BRITISH STANDARD

BS 6387:1994

Specification for

Performance requirements for cables required to maintain circuit integrity under fire conditions

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Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Cables and Insulation Standards Policy Committee (CIL/-) to Technical Committee CIL/20 upon which the following bodies were represented:

Aluminium Federation
Association of Consulting Engineers
Association of Manufacturers of Domestic Electrical Appliances
British Approvals Service for Cables
British Cable Makers Confederation (BCMC)
British Plastics Federation
British Steel Industry
Department of the Environment (Property Services Agency)
Department of Trade and Industry (Consumer Safety Unit, CA Division)
Electricity Association
Engineering Equipment and Materials Users' Association
Institution of Electrical Engineers
London Regional Transport

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

British Railways Board
British Rubber Manufacturers' Association Ltd.
British Telecommunications plc
ERA Technology Ltd.
GAMBICA (BEAMA Ltd.)
Institution of Incorporated Executive Engineers
London Underground Ltd.
Queen Mary and Westfield College
Telecommunication Cables Group of BCMC
Warrington Fire Research Centre

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Foreword

This British Standard has been prepared under the direction of the Cables and Insulation Standards Policy Committee to specify performance requirements and provide test methods to enable designers of installations to make an assessment of the fire performance characteristics of various types of cable, particularly with regard to maintaining circuit integrity for a period after commencement of a fire. A number of alternative time and temperature parameters are given to allow the designer to select those considered to be the most appropriate for the intended use. No attempt is made to specify any additional mechanical protection which may be desirable for such cables under particular installation conditions, nor to deal with cable terminations or connected equipment which require separate but parallel consideration in relation to the duty to be performed.

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

It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified staff and experienced people, for whose guidance it has been prepared.

At the time of publication of this British Standard there is no corresponding international standard. In preparing the standard, however, use has been made of IEC Publication 331 of the International Electrotechnical Commission (IEC) *Fire-resisting characteristics of electric cables.*

This edition incorporates Amendment Nos. 1 and 2 and introduces technical changes to bring the standard up-to-date but it does not reflect a full review or revision of the standard, which will be undertaken in due course. Changes to the 1983 edition are indicated by a line in the margin. BS 6387:1994 supersedes BS 6387:1983 which is withdrawn.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

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

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This British Standard specifies performance requirements and gives test methods for mechanical and fire tests applicable to cables rated at voltages not exceeding 450/750 V and for mineral-insulated cables conforming to BS 6207.

NOTE The test methods for fire tests may be extended up to and including 600/1 000 V cables, in which case guidance should be sought from the manufacturer.

The cables are intended to be used for wiring and interconnection where it is required to maintain circuit integrity under fire conditions for longer periods than can be achieved with cables of conventional construction.

This standard specifies those requirements of the cables related to characteristics required to enable circuit integrity to be maintained under fire conditions.

2 References

2.1 Normative references

This British Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed on the inside back cover. For dated references, subsequent amendments to or revisions of any of these publications apply to this British Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publications referred to applies.

2.2 Informative reference

This British Standard refers to another publication that provides information or guidance. The edition of this publication current at the time of issue of this standard is listed on the inside back cover, but reference should be made to the latest edition.

3 Definitions

For the purposes of this British Standard, the definitions given in BS 4727-2:Group 08 apply, together with the following.

3.1
rated voltage U_o

the power-frequency voltage to earth for which the cable is designed

3.2
rated voltage U

the power-frequency voltage between conductors for which the cable is designed

3.3
routine test

a test to be conducted on all manufactured lengths

3.4
sample test

a test made by the manufacturer on samples of completed cable, or components taken from a completed cable, at a frequency to verify that the finished product meets the design specification

3.5
type test

a test required to be made before supplying, on a general commercial basis, a type of cable covered by this standard in order to demonstrate satisfactory performance characteristics to meet the intended application, and that is of such a nature that after it has been made it need not be repeated unless changes are made in the cable materials or design which might change the performance characteristics

4 Voltage designation

4.1 The cable shall be designated by the rated voltages U_0 and U expressed in the form U_0/U unless otherwise specified in the appropriate cable standard.

4.2 The rated voltages recognized for the purposes of this standard are 300/500 V and 450/750 V and those applicable to mineral-insulated cables as specified in BS 6207.

NOTE In an a.c. system, the rated voltage of a cable should be at least equal to the nominal voltage of the system for which it is intended. This condition applies both to the value U_0 and the value U.

In a d.c. system, the rated voltage of a cable should be not less than two-thirds of the nominal voltage of the system for which it is intended.

It should be noted in regard to both the above, that it is possible for the operating voltage of a system to exceed permanently the nominal voltage of the system by 10 %.

5 Tests

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

Cables shall meet the requirement of the tests as shown by the letter "x" in Table 1. When specified in the appropriate cable standard or by the purchaser at the time of enquiry or order, cables shall also meet the requirements shown by the letter "o" (optional).

The tests shall be applied to cables having two or more insulated conductors, whether or not the cables incorporate other metallic elements such as armour, screen or circuit protective conductor. The tests shall also be applied to cables having one insulated conductor provided that the cable incorporates at least one other metallic element.

The tests shall not be applied to cables having one insulated conductor but no other metallic element.

6 Categories of cable

Cables shall be categorized by a letter symbol or series of symbols according to the requirements for fire resistance characteristics which they meet, the test temperatures selected (see **D.2** and **D.4**) and the duration of the test for resistance to fire alone (see **D.2**).

The first letter symbol (or symbols) shall be as follows.

Resistance to fire alone (see **D.2**)

	Symbol
650 °C for 3 h	A
750 °C for 3 h	B
950 °C for 3 h	C
950 °C for 20 min (short duration)	S

Where an optional test is applied to further categorize the cable, this letter shall be followed by one or more of the following letter symbols.

