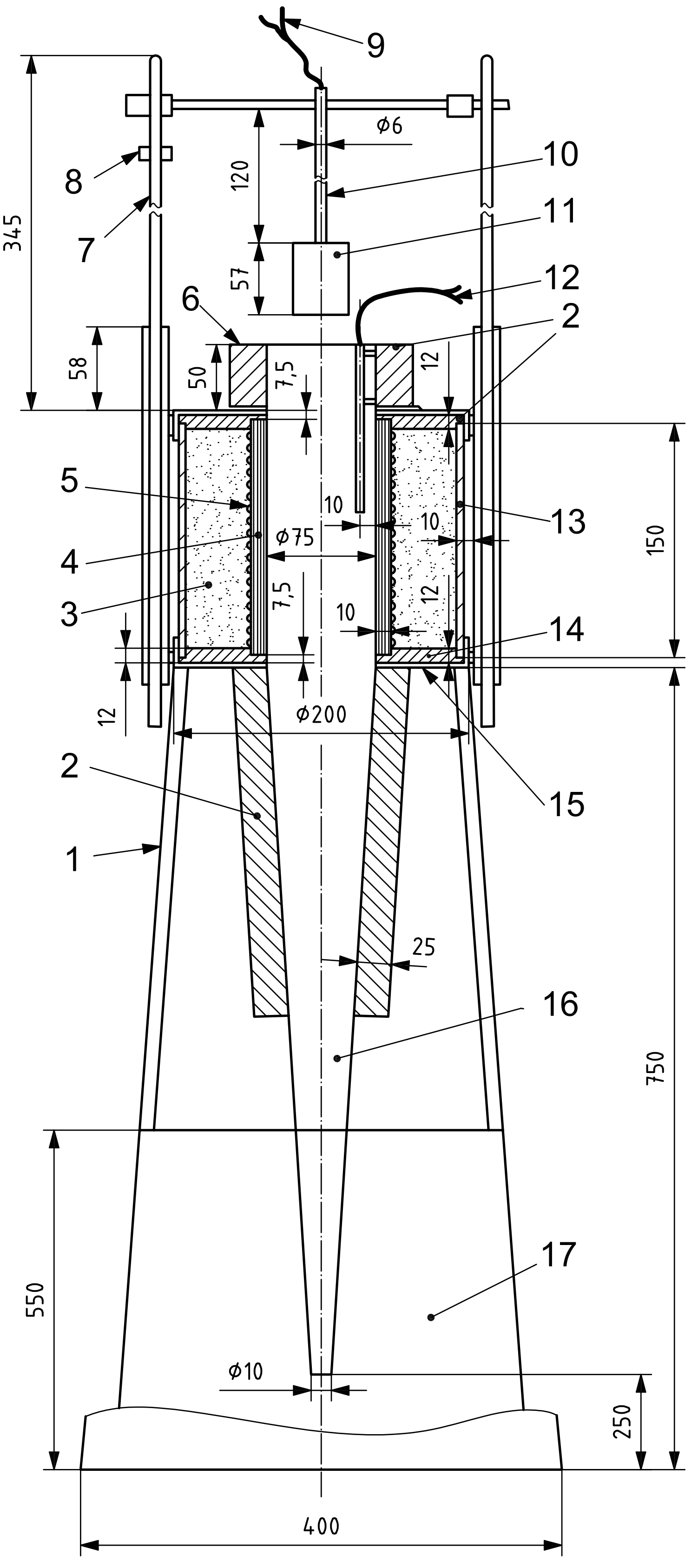
B.3 Airflow stabilizer

The upper half of the stabilizer may be insulated externally with a 25 mm thick layer of mineral fibre insulating material having a thermal conductivity of (0,04 ± 0,01) W/(m·K) at a mean temperature of 20 °C.

B.4 Draught shield

The exterior of the draught shield may be insulated with a 25 mm layer of mineral fibre insulation, having a thermal conductivity of (0,04 ± 0,01) W/(m·K) at a mean temperature of 20 °C.

