BRITISH STANDARD

Method for assessment of fire integrity of large diameter power cables for use as components for smoke and heat control systems and certain other active fire safety systems

ICS 13.220.40; 29.060.20

Publishing and copyright information

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Contents

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 20, an inside back cover and a back cover.

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Foreword

Publishing information

This British Standard is published by BSI and came into effect on 31 January 2008. It was prepared by Subcommittee GEL/20/18, *Fire testing*, under the authority of Technical Committee GEL/20, *Electric cables*. A list of organizations represented on this committee can be obtained on request to its secretary.

Relationship with other publications

The test method given in this British Standard is technically identical with the test method given in BS 7346-6:2005, Annex B. It is intended that when BS 7346-6:2005 is amended Annex B will be taken out.

Information about this document

The test method given in this British Standard includes subjecting the cable under test to radiation via direct impingement corresponding to a constant temperature attack of 842 °C, to direct mechanical impacts corresponding to a force of approximately 10 N, and to direct application of a water jet simulating a water fire fighting jet.

NOTE Although this test method has changes to accommodate the application of impacts and the water jet, it is based on the test method given in BS EN 50362, which has the constant temperature attack of 842 °C. This is the same constant temperature attack as used in the test method given in BS EN 50200.

BS 7346-6 specifies three fire survival times depending upon the application of the cables: either 30 min or 60 min for life safety systems (LS), and 120 min for fire fighting systems (FF). The test method given in this British Standard includes three different test durations to allow testing of cables intended for these different applications.

It is emphasized that fire tests do not assess a fire hazard, nor can the results of fire tests alone guarantee safety. They only provide information to assist in the assessment of the suitability of a cable for a given application.

Hazard warnings

WARNING. This British Standard calls for the use of substances and/or procedures that can be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

The test given in this British Standard may involve the use of dangerous voltages and temperatures. Suitable precautions should be taken against the risk of shock, burning, fire and explosion that may be involved and against any noxious fumes that may be produced.

Use of this document

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its methods are expressed as a set of instructions, a description, or in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

This British Standard describes a method for assessment of the fire integrity of large diameter power cables for use as components for smoke and heat control systems as given in BS 7346-6, and certain other active fire safety systems. It is applicable to cables of rated voltage not exceeding 600/1 000 V and of overall diameter greater than 20 mm.

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.

BS EN 60529:1992, *Specification for degrees of protection provided by enclosures (IP code)*

BS EN 60584-1, *Thermocouples – Part 1: Reference tables*

BS EN 60695-4, *Fire hazard testing – Part 4: Terminology concerning fire tests for electrotechnical products*

BS EN ISO 13943, *Fire safety – Vocabulary*

IEC 60269-3, *Low-voltage fuses – Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and similar applications) – Examples of standardized systems of fuses A to F*

3 Terms and definitions

For the purposes of this British Standard the terms and definitions given in BS EN ISO 13943 and BS EN 60695-4 apply.

4 Test chamber

WARNING. The test method given in this British Standard may involve the use of dangerous voltages and temperatures. Suitable precautions should be taken against the risks of shock, burning, fire and explosion that may be involved and against any noxious fumes that may be produced.

The test shall be carried out in a suitable chamber of minimum volume 10 m^3, with facilities for disposing of any noxious gases resulting from burning. Sufficient ventilation shall be available to sustain the burner flame (see **5.3**) for the duration of the test.

The locations of any air inlets and exhaust chimney shall be such that the burner flame remains stable during the verification procedure and during the tests.

NOTE 1 It might be necessary to have suitable shielding of the burner flame to ensure its stability.

The same ventilation and shielding conditions shall be used in the chamber during both the verification and the test procedures.

NOTE 2 Guidance on the choice of suitable chambers and on ventilation and shielding conditions is given in Annex A.

The atmosphere in the chamber shall be between 10 °C and 40 °C at the start of each test.

5 Apparatus

NOTE The arrangement of the apparatus is shown in Figure 1, Figure 2 and Figure 3.

5.1 *Test ladder*, for mounting the test specimen, comprising a steel framework as shown in Figure 1. The two central vertical elements of the ladder shall be adjustable in order to accommodate test specimens of different sizes of cable. The test ladder shall be (1 200 ± 100) mm long and (600 ± 50) mm high, and the total mass of the test ladder shall be (18 ± 1) kg. Ballast, if required, shall be placed on the test ladder.

*NOTE 1 Angle iron, (45 ±5) mm wide and (6 ±1) mm thick with slots cut to allow for movement of the vertical elements and the fixing of the bolts and clips (see **7.2**), has been found to be a suitable material for construction of the test ladder.*

The test ladder shall be fastened to a rigid support framework by four bonded rubber bushes of hardness 50 to 60 Shore A. To enable this to be done, each horizontal element of the test ladder shall be extended beyond the end vertical elements and shall have a mounting hole not more than 200 mm from each end vertical element, the exact position and diameter being determined by the particular bushes and supporting framework used. The bushes shall be fitted between the horizontal elements of the ladder and the support framework, as illustrated in Figure 1 and Figure 2, so as to allow movement of the test ladder under impact.

NOTE 2 A typical rubber bush is illustrated in Figure 4.

5.2 *Circuit continuity checking and voltage withstand arrangement*, comprising a three-phase star-connected transformer, or one or more single-phase transformers, of sufficient capacity to maintain the test voltage, up to the maximum leakage current allowable, together with a suitable load and an indicating device (e.g. a lamp).

*NOTE 1 Consideration should be given to the characteristics of the fuse or circuit breaker (see **5.9**) when selecting the power rating of the transformer.*

NOTE 2 A lamp would constitute both a load and an indicating device. If a load other than a lamp is used a separate indicating device would be needed, such as a bell or a buzzer.

5.3 *Source of heat*, comprising a horizontally mounted ribbon type propane gas burner with a venturi mixer. The burner face length shall be (500 ± 25) mm and the burner face width shall be nominally 10 mm. The face of the burner shall have three staggered rows of round holes centred on the face of the burner, 1.32 mm in diameter and drilled at 3.2 mm centres, as shown in Figure 5.

NOTE 1 A centre feed burner is recommended.

NOTE 2 In addition to the three rows of holes specified, a row of small holes milled on each side of the burner face is permitted, to serve as pilot holes for keeping the flame burning.

The flow rates of propane gas and of air to the burner shall be monitored by flow meters. Mass flow meters should be used as a means of controlling accurately the input flow rates. Rotameter type flow meters may be used as an alternative but are not recommended.

If rotameter type flow meters are used, correction factors shall be applied to the readings to take account of the temperature and pressure of the propane gas and the air supply.

NOTE 3 Guidance on the use of rotameter type flow meters, and the application of appropriate correction factors, is given in BS EN 50200:2006, Annex B.

The volume flow rate of propane gas to the burner shall be (10 ± 0.4) l/min, which is equivalent to a mass flow rate of (319 ± 13) mg/s. The volume flow rate of air to the burner shall be (160 ± 8) l/min, which is equivalent to a mass flow of (3 267 ± 163) mg/s.