Table 1 — List of applicable tests

Clause reference	Test description	Category of test	Mineral-insulated cables conforming to requirements of BS 6207	Other cables with overall diameter < 20 mm	Other cables with overall diameter ≥20 mm
7.1	Conductor resistance test	Sample	x (as BS 6207)	x	x
	Voltage tests on completed cable				
7.2.1, **A.1** and **A.2**	Full length test	Routine	x (as BS 6207)	x	x
7.2.2, **A.1** and **A.3**	Test in water	Sample	x (as BS 6207)	x	x
	Tests for bending characteristics				
8, **B.1** and **B.3**	Bend test at ambient temperature	Type	x (as BS 6207)	x	—
8, **B.2** and **B.3**	Bend test at 0 °C	Type	—	x	—
	Tests for resistance of cable to impact				
9.1 and annex C	Test for resistance to impact at ambient temperature	Type	—	x	x
9.2	Test for resistance of sheath to cold impact	Type	—	x	x
10	*Test for electric cables under fire conditions*	Type	x (as BS 6207)	x	x
	Tests for fire resistance characteristics				
11.1, **D.1** and **D.2**	Resistance to fire alone	Type	x	x	x
11.2, **D.1** and **D.3**	Resistance to fire with water	Type	o[a]	o	o[a]
11.3, **D.1** and **D.4**	Resistance to fire with mechanical shock	Type	o[a]	o	o[a]

"x" means the test is applied.

"–" means the test is not applied.

"o" means the test is optional.

[a] Not all sizes or types of cable with overall diameters greater than 20 mm can be presently accommodated within the standard and guidance on testing these cables should be sought from the manufacturer.

Resistance to fire with water (see **D.3**) **W**

Resistance to fire with mechanical shock (see **D.4**)

650 °C	X
750 °C	Y
950 °C	Z

Thus, a cable meeting the performance requirements of **11.1** at 950 °C for 3 h and **11.3** at 750 °C, but not **11.2**, would be category CY, or a cable meeting the requirements of **11.1** at 650 °C for 3 h and 950 °C for 20 min and also **11.2**, and **11.3** at 650 °C would be category ASWX. The listing of the test methods indicated above does not imply that cables exist to meet all the permutations of categories possible.

7 Electrical requirements for completed cable

7.1 Conductor resistance test

The d.c. resistance of each conductor measured on a sample of cable at least 1 m in length, after correction for ambient temperature, shall be not more than the value specified in the appropriate table of BS 6360 for the type and size of conductor used.

7.2 Voltage tests on completed cable

7.2.1 *Full length test*

When a manufactured length of completed cable is tested as described in **A.1** and **A.2**, no breakdown of the insulation shall occur during the test.

7.2.2 *Test in water*

When a sample of completed cable is tested as described in **A.1** and **A.3.1**, no breakdown of the insulation shall occur during the test.

When a sample of completed cable, having a metallic layer or a non-insulated circuit protective conductor, is tested as described in **A.1** and **A.3.2**, no breakdown of the sheath shall occur during the test.

8 Bending characteristics

When a sample of cable is tested either at ambient temperature (see **B.1** and **B.3**) or at 0 °C (see **B.2** and **B.3**) as described in annex B, the sheath of the sample of cable shall be free from splits and no breakdown of the insulation shall occur during the test.

9 Resistance of cable to impact

9.1 Resistance to impact at ambient temperature

There shall be no breakdown of the insulation of any of the samples when they are tested as described in annex C.

9.2 Resistance of sheath to cold impact

When samples of cable are tested for impact at a temperature of – 15 ± 2 °C in accordance with **8.5** of BS 6469-1.4:1992 the requirement given in **8.5.6** of BS 6469-1.4:1992 shall be met.

10 Test requirements for electric cable under fire conditions

A sample of cable shall be tested in accordance with BS 4066-1 and shall meet the requirements of that standard.

11 Fire resistance characteristics

11.1 Resistance to fire alone

When a cable sample is tested as described in **D.1** and **D.2**, no fuse shall be ruptured nor any lamp extinguished during the period of the test. If the sample fails to conform to this requirement, two further samples shall be prepared and tested and both shall conform to this requirement.

11.2 Resistance to fire with water

When a cable sample is tested as described in **D.1** and **D.3**, no fuse shall be ruptured nor any lamp extinguished during the period of the test. If the sample fails to conform to this requirement, two further samples shall be prepared and tested and both shall conform to this requirement.

11.3 Resistance to fire with mechanical shock

When a cable sample is tested as described in **D.1** and **D.4**, no fuse shall be ruptured nor any lamp extinguished during the period of the test. If the sample falls to conform to this requirement, two further samples shall be prepared and tested and both shall conform to this requirement.

Annex A Voltage tests on completed cable

A.1 Test conditions and voltage

Carry out the tests described in **A.2** and **A.3** at a temperature of 20 ± 5 °C using an alternating voltage approximately of sinewave form, having a frequency in the range 49 Hz to 61 Hz, the ratio peak value/r.m.s. value being equal to $\sqrt{2}$ with a tolerance of ± 7 %.

A.2 Full length test

Test each manufactured length of twin and multicore cable without immersion in water. Apply the test voltage, increasing this gradually and maintaining it at the full r.m.s. value given in Table 2 for 5 min between each conductor in turn and all the others connected together and also connected to the circuit protective conductor, drain wire and metallic layer, if any.

A.3 Test in water

A.3.1 Immerse a sample of cable, 20 m in length, in water for at least 24 h, the ends of the cores protruding sufficiently above the water level to prevent damage due to leakage current along the surface of the cable when the required voltage is applied between the conductor and the water. Apply the test voltage, increasing the voltage gradually and maintaining it at the full r.m.s. value given in Table 2 for 15 min, between each conductor in turn and all the others connected together and also connected to the circuit protective conductor, drain wire and metallic layer, if any, and to the water; also apply the test voltage between all the conductors connected together and the water.