Dimensions in millimetres

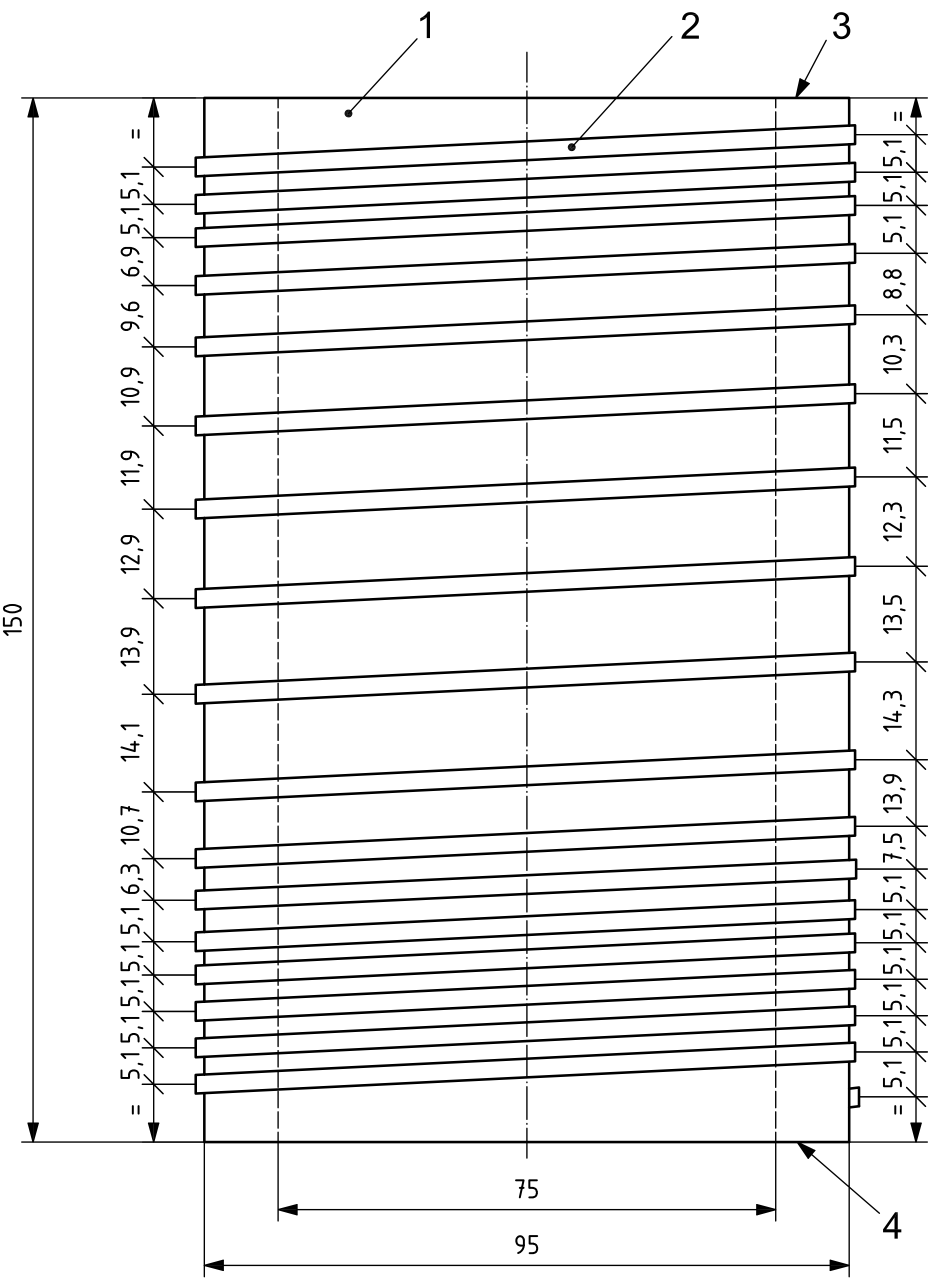


Key

1 stand
2 insulation
3 magnesium oxide powder
4 furnace tube
5 heating coils
6 draught shield
7 heat-resisting steel rod for insertion device
8 stop
9 specimen thermocouples (optional)
10 stainless steel tube
11 specimen holder
12 furnace thermocouple
13 external insulating wall
14 mineral fibre cement
15 seal
16 stabilizer cone
17 draught screen (metal sheet)

Figure B.1 — Typical arrangement of test apparatus

Dimensions in millimetres



Key

1 furnace tube

2 electrical resistance tape

3 top

4 bottom

Figure B.2 — Furnace windings

Annex C
(normative)

Thermocouples for additional measurements

C.1 General

In addition to the thermocouple for the measurement of furnace temperature and furnace wall temperature (4.1), if required, thermocouples shall also be provided for measurement of the temperature in the geometric centre of the specimen and on the surface of the specimen. Details of these two additional thermocouples and their use are given in C.2 to C.4.