NOTE 4 The mass flow rates given above have been calculated from the specified volume flow rates at reference conditions of 100 kPa (= 1 bar) and 20 °C.

*NOTE 5 The purity of the propane gas is not specified. Use of an industrial grade of propane gas that contains impurities is permitted provided that the burner meets the performance requirements specified in **6.4**.*

The performance of the burner and associated controls shall be verified using the procedure given in Clause **6**. The exact burner position to be used during testing shall be determined during the verification procedure, when the values of *V* and *H* to be used shall be determined. The burner shall be rigidly fixed during the test so as to prevent movement relative to the test specimen.

For the purposes of this test, the air supplied to the burner shall have a dew point not higher than 0 °C.

NOTE 6 If the air is supplied from a compressor, an in-line drying facility needs to be used to achieve this.

*NOTE 7 The source of heat and associated controls are the same as those specified in BS EN 50362:2003, **6.4**.*

5.4 *Impact device*, comprising a round, mild steel bar (25 ± 0.1) mm in diameter and (600 ± 5) mm long. The bar shall be arranged and supported so that it can pivot freely about an axis parallel to the plane of the test ladder, which is in the same horizontal plane as, and (200 ± 5) mm away from, the front face of the test ladder. The pivoting point shall be (400 ± 5) mm from one end of the bar and (200 ± 10) mm from the other end, and the bar shall be arranged so that it can drop under its own weight from an angle of $60^{+5.0}_{0}$ ° to the horizontal to strike the midpoint of the test specimen. (See Figure 3 and Figure 6.)

5.5 *Water jet device*, comprising a 6.3 mm hose nozzle as specified in BS EN 60529:1992, Clause **14**, mounted above the test specimen at an angle of (45 ± 5)° to the vertical and at a distance of (500 ± 25) mm from the point of impact of the impact device and secured such that the water jet strikes the test specimen at the point of impact, as shown in Figure 6.

The nozzle shall be supplied with water at a flow rate of 12.5 l/min via an on/off valve. The flow rate shall be measured by a volumetric method prior to the test and the water supply adjusted if necessary. The water supply pipe shall be fitted with an in-line flow meter so that the water flow rate can be monitored during the test.

5.6 *Test wall*, for use in the verification of the source of heat, comprising a board made of non-metallic heat resisting, non-combustible material. The board shall be (900 ± 100) mm long, (300 ± 50) mm high and (10 ± 2) mm thick and shall be fitted with thermocouples (see **5.7**) for measuring the flame temperature of the source of heat, as illustrated in Figure 7.

5.7 *Two 1.5 mm diameter, mineral insulated, stainless steel sheathed thermocouples*, Type K conforming to BS EN 60584-1.

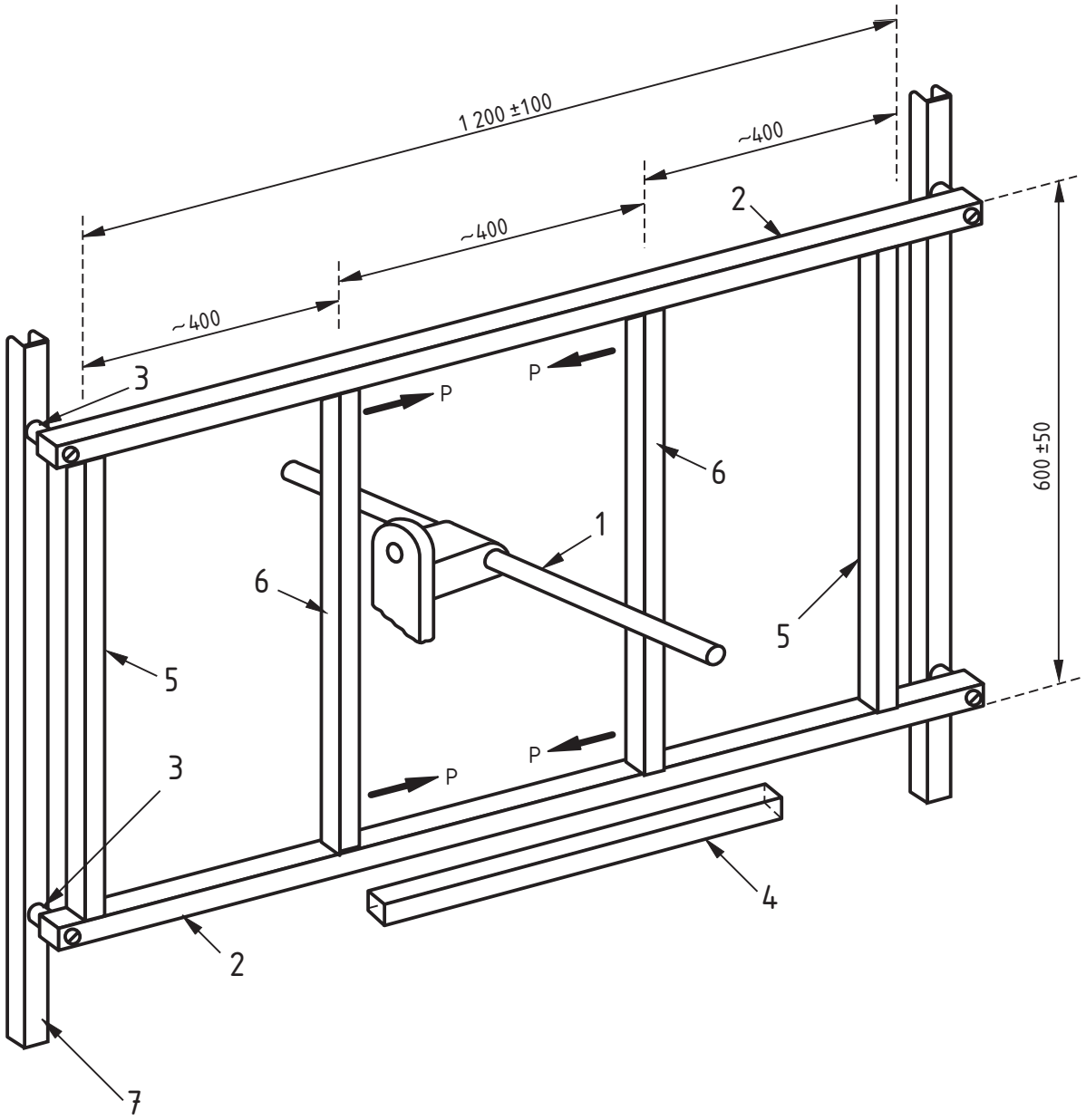
5.8 *Timer*, measuring in seconds, for measuring the test duration and timing the application of impacts to the test specimen.

5.9 *Fuses*, 2 A, Type DII, conforming to IEC 60269-3, or circuit breakers with equivalent characteristics. In case of dispute the use of fuses shall be the reference method.

5.10 *Metal bolts and clips*, for fixing the test specimen to the test ladder, comprising two U-bolts, and P-clips made of metal strip (20 ± 2) mm wide for use with test specimens up to 50 mm diameter and (30 ± 3) mm wide for use with test specimens over 50 mm diameter. All clips and bolts shall be earthed.