A.3.2 If the cable has a metallic layer or a non-insulated circuit protective conductor, carry out the following additional test while the sample is still immersed. Disconnect the circuit protective conductor, drain wire and the metallic layer from the water and connect them together. Apply a voltage of 1 kV for 5 min between these and the water.

Table 2 — Test voltages for completed cable

Rated voltage of cable V	Test voltage (r.m.s.) V
300/500	2 000
450/750	2 500

Annex B Tests for bending characteristics

B.1 Bending test at ambient temperature

Take a sample of cable and subject it to the bending test in accordance with the test method given in **B.3** at a temperature of 20 ± 5 °C.

B.2 Bending test at 0 °C

Take a sample of cable and, together with the test mandrel, cool it for 2 h at 0 ± 2 °C. Then immediately subject it to the bending test in accordance with the test method given in **B.3**.

B.3 Test method

B.3.1 *Apparatus*

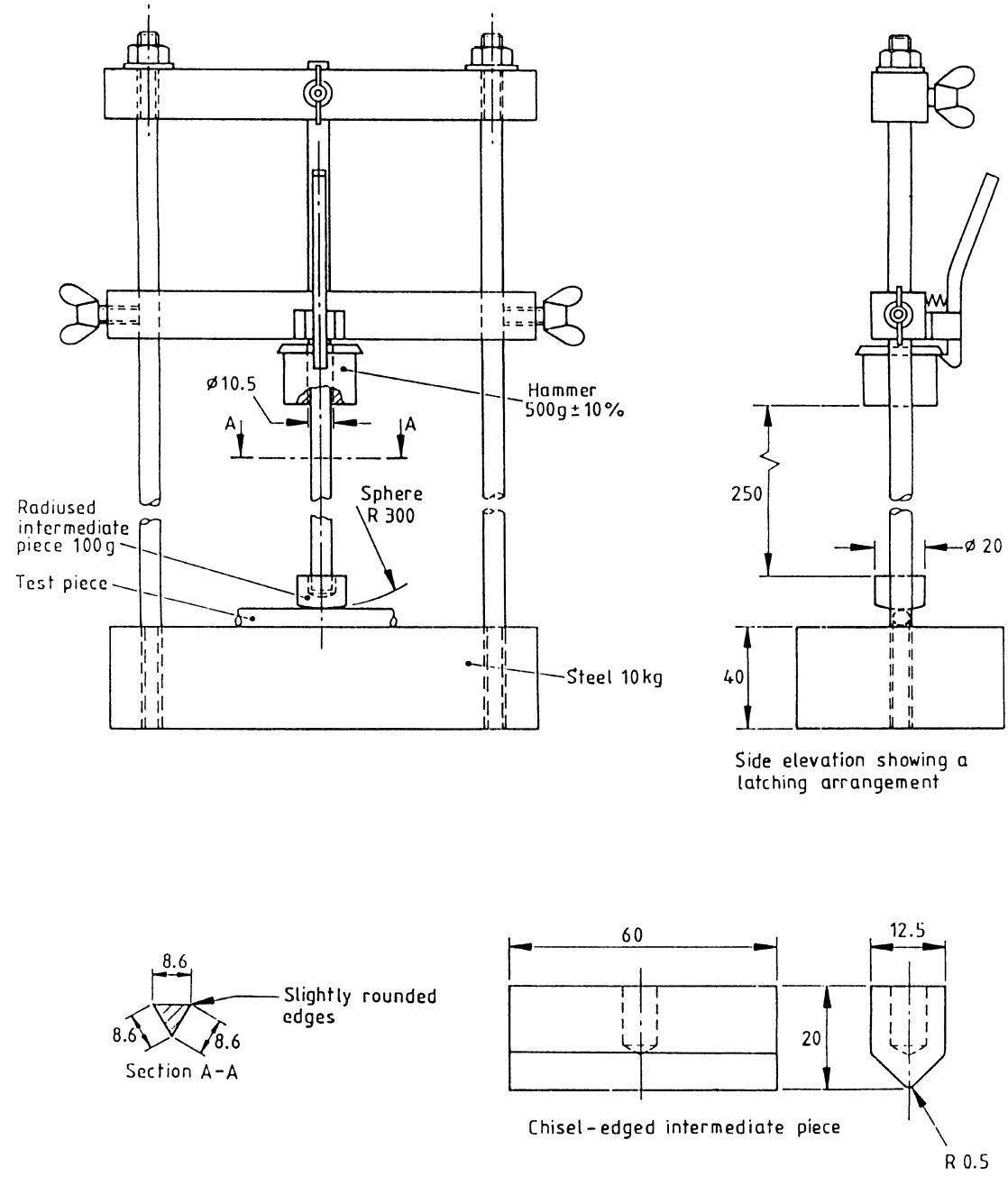
A test mandrel having a diameter $12D$ ± 5 % where D is the external diameter of the completed cable.

B.3.2 *Procedure*

Take a cable sample having a length at least five times the mandrel diameter and not less than 1 500 mm if the test for resistance to fire with water is later to be carried out (see **D.3.2**). Mount the test mandrel on a horizontal or vertical axis about which it is free to rotate. Lay out the cable sample straight on a level surface and secure one cable end to the test mandrel through a swivel connection. Draw a reference line along the top of the cable parallel to its longitudinal axis.

Rotate the mandrel steadily so that all the cable is wound on in a closely wrapped coil, preventing the cable from twisting during the operation. Then rotate the mandrel in the opposite direction so that the cable is unwound and again laid straight on the level surface. Rotate the cable through 180° around its longitudinal axis and repeat the winding and unwinding processes.