C.2 Location of thermocouples

C.2.1 Specimen centre thermocouple

The specimen centre thermocouple shall be positioned such that its hot junction is located at the geometric centre of the specimen (see Figures 1 and 2). This shall be achieved by means of a hole of 2 mm in diameter made axially in the top of the test specimen.

C.2.2 Specimen surface thermocouple

The specimen surface thermocouple shall be positioned such that its hot junction is in contact with the specimen at mid-height of the specimen at the start of the test and shall be located diametrically opposite the furnace thermocouple (see Figures 1 and 2).

C.3 Test procedure

Carry out the test as described in Clause 7 and record the temperatures measured by both thermocouples throughout the test.

NOTE In some cases the specimen centre thermocouple provides no additional information and in such cases it need not be used. This can apply to materials which are thermally unstable.

C.4 Observations during the test

In addition to the observations required in 7.5, the following shall be recorded:

a) the maximum specimen centre thermocouple temperature, T_C (max);

b) the final specimen centre thermocouple temperature, T_C (final);

c) the maximum specimen surface thermocouple temperature, T_S (max);

d) the final specimen surface thermocouple temperature, T_S (final).

The maximum and final temperatures for the centre and surface thermocouples are defined in 7.5.3 for T_{max} and T_f, respectively.

C.5 Expression of results

The temperature rise, in degrees Celsius (°C), shall be calculated from the temperatures recorded by the two thermocouples for each specimen as follows:

a) specimen centre thermocouple:

$\Delta T_C = T_C$ (max) – T_c (final)

b) specimen surface thermocouple:

$\Delta T_S = T_S$ (max) – T_S (final)

Annex D
(informative)

Temperature recording

D.1 Initial temperature stabilization

D.1.1 The criteria defining the initial temperature stabilization are given in 7.2.4. The conditions, over 10 min, are:

a) an average temperature, T_{avg} = (750 ± 5) °C;

b) $|T - T_{avg}| \leqslant$ 10 °C;

c) a drift (linear regression) $\leqslant$ 2 °C.

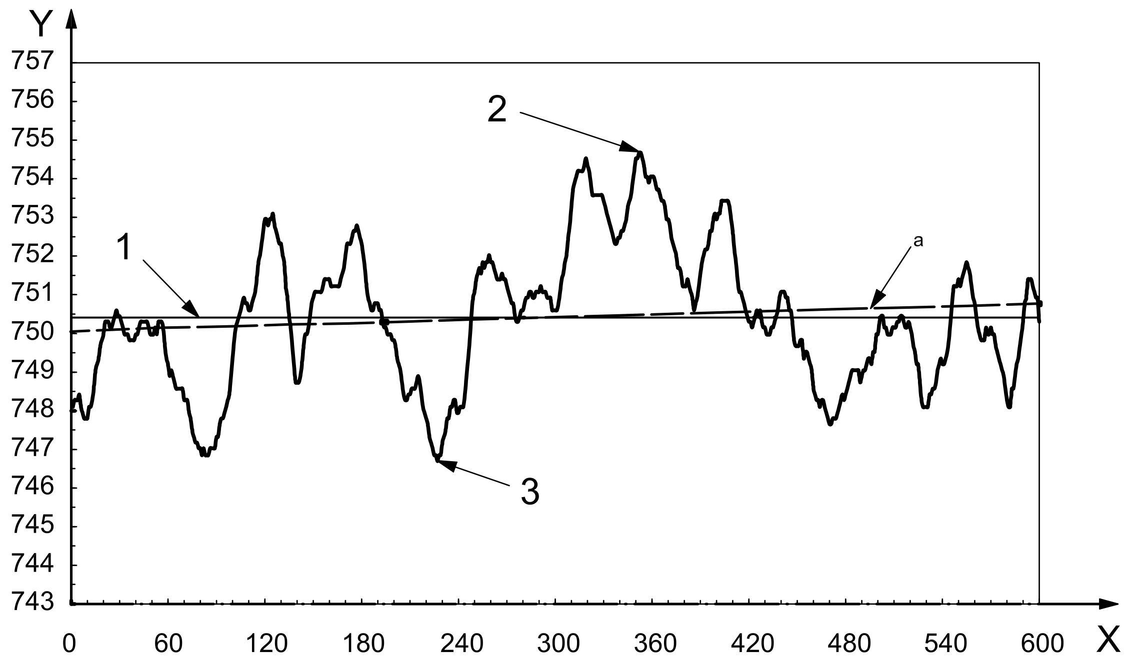
D.1.2 This is illustrated by the example presented in Figure D.1:

— average temperature: 750,4 °C;

— maximum deviation of the temperature = 4,3 °C;

— drift = 0,7 °C.