Figure 1 **Schematic of the test configuration**

Dimensions in millimetres

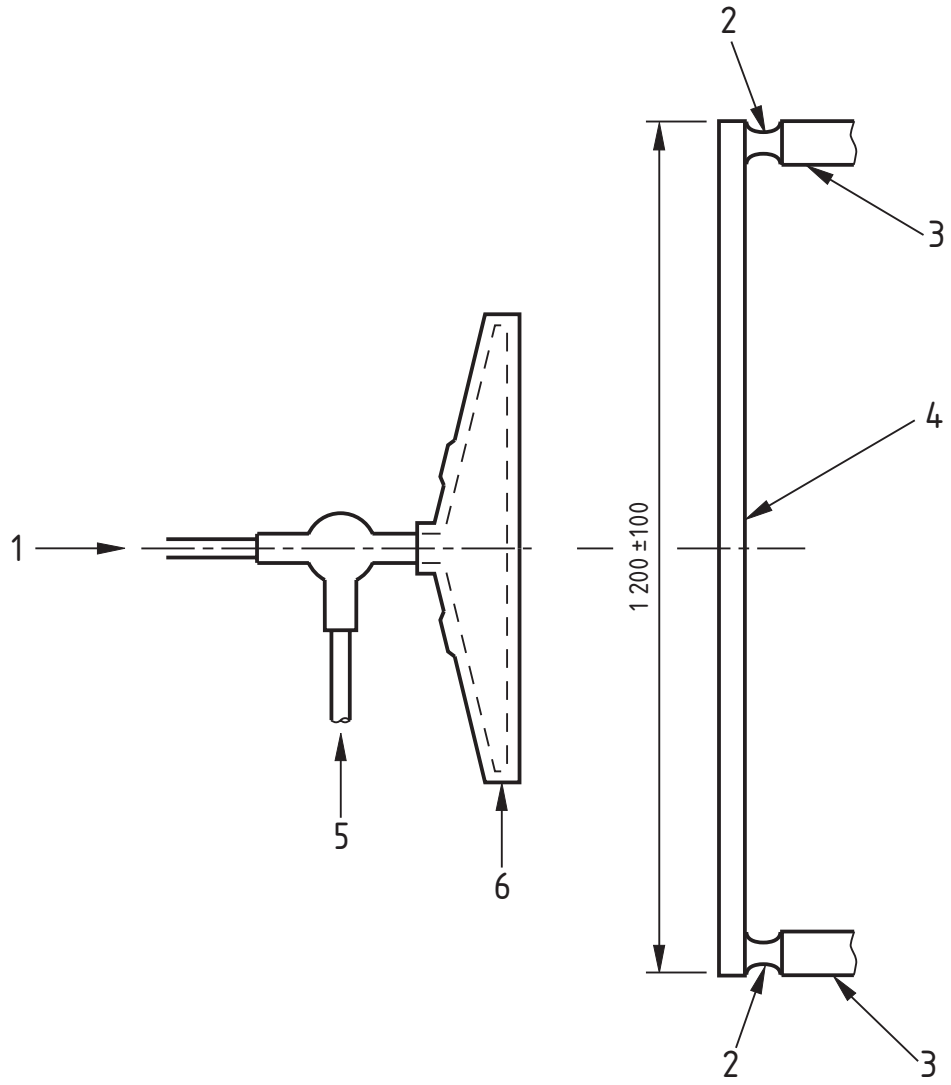


Key

1	Impact device	5	Fixed vertical elements of test ladder
2	Test ladder	6	Adjustable vertical elements of test ladder
3	Rubber bushes	7	Rigid support framework
4	Gas burner	P	Plane of adjustment

Figure 2 **Plan view of apparatus**

Dimensions in millimetres

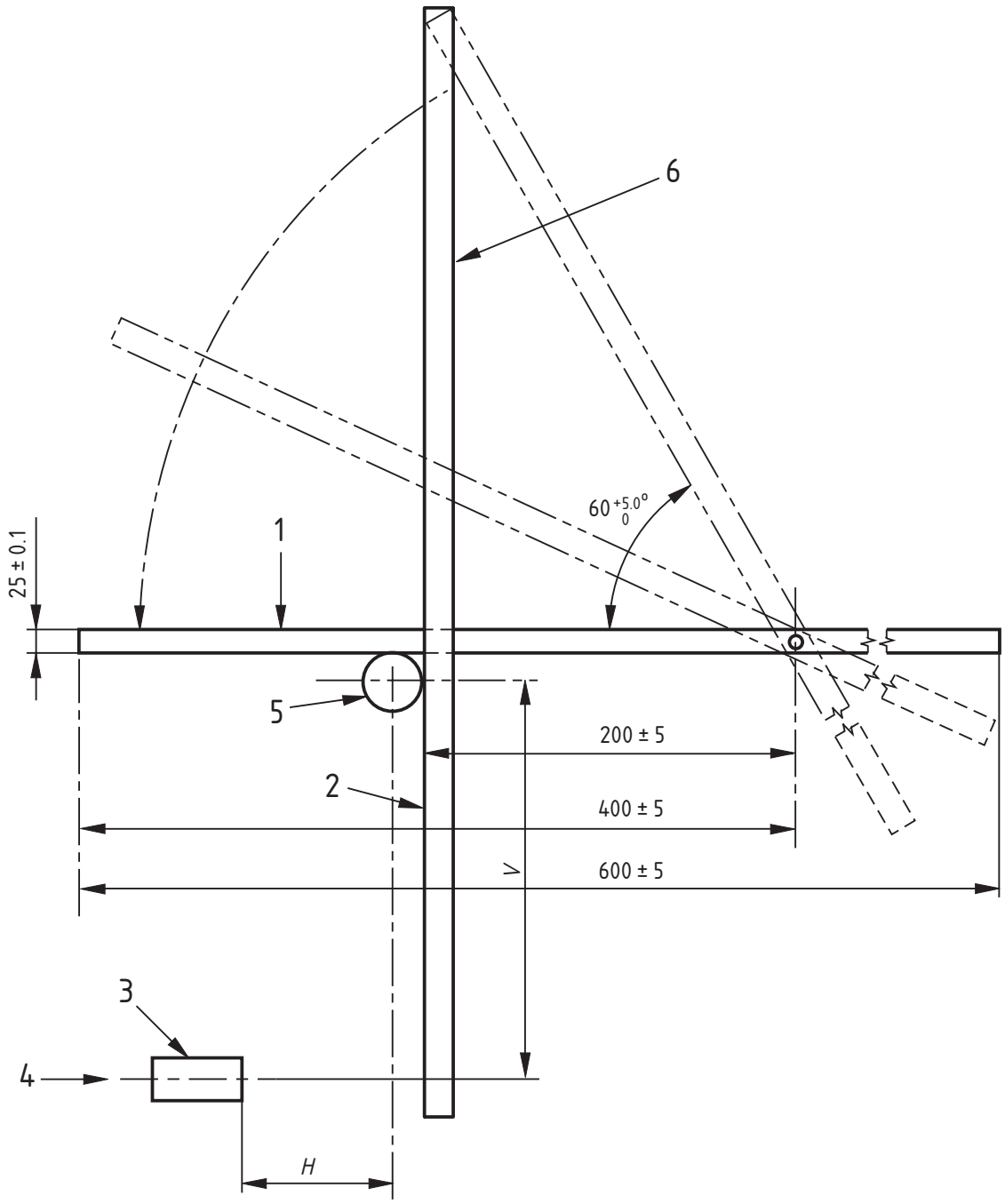


Key

1 Air inflow
2 Rubber bushes
3 Rigid support framework
4 Test ladder
5 Propane gas inflow
6 Burner

Figure 3 **End elevation view of apparatus**

Dimensions in millimetres



Key

1 Impact device
2 Test ladder
3 Gas burner
4 Centre line of burner face
5 Test specimen
6 Test ladder

H Horizontal distance from centre line of test specimen to burner face

V Vertical distance from centre line of test specimen to centre line of burner face