Apply the test voltage, increasing the voltage gradually and maintaining it at the full r.m.s. value given in Table 2 for 1 min, between each conductor in turn and all the other conductors connected together and also connected to the circuit protective conductor, drain wire and metallic layer, if any.



All dimensions are in millimetres.

Figure 1 — Apparatus for test for resistance to impact

Annex C Test for resistance to impact at ambient temperature

Cables shall be tested for resistance to impact at a temperature of 20 ± 5 °C using the apparatus illustrated in Figure 1, both with a chisel-edged intermediate piece placed with its longitudinal axis at right angles to that of the cable and also a radiused intermediate piece.

Stand the impact test apparatus on a firm base. Take six samples of cable, each approximately 500 mm long, and remove 100 mm of each sheath from each end to allow the cores to be separated. Place the six samples successively in position on the impact test apparatus and allow the 500 g hammer to fall from a height of 250 mm, three samples being tested with the chisel-edged intermediate piece and three with the radiused intermediate piece. A reference line shall be drawn along the top of the cable parallel to its longitudinal axis prior to cutting the six samples. For each set of three samples, the impact position on each successive sample shall be approximately 120° from the previous position.

Then apply the test voltage, increasing the voltage gradually and maintaining it at the full r.m.s. value given in Table 2 for 1 min, to each of the samples, between each conductor in turn and all the others connected together and also connected to the circuit protective conductor, drain wire and metallic layer, if any.

Annex D Tests for fire resistance characteristics

D.1 Test conditions

Carry out the tests in a suitable chamber provided with the means of disposing of noxious gases resulting from the burning and with draught shields fitted near the burner assembly, if found necessary.

D.2 Resistance to fire alone

D.2.1 ***Apparatus***

D.2.1.1 *General*

The test rig for verifying resistance to fire alone consists of the following:

a) a cable supporting system, as described in **D.2.1.2**;

b) a continuity checking arrangement, as described in **D.2.1.3**;

c) a source of heat, as described in **D.2.1.4**.

D.2.1.2 *Cable supporting system*

The cable is held horizontally by means of suitable clamps at each end of the sheathed or protected portion. The middle portion of the cable is supported by two metal rings placed approximately 300 mm apart and these as well as any other metal parts of the supporting apparatus are earthed. The cable supporting arrangement is shown in Figure 2. For unarmoured cables less than 10 mm in diameter, or for other cables where significant movement of the cable occurs during the test, three additional metal supporting rings, each placed approximately 150 mm from the two previously specified rings, shall be used to support the cable.

D.2.1.3 *Continuity checking arrangement*

During the test a current is passed through all cores of the cable and this is provided by a three-phase star-connected transformer or three single-phase transformers (or one single-phase transformer if testing a single-core cable) of sufficient capacity to maintain the test voltage up to the maximum leakage current allowable, i.e. to 3 A. At the opposite end of the cable a lamp (with ballast resistor if necessary) is connected to each core with a power rating such that each core carries a current of approximately 0.25 A at the rated voltage of the cable.

D.2.1.4 *Source of heat*

The recommended source of heat is a 610 mm long tube-type gas burner which produces a line of closely spaced flames using propane or other gas with a forced air supply, but other equipment may be used for the tests provided that the temperature and time test conditions are achieved.

NOTE Experience has shown that gases other than propane may be required for 650 °C.

A thermocouple not more than 2 mm in diameter suitable for the temperature (e.g. platinum-iridium) is inserted in the flame at the end close to the gas inlet with the thermocouple parallel to the burner and situated 75 mm above it.

D.2.2 ***Flame temperature and duration of test***

The flame temperature used and the duration of the test shall be selected from the following categories:

category A 650 ± 40 °C for 3 h

category B 750 ± 40 °C for 3 h

category C 950 ± 40 °C for 3 h

category S 950 ± 40 °C for 20 min.

D.2.3 ***Sample***

The sample to be tested shall be a piece of the completed cable not less than 1 200 mm long, with 100 mm of sheath and outer coverings removed from each end. At the ends of the cable the conductors shall be suitably prepared for electrical connections in accordance with the manufacturer's recommendations.

D.2.4 ***Procedure***

Mount the sample of cable in the clamps and adjust the metal supporting rings as described in **D.2.1.2**.

Connect the transformer or transformers to the conductors at one end of the cable, excluding any conductor that is specifically identified as intended for use as a neutral or protective conductor. For single, twin or three conductor cables, connect each conductor to be connected to a separate phase of the transformer output with a 3 A fuse or circuit breaker in each phase. For cables with more than three conductors to be connected divide the conductors into three groups, ensuring that adjacent conductors are in different groups, as far as possible. Connect the conductors in each group in parallel and connect each group to a separate phase of the transformer output, with a 3 A fuse or circuit breaker in each phase. Alternatively, place a 3 A fuse or circuit breaker in series with each conductor; in the case of dispute this alternative shall be the reference method. An example of the alternative circuit arrangements for a four conductor cable is shown in Figure 10, where Figure 10(b) shows the reference method. At the transformer end of the sample, earth the neutral conductor, the protective conductor and any drain wire and metallic layer. At the other end of the cable, connect one terminal of a lamp as described in **D.2.1.3** to each phase conductor and the other terminal to the neutral conductor if there is one, or otherwise to the protective conductor if there is one, or otherwise to any metallic layer.

Adjust the apparatus so that the cable may later be lowered into position with the minimum of readjustment.

Switch on the electricity supply and adjust the voltage between phases to the rated voltage U (or in the case of a single-core cable to the rated voltage to earth U_0).

NOTE For cables with rated voltages other than specified in **4.2**, the test voltage should be the rated voltage (see scope).

With the thermocouple in position, light the burners and adjust the gas and air supplies until the test temperature for the appropriate category in accordance with **D.2.2** is steadily registered.

Remove the thermocouple and lower the cable into position, so that it is parallel with the burner and the lower surface of the cable is 75 mm above the burner. Continue the test for the duration for the appropriate category in accordance with **D.2.2**.