According to the definition of the initial temperature given in 7.5.3, T_i °C is equal to T_{avg}. This is illustrated by the example presented in Figure D.1: T_i = 750,4 °C.



Key

X time (s)

Y temperature (°C)

[a] Drift = 0,7 °C.

1 T_{avg} = 750,4 °C

2 T_{max} = 754,7 °C (354 s)

3 T_{min} = 746,7 °C (227 s)

Figure D.1 — Example of initial temperature stabilization

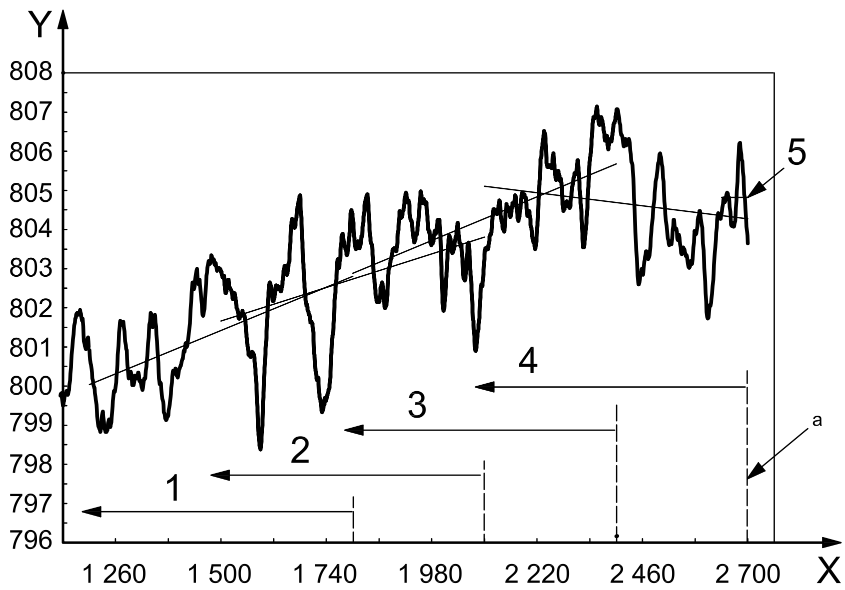
D.2 Final temperature stabilization

If the stabilization criterion is reached within 30 min, the end of the test shall be at 30 min. If the stabilization criterion is reached between 30 min and 60 min, that time shall be the end of the test. If no stabilization criterion is reached, the test should be terminated at 60 min.

The stabilization criterion should be reached when the drift (linear regression) of the temperature is within 2 °C for a period of 10 min, calculated at 5 min intervals.

This is illustrated by the example presented in Figure D.2 and Table D.1.

The drift (linear regression) of the temperature is lower than 2 °C between 35 min and 45 min (period of 10 min). The final temperature stabilization criterion is, therefore, reached at 45 min and thus the end of the test is 45 min.



Key

X time (s)

Y temperature (°C)

1 drift [20 min – 30 min] = 2,76 °C

2 drift [25 min – 35 min] = 2,15 °C

3 drift [30 min – 40 min] = 2,80 °C

4 drift [35 min – 45 min] = 0,84 °C

5 $T_f = T_{avg}$ [44 min – 45 min] = 804,8 °C

a End of test = 5 min.