Figure 4 **Rubber bush**

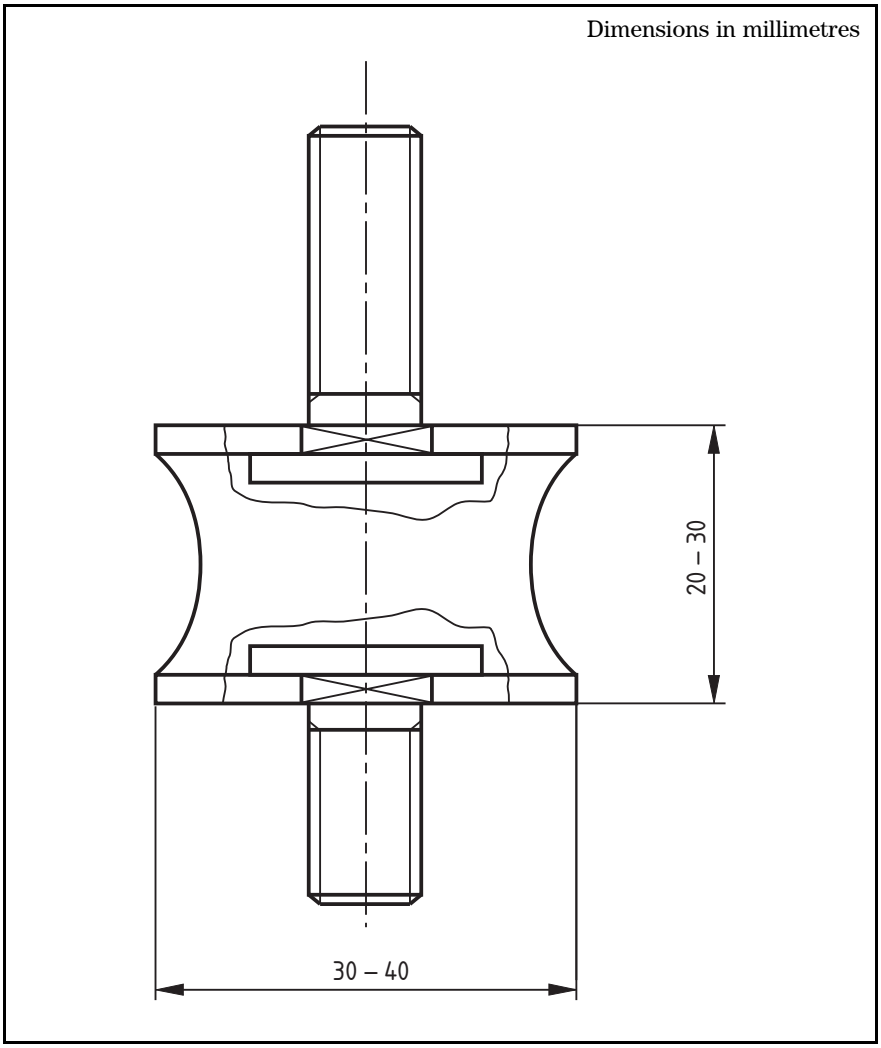


Figure 5 **Arrangement of holes on burner face**

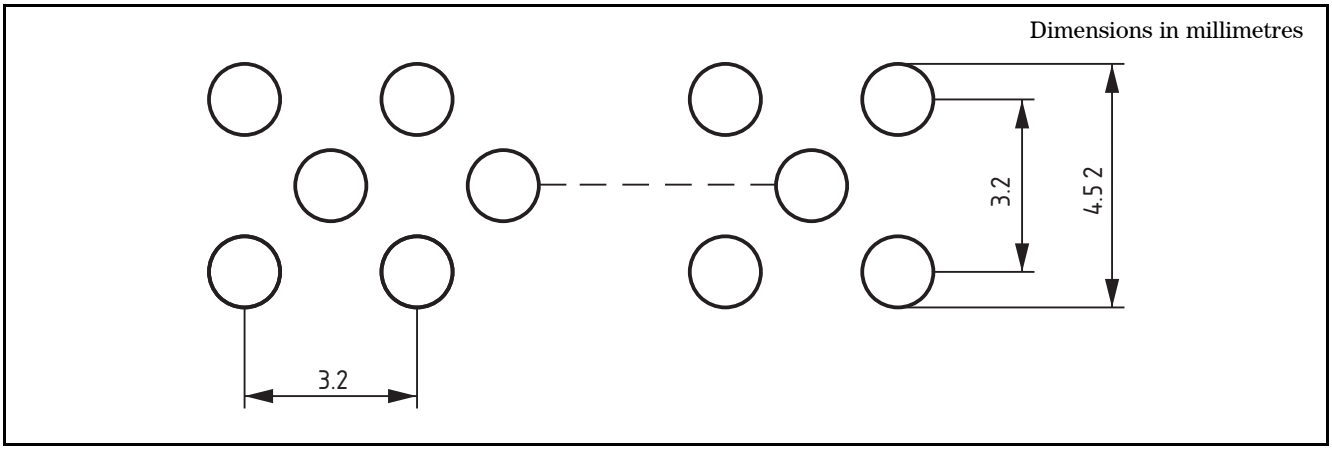


Figure 6 **Position of water jet device**

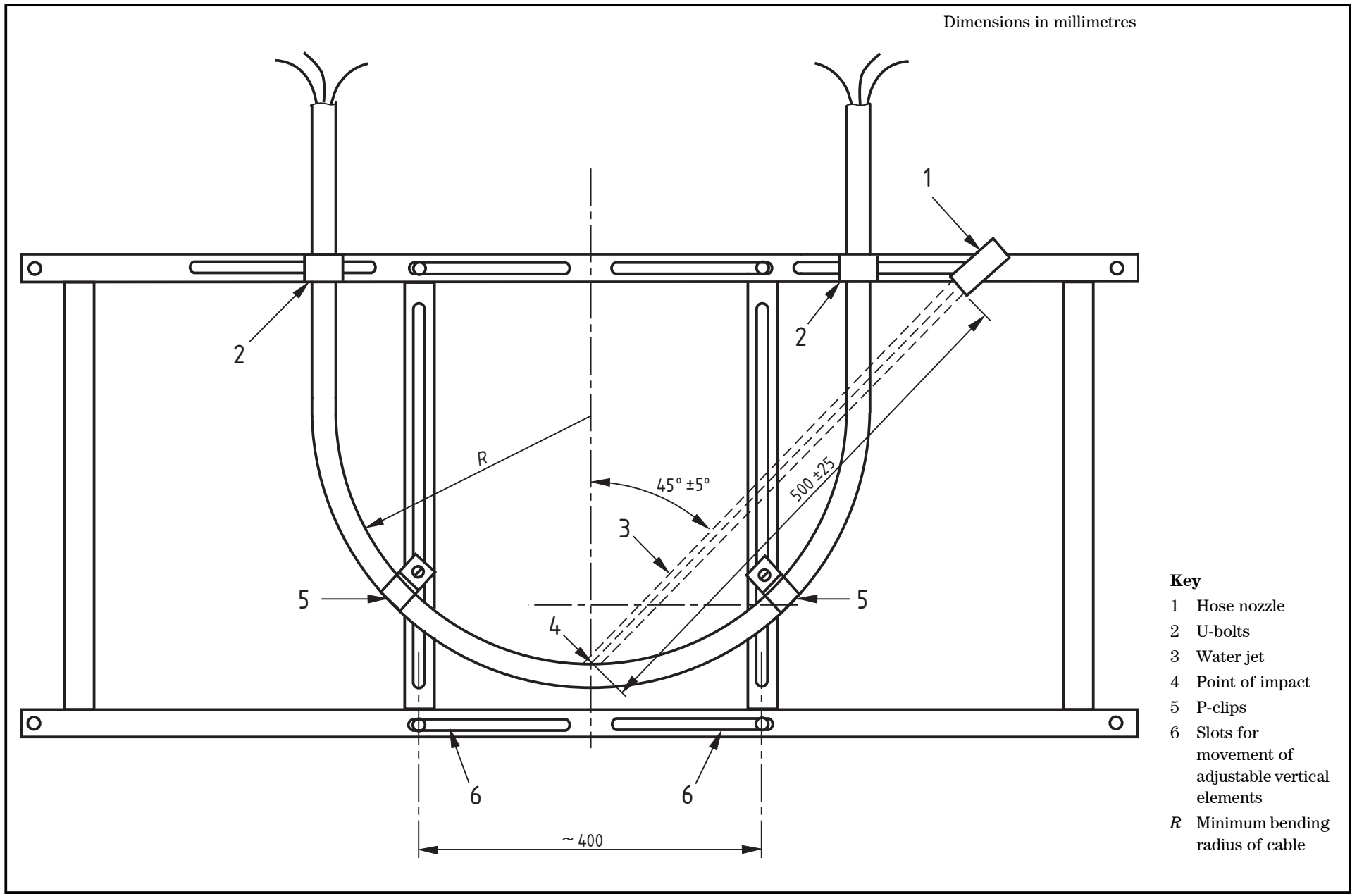
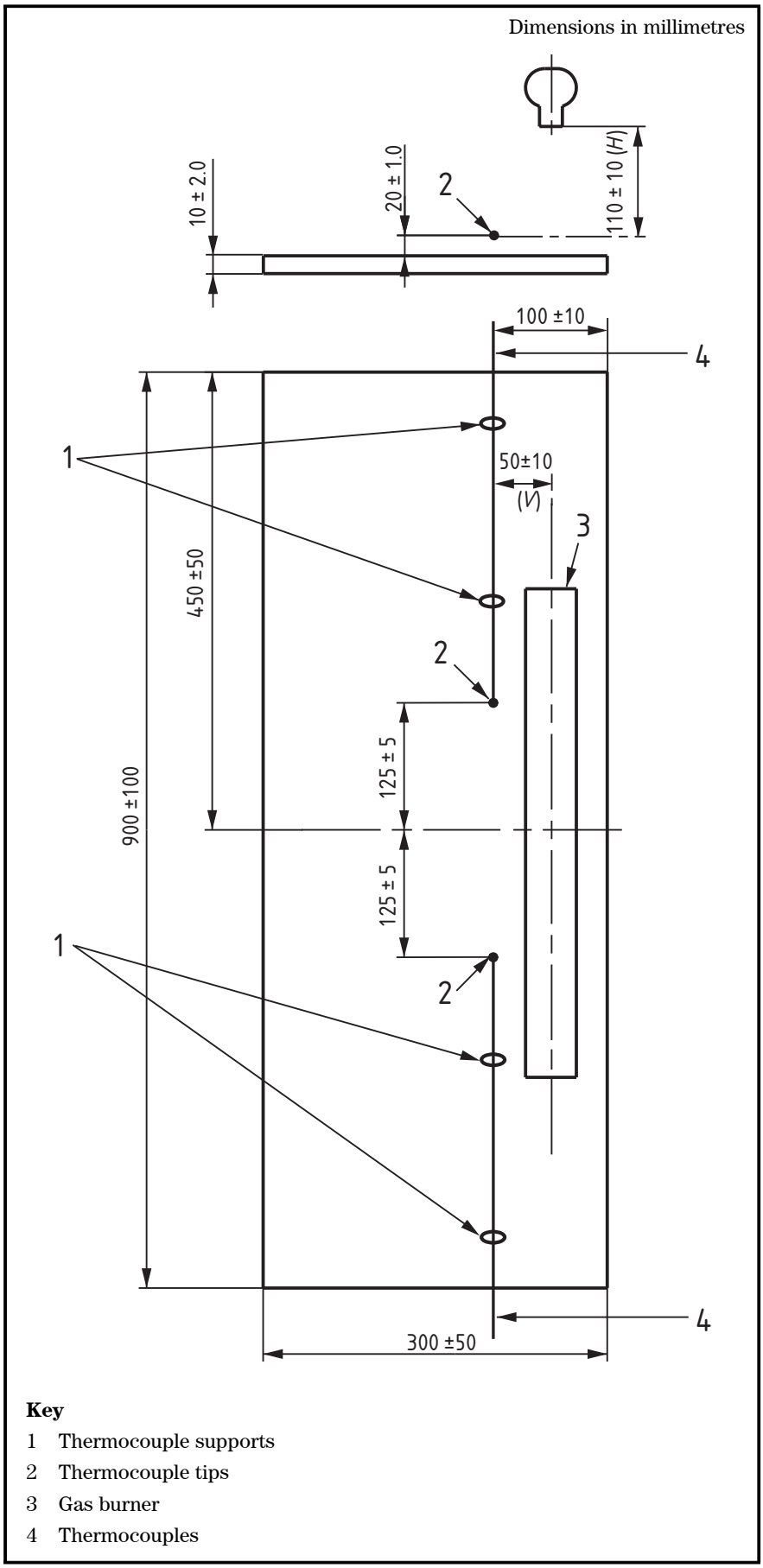


Figure 7 **Temperature measuring arrangement**



Key

1 Thermocouple supports
2 Thermocouple tips
3 Gas burner
4 Thermocouples

6 Verification procedure for the source of heat

6.1 Fix the test wall (**5.6**) to the rigid support framework (see **5.1**) and position it vertically in the test chamber (see Clause **4**). Fit the thermocouples (**5.7**) to the test wall so that they lie horizontally with their centre lines (100 ± 10) mm above the bottom edge of the test wall and so that the tips of the thermocouples are (20 ± 1.0) mm in front of the test wall.