The burner surface shall be periodically cleaned, throughout the test, to ensure the removal of fallen debris. If, for safety reasons, the test supply voltage needs to be switched off during the cleaning, extend the test time accordingly.

D.3 Resistance to fire with water

D.3.1 ***Apparatus***

D.3.1.1 *General*

The test rig for verifying resistance to fire with water consists of the following items:

a) a cable supporting system as described in **D.3.1.2**;

b) a continuity checking arrangement as described in **D.3.1.3**;

c) a source of heat as described in **D.3.1.4**;

d) a water spray as described in **D.3.1.5**.

D.3.1.2 *Cable supporting system*

The cable is attached to a metal support consisting of two strips of steel 25 mm wide by means of metal clips as shown in Figure 3, the spacing of the clips being approximately 200 mm. This assembly with the cable attached is supported in the test frame as shown in Figure 4 and Figure 5 and this frame is earthed.

D.3.1.3 *Continuity checking arrangement*

During the test a current is passed through all cores of the cable and this is provided by a three-phase star-connected transformer or three single-phase transformers (or one single-phase transformer if testing a single-core cable) of sufficient capacity to maintain the test voltage up to the maximum leakage current allowable, i.e. to 3 A. At the opposite end of the cable a lamp (with ballast resistor if necessary) is connected to each core with a power rating such that each core carries a current of approximately 0.25 A at the rated voltage of the cable.

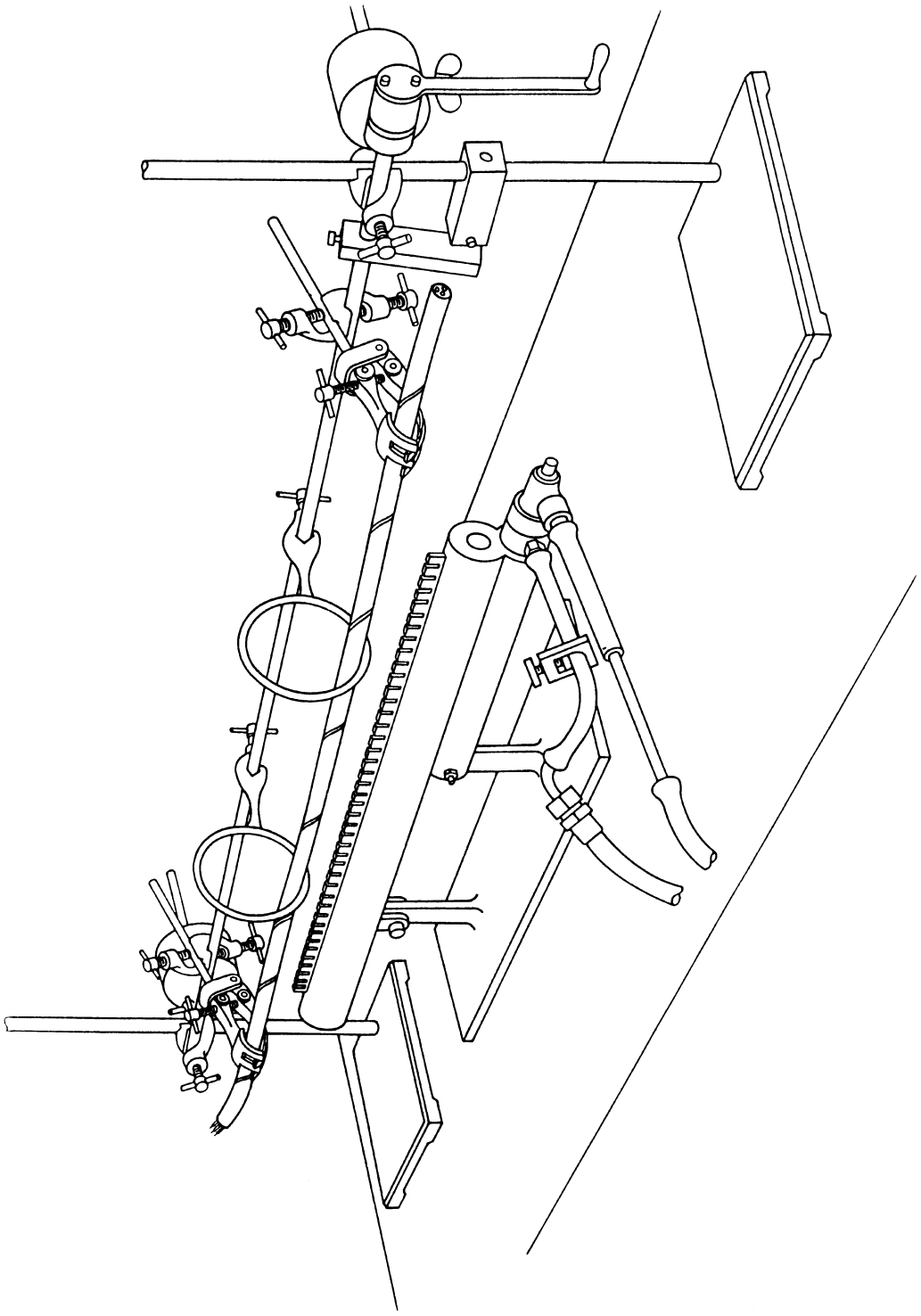


Figure 2 — Cable supporting arrangement for test for fire resistance alone

D.3.1.4 *Source of heat*

The source of heat shall be a burner assembly consisting of either a) or b).

a) Five separate propane or natural gas burners, each having an orifice 36 mm long and 5 mm wide (± 5 %), mounted horizontally at 100 mm centres.

NOTE For information on a suitable type of burner write to Customer Services, Information, BSI, Linford Wood, MK14 6LE.

b) A ribbon propane or natural gas burner at least 400 mm in length.