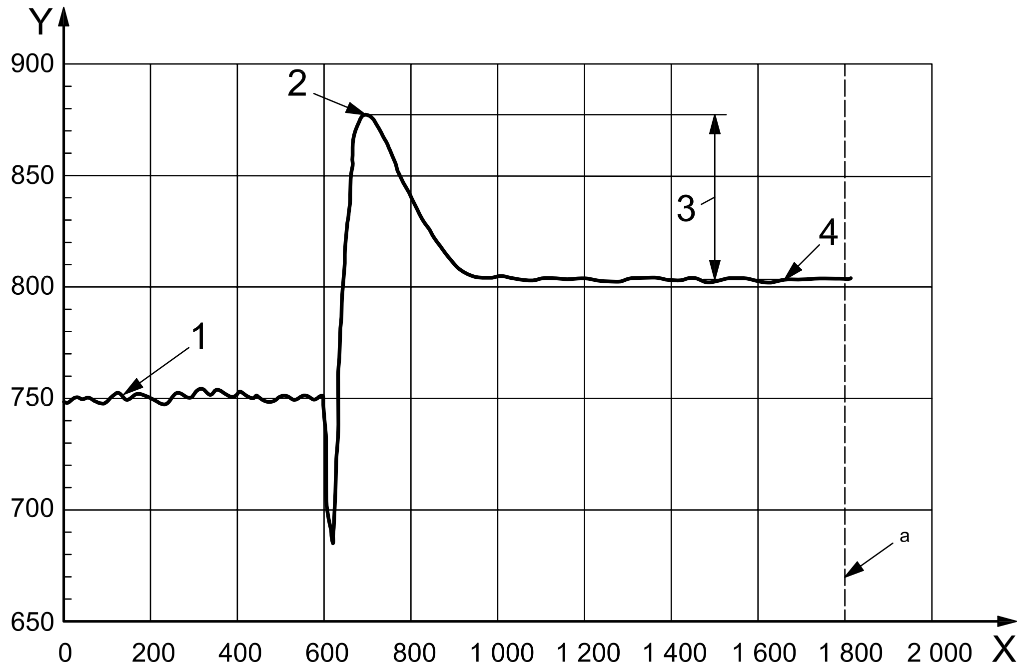
Figure D.2 — Example of final temperature stabilization

D.3 Determination of temperature rise

The temperature increase is specified in 8.3, calculated from T_{max} °C and T_f °C. This is illustrated by the two typical examples of temperature recording presented in Figures D.3 and D.4, for which the results are summarized in Table D.1.

Table D.1 — Test results

Example	End of test	T_i	T_{max}	T_f	$T_{max} - T_f$
Figure D.3	30 min	750,4 °C	877,8 °C	802,3 °C	75,5 °C
Figure D.4	45 min	748,4 °C	807,4 °C	804,8 °C	2,6 °C



Key

X time (s)

Y temperature (°C)

1 T_i = 750,4 °C

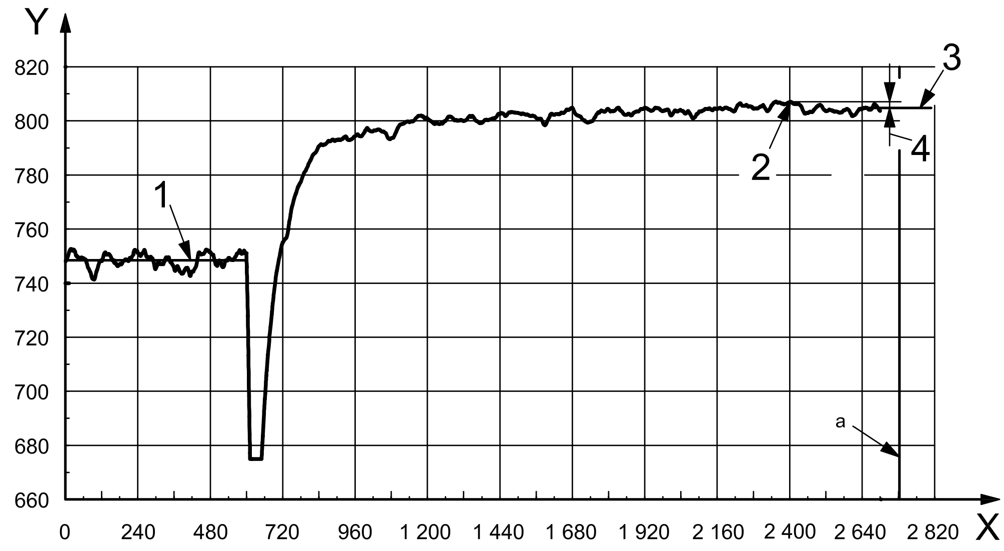
2 T_{max} = 877,8 °C

3 $T_{max} - T_f$ = 75,5 °C

4 T_f = 802,3 °C

[a] End of test = 30 min.

Figure D.3 — Example of temperature recording during one test A



Key

Y temperature (°C)

X time (s)

1 $T_i = 748,5$ °C

2 $T_{max} = 807,4$ °C

3 $T_f = 804,8$ °C

4 $T_{max} - T_f = 2,6$ °C

a End of test = 45 min.

Figure D.4 — Example of temperature recording during one test B

Bibliography

[1] ISO 5725-2, *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*

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