6.2 Position the burner in front of, and below, the thermocouples such that the horizontal distance (*H*) between the burner face and the thermocouples is (110 ± 10) mm and the vertical distance (*V*) between the centre line of the burner and the thermocouples is (50 ± 10) mm, as illustrated in Figure 7.

Ignite the burner and adjust the propane gas and air supplies give the flow rates specified in **5.3**.

6.3 Record the temperature measurement from each of the thermocouples at least every 30 s over a period of 10 min and obtain the arithmetic mean of the readings from each of the two thermocouples over the 10 min period and the overall arithmetic mean of all the readings.

NOTE It is recommended that a recorder with averaging facilities is used in order to damp the variability in readings that can be caused by point measurements.

6.4 The burner position and the propane gas and air flow rates shall be considered satisfactory for use in the test if the following conditions are met:

a) the overall arithmetic mean of the readings from the two thermocouples over the 10 min period falls within the temperature range $830\ ^{+40}_{0}$ °C; and

b) the difference between the mean readings from each of the two thermocouples over the 10 min period does not exceed 40 °C.

6.5 If the verification is not successful (i.e. the conditions specified in **6.4** are not met), alter the flow rates of propane gas and air to the burner, within the tolerances given in **5.3**, and carry out a further verification.

6.6 If this second verification is not successful, alter the distances (*H* and *V*) between the burner and the thermocouples (within the tolerances given in **6.2**) and carry out a further verification.

6.7 Record the distances (*H* and *V*) established for successful verification and the flow rates used.

6.8 If no successful verification can be achieved within the tolerances given, then consider the burner system as incapable of providing the source of heat required by this British Standard.

7 Test specimens

7.1 Specimen preparation

Cut a test specimen not less than 1 500 mm long from the cable under test. At each end of the specimen remove the sheath or outer coverings for a distance of 100 mm and strip back the insulation to expose the cores. Spread the cores apart so that they are not in contact with each other.

7.2 Test specimen mounting

Bend the test specimen to form approximately an arc of a circle, with an internal bending radius the same as the manufacturer's declared minimum bending radius, as shown in Figure 8 or Figure 9.

For larger diameter cables, mount the test specimen centrally on the test ladder using the metal bolts and clips (**5.10**). Use the U-bolts to attach the test specimen to the upper horizontal elements of the test ladder and use the P-clips, formed to the same diameter as the test specimen, to attach the test specimen to the central vertical elements of the test ladder, as shown in Figure 8.

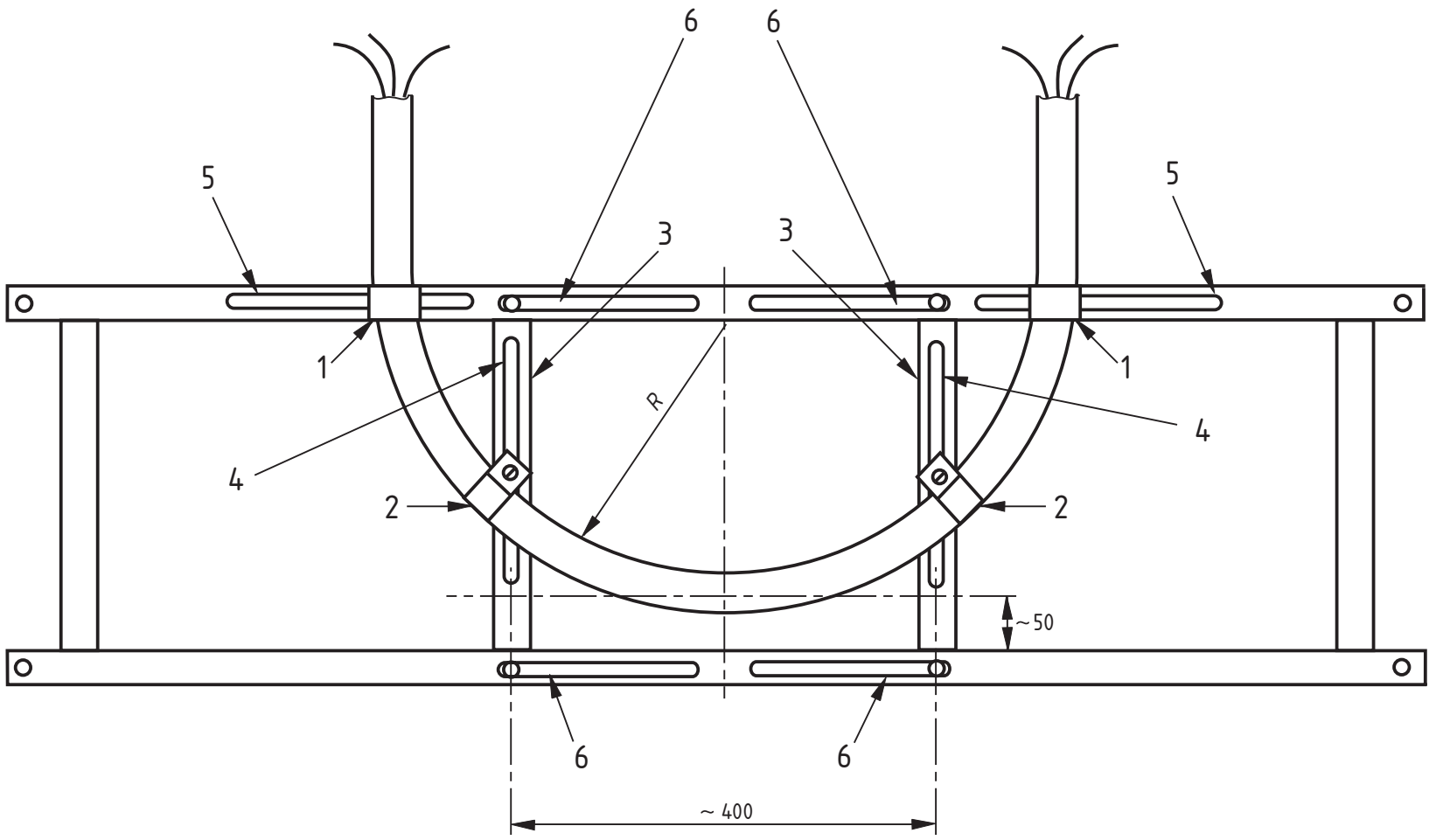
For smaller diameter cables, where the test specimen is too small to be mounted on the central vertical elements when they are in the position shown in Figure 8, reposition these elements closer to the centre of the test ladder (still equidistant from the centre) so that the test specimen can be mounted as shown in Figure 9.

NOTE 1 For the purposes of the cables within the scope of this test, and the arrangements shown in Figure 8 and Figure 9, smaller cables would typically be below 50 mm diameter and larger cables typically above 50 mm diameter. The exact choice will depend also upon the manufacturer's declared minimum bending radius.