The burner assembly shall be arranged so as to burn approximately 400 mm of the cable sample. The burner assembly shall be adjusted to give a luminous flame having a temperature of 650 ± 40 °C when measured using a thermocouple, not more than 2 mm in diameter, placed at the position that the lower surface of the cable sample will occupy during the test.

In the case of five separate burners, all shall be adjusted to give similar flame conditions.

D.3.1.5 *Water spray*

A sprinkler head as shown in Figure 6[1)] is fixed to the test frame as shown in Figure 4 and Figure 5, positioned centrally with respect to the burner assembly. It uses water at a supply pressure between 250 kPa and 350 kPa with a rate of water application in the vicinity of the cable sample between 0.25 l per square metre per second and 0.30 l per square metre per second. The rate shall be measured using a collection tray, of sufficient depth, placed centrally about the position to be occupied by the cable with its long axis placed along the cable axis. The tray shall be approximately 100 mm wide and 400 mm long.

D.3.2 ***Sample and sample treatment***

The sample to be tested shall be a piece of completed cable at least 1 500 mm long, which has been subjected to the bending test at ambient temperature, with 100 mm of the sheath or outer covering removed from each end. At the ends of the cable the conductors shall be suitably prepared for electrical connections in accordance with the manufacturer's recommendations.

D.3.3 Procedure

Connect the transformer or transformers to the conductors at one end of the cable, excluding any conductor that is specifically identified as intended for use as a neutral or protective conductor. For single, twin or three conductor cables, connect each conductor to be connected to a separate phase of the transformer output with a 3 A fuse or circuit breaker in each phase. For cables with more than three conductors to be connected divide the conductors into three groups, ensuring that adjacent conductors are in different groups, as far as possible. Connect the conductors in each group in parallel and connect each group to a separate phase of the transformer output, with a 3 A fuse or circuit breaker in each phase. Alternatively, place a 3 A fuse or circuit breaker in series with each connector; in the case of dispute this alternative shall be the reference method. An example of the alternative circuit arrangements for a four conductor cable is shown in Figure 10 where Figure 10(b) shows the reference method. At the transformer end of the sample, earth the neutral conductor, the protective conductor and any drain wire and metallic layer. At the other end of the cable connect one terminal of a lamp as described in **D.3.1.3** to each phase conductor and the other terminal to the neutral conductor if there is one, or otherwise to the protective conductor if there is one, or otherwise to any metallic layer.

Open the gas supply fully and ignite the burner(s). Adjust the flame temperature to 650 ± 40 °C by means of regulator valves in the supply.

Extinguish the flames by turning off the gas supply to the burner assembly, leaving the position of the regulator valves in the supply unchanged.

Attach the cable sample to the steel support as described in **D.3.1.2** and place the assembly in position on the test frame (see Figure 4).

Switch on the electrical supply and adjust the voltage between phases to the rated voltage U (or in the case of a single-core cable to the rated voltage to earth U_o).

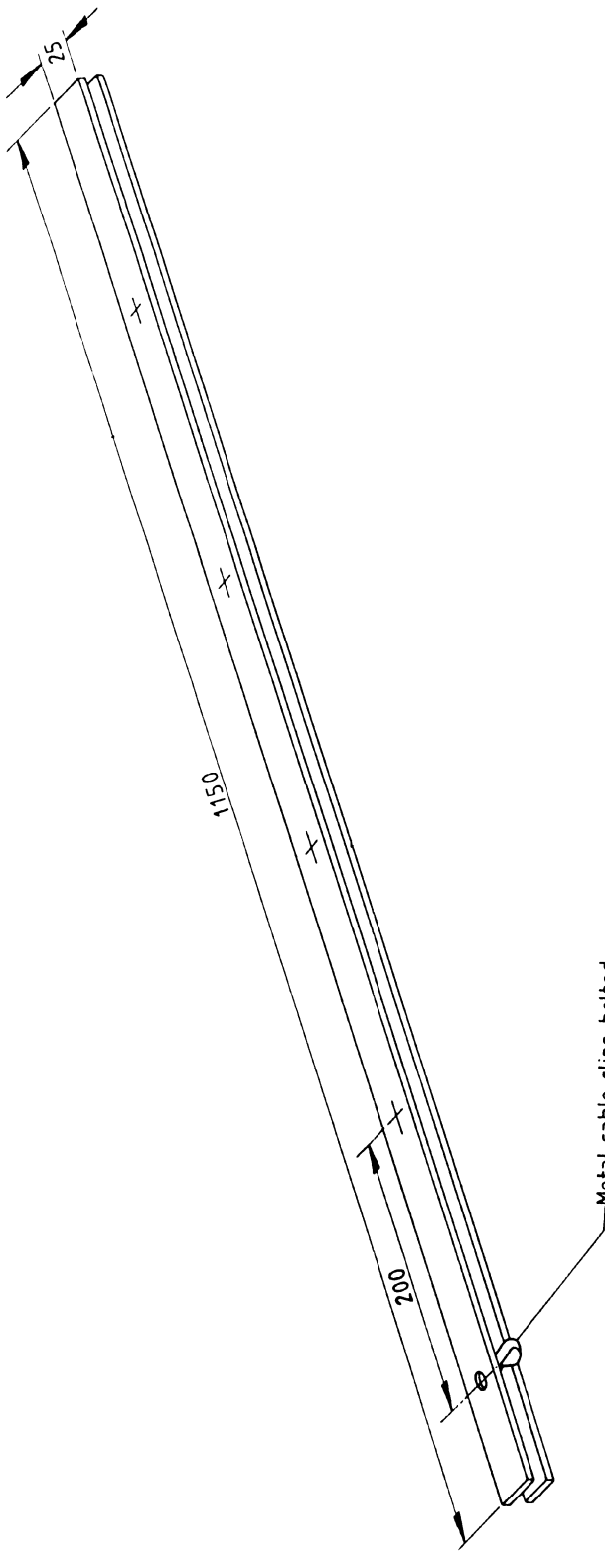
NOTE For cables with rated voltages other than specified in **4.2**, the test voltage should be the rated voltage (see scope).