NOTE 2 It is important that the test specimen is securely mounted on the test ladder to prevent the test specimen moving during the test, particularly when it is subjected to impacts.

Figure 8 **Example of mounting of a larger diameter test specimen**

Dimensions in millimetres

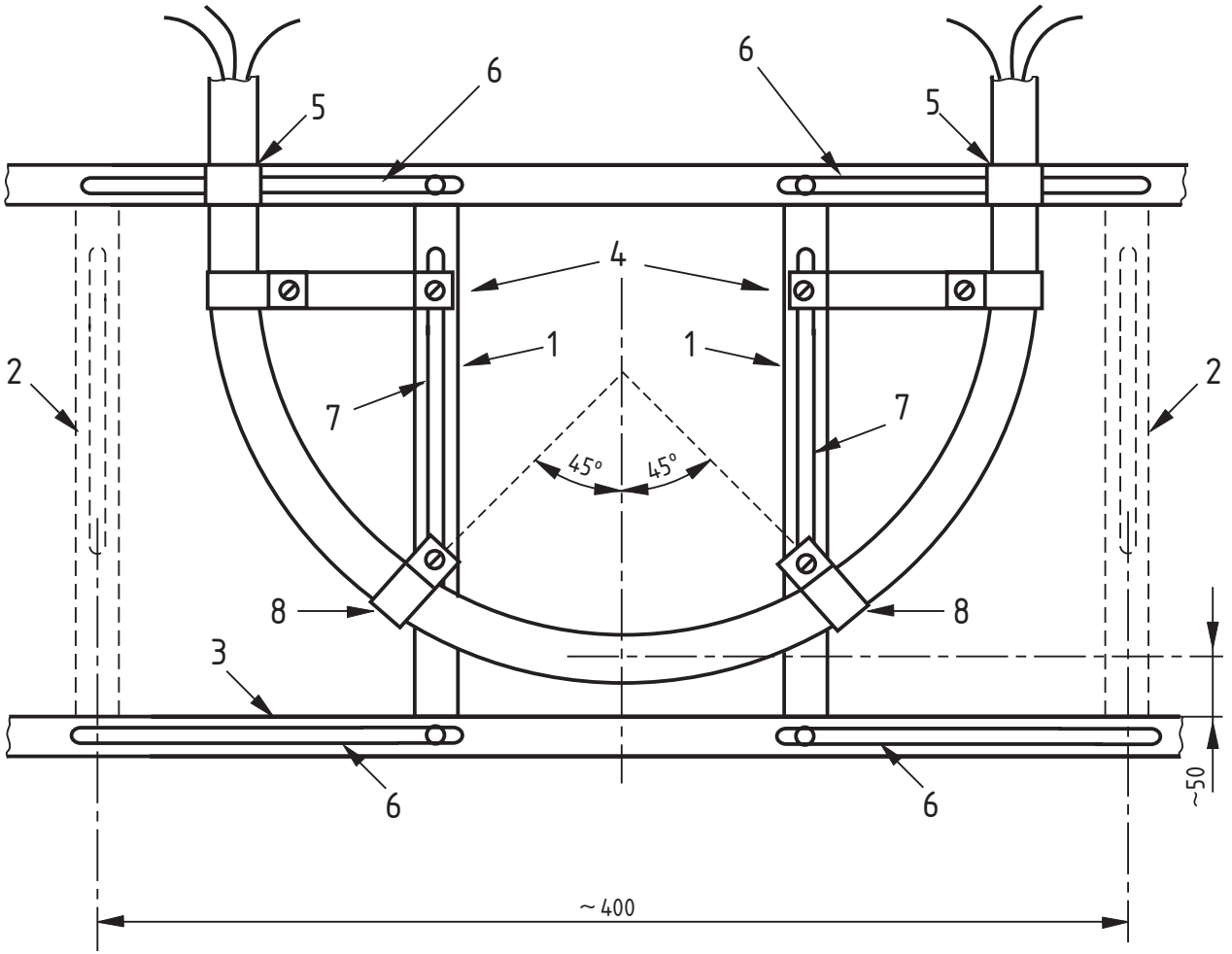


Key

1 U-bolts
2 P-clips
3 Adjustable vertical elements of test ladder
4 Slots for P-clip fixing
5 Slots for U-bolts
6 Slots for movement of adjustable vertical elements
R Minimum bending radius of cable

Figure 9 **Example of mounting of a smaller diameter test specimen**

Dimensions in millimetres



Key

1 Adjusted position of adjustable vertical elements of test ladder
2 Normal position of adjustable vertical elements of test ladder
3 Lower horizontal element of test ladder
4 Additional clips to maintain shape of test specimen (if required)
5 U-bolts
6 Slots for movement of adjustable vertical elements
7 Slots for P-clip fixing
8 P-clips

8 Test procedure

8.1 Electrical connections to the test specimen

At the end of the test specimen which is to be connected to the transformer(s), earth the neutral conductor and any protective conductor. Interconnect and earth any metal screens, drain wire or metallic layer. Connect the transformer(s) to the conductors, excluding any conductor which is specifically identified as intended for use as a neutral or a protective conductor, as shown in the circuit diagram in Figure 10.

Where a metallic sheath, armour or screen acts as a neutral or protective conductor, connect as for a neutral or protective conductor as shown in the circuit diagram in Figure 10.

For test specimens of single, twin or three-phase conductor cables, connect each phase conductor to a separate phase of the transformer(s) with a 2 A fuse or circuit breaker (**5.9**) in each phase.

For test specimens of multi-core cables having four or more conductors (excluding any neutral or protective conductors), divide the conductors into three roughly equal groups, ensuring that adjacent conductors are, as far as possible, in different groups.

Connect the conductors in each group in series and connect each group to a separate phase of the transformer with a 2 A fuse or circuit breaker (**5.9**) in each phase.

NOTE 1 For cable constructions not specifically identified above, electrical connections should be made, as far as is practicable, such that adjacent conductors are connected to different phases of the transformer(s).

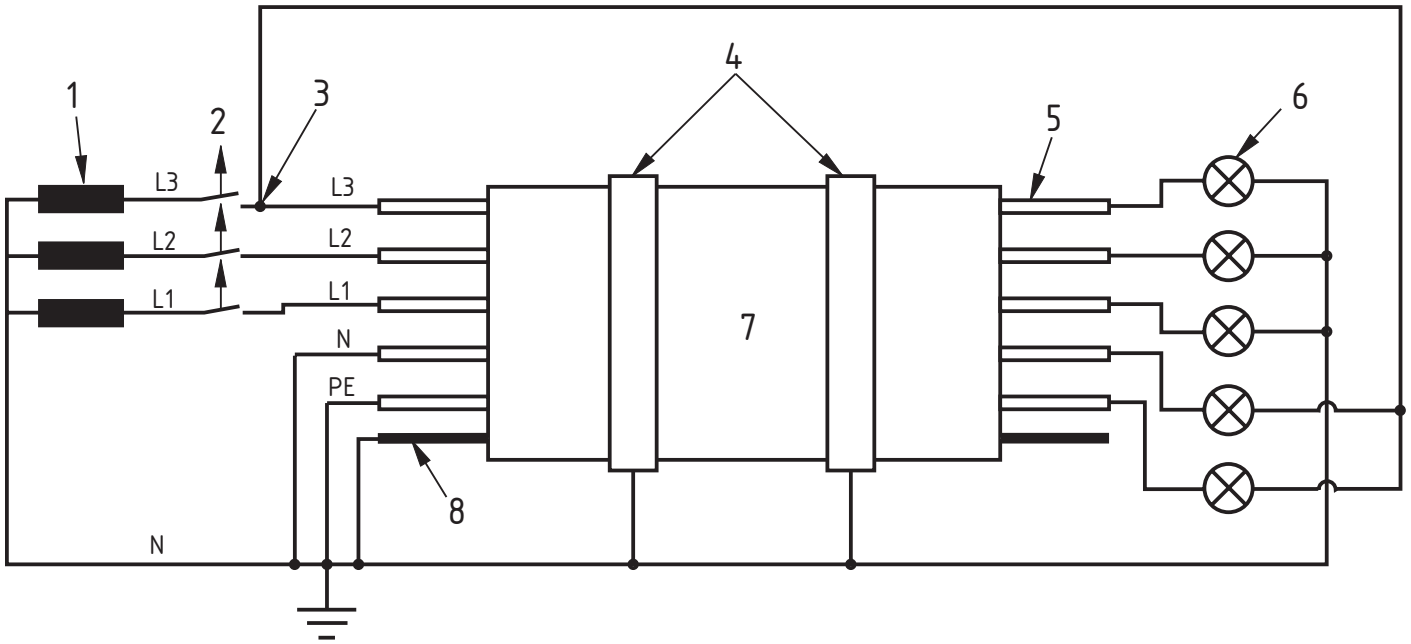
At the end of the test specimen remote from the transformer(s):

a) connect each phase conductor, or group of conductors, to one terminal of a suitable load and an indicating device (see **5.2**), such that a current for circuit continuity checking is achieved, the other terminal of each device being earthed;

   NOTE 2 A current of 0.25 A at the test voltage, through each conductor or group of conductors, is suitable.

b) connect the neutral conductor and any protective conductor to one terminal of a load and indicating device (see **5.2**), the other terminal of each device being connected to phase conductor L1 (or L2 or L3) at the transformer end of the test specimen, as illustrated in Figure 10.

Figure 10 **Basic circuit diagram**



Key

1 Transformer(s)
2 Fuse(s)
3 Connection to phase conductor L1 or L2 or L3
4 Metal clips
5 Conductor or group of conductors
6 Load and indicating device
7 Test specimen
8 Metal screen (if present)

L1, L2, L3 Phase conductor(s) (L2, L3 if present)
N Neutral conductor (if present)
PE Protective conductor (if present)

8.2 Setting up the apparatus and starting the test

Attach the test specimen to the test ladder (see **7.2**) which is fixed to the rigid support framework and positioned with all the electrical circuitry in the test chamber (see Clause **4**).

Position the burner such that the horizontal distance between the burner face and the centre line of the test specimen is ($H \pm 2$) mm and the vertical distance between the centre line of the burner face and the centre line of the test specimen is ($V \pm 2$) mm, as shown in Figure 3, using the values of H and V determined in the verification procedure given in Clause **6**. Ensure that the burner is positioned in the test chamber such that it is at least 200 mm above the floor of the chamber or any solid mounting table and 500 mm from the chamber walls.

Ignite the burner and adjust the flow rates of propane gas and air to those obtained during the verification procedure as given in Clause **6**. Immediately after igniting the burner start the timer.

8.3 Test voltage application

Immediately after starting the timer, switch on the electricity supply and adjust the voltage to the rated voltage of the cable, or to 100 V a.c., whichever is larger, i.e. the test voltage between conductors shall be equal to the rated voltage between conductors and the test voltage from conductor to earth shall be equal to the rated voltage from conductor to earth.

8.4 Application of impacts

Subject the test specimen to an impact from the impact device (**5.4**) 10 min ± 10 s after lighting the burner. Subject the test specimen to further impacts 10 min ± 10 s after the first impact and subsequently at intervals of 10 min ± 10 s, so that the test specimen receives a minimum of three impacts in a 30 min test, six impacts in a 60 min test or 12 impacts in a 120 min test, unless the test specimen fails before the end of the relevant test period (see **8.5**). After each impact, raise the impact device from the test specimen within 20 s of the impact.

8.5 Duration of flame application with impact phase

Continue the flame application and impacts for 30 min, 60 min or 120 min, as applicable, unless the test specimen fails before the relevant time has elapsed.

8.6 Water drenching phase

Five minutes before the end of the flame application with impact phase, activate the water jet device and apply a burst of water of 5 s duration. Sixty seconds after the start of this burst of water apply a further burst of water of 5 s duration. Repeat this procedure until a total of 5 bursts of water have been applied. Maintain the test voltage throughout the water drenching phase even if the flame is extinguished by the water.

8.7 Assessment of test specimen performance

The test specimen shall be deemed to have failed the test if either:

a) one of the fuses blows or one of the circuit breakers interrupts the circuit; or

b) a conductor in the test specimen ruptures, as indicated by one of the circuit continuity indicating devices (e.g. a lamp extinguishes).

8.8 Recording of results

Record whether the test specimen survived the test, or whether it failed, in which case record the time after which it failed.

9 Test report

The test report shall include the following information:

a) the number and date of this British Standard;

b) a full description of the cable tested;

c) the name and address of the manufacturer of the cable tested;

d) the test voltage;

e) the actual bending radius of the test specimen used for the test;

f) the type(s) and arrangement of fixings used to attach the test specimen to the test ladder;

g) the survival time achieved.

Annex A (informative)

Guidance on the provision of a suitable test chamber

It is essential that the chamber has a sufficient volume that fire effluents released during combustion do not alter the test conditions. Experience has shown a chamber similar to the 3 m cube specified in BS EN 61034-1:2005 to be suitable, although other chambers of suitable volume may be used. Windows may be installed in the walls of the chamber in order to observe the behaviour of the test specimen during the test. For the removal of fire effluents, the chamber should be fitted with a chimney located at least 1 m from the burner. A damper may be fitted for adjustment of ventilation.

The chamber should have air inlets near the base. The locations of the air inlets and the chimney should be such that the burner flame remains stable during the verification procedure and during the tests.

Experience has shown that the flame geometry is influenced by any draughts in the test chamber and it is recommended that the burner be shielded from any draughts by the use of appropriate draught shields.

Bibliography

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 7346-6, *Components for smoke and heat control systems – Part 6: Specification for cable systems*

BS EN 50200:2006, *Method of test for resistance to fire of unprotected small cables for use in emergency circuits*

BS EN 50362:2003, *Method of test for resistance to fire of larger unprotected power and control cables for use in emergency circuits*

BS EN 61034-1:2005, *Measurement of smoke density of cables burning under defined conditions – Part 1: Test apparatus*

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