Turn on the gas supply and re-ignite the burner(s).

After 15 min of burning, turn on the water supply to the sprinkler head to give a spray of water over the burned area of the cable sample.

Continue the flame and water spray for a further 15 min.

[1)] There is at present no British Standard for this sprinkler jet. An ISO standard has been published and it is expected that this will eventually lead to a British Standard to which cross-reference can be made. If this ISO standard is published as a British Standard, BS 6387 will be reviewed for possible amendment.



All dimensions are in millimetres and are approximate.

Figure 3 — Method of supporting cable for test for resistance to fire with water

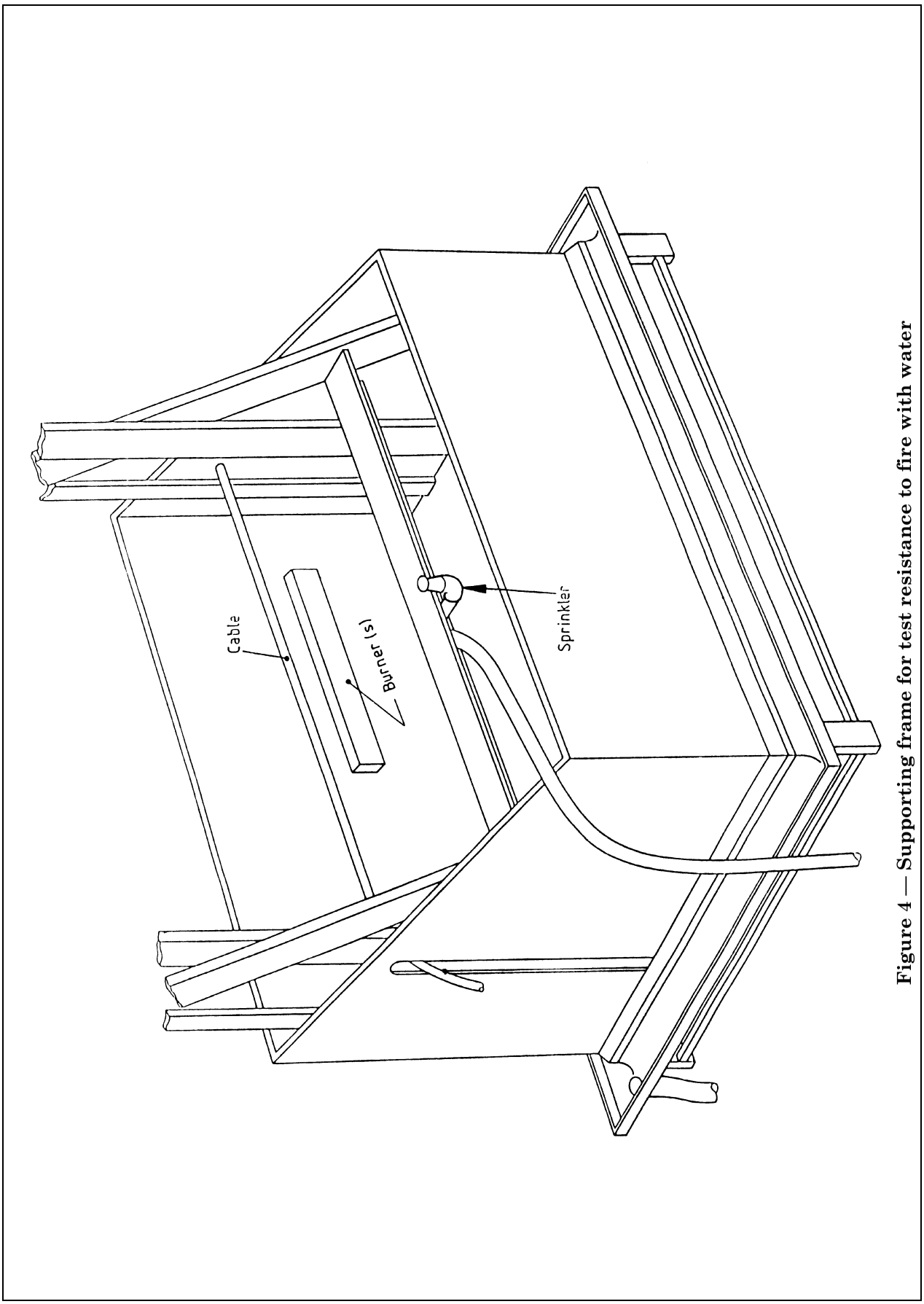
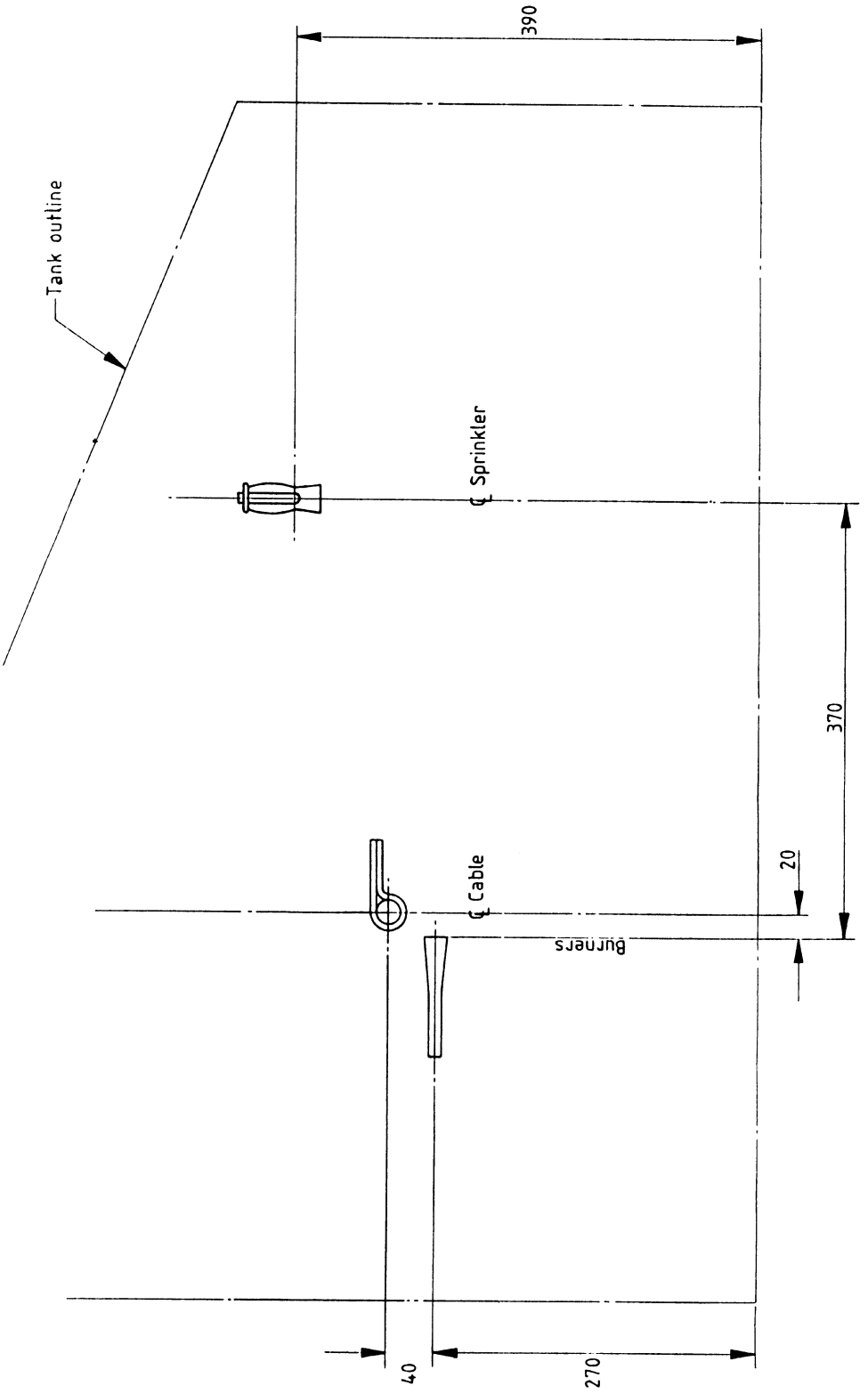


Figure 4 — Supporting frame for test resistance to fire with water



Tolerance on all dimensions ± 5 %.
All dimensions are in millimetres.

Figure 5 — End elevation of supporting frame for test for resistance to fire with water

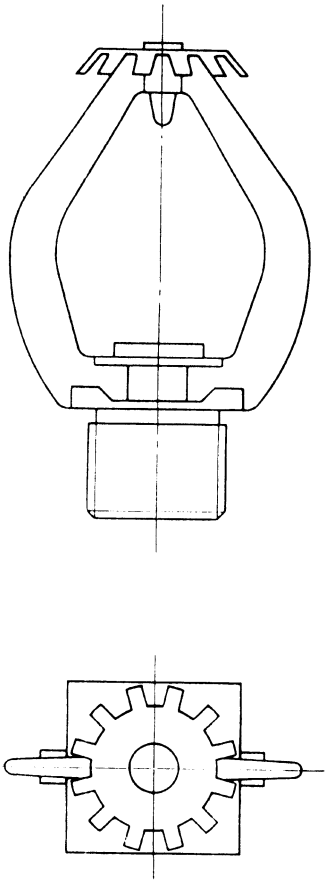


Figure 6 — Typical sprinkler head for test for resistance to fire with water

D.4 Resistance to fire with mechanical shock

D.4.1 *Apparatus*

D.4.1.1 *General*

The test rig for verifying resistance of cables to fire with mechanical shock consists of the following items:

a) a vertical wall on to which the cable is mounted, comprising a board of heat-resisting incombustible material fastened to steel runners, as described in **D.4.1.2**;

b) a transformer or transformers with fuses and electric lamps for indicating that continuity is maintained, as described in **D.4.1.3**;

c) a shock producing device, as described in **D.4.1.4**;

d) a source of heat, as described in **D.4.1.5**.

A general arrangement of the test rig is shown in Figure 7. A slotted angle framework is a suitable means of supporting the components in their relative positions.

D.4.1.2 *The wall and its mounting*

The wall consists of a board of heat-resisting non-combustible material fastened rigidly to two horizontal steel runners, one at the top of the board and the other at the bottom. The board is approximately 900 mm long, 300 mm deep and 9 mm thick and the total mass of the wall (i.e. board plus supporting frame) shall be 10 ± 2 kg. Each runner is made from 25 mm square steel tube approximately 1 m in length. Ballast, if required, shall be placed inside the steel runners. It is important that the top runner is fastened to the board so that its upper face is flush with the upper edge of the board. Each runner has a horizontal hole drilled into it at each end outside the board, the exact position of each hole and its diameter being determined for the particular supporting bush used and the requirements of the supporting framework. The wall is fastened to the framework by four bonded rubber bushes approximately 32 mm in diameter and 20 mm thick as shown in Figure 8.

NOTE For information on suitable board material and rubber bushes write to Customer Services, Information, BSI, Linford Wood, MK14 6LE.

D.4.1.3 *Continuity checking arrangement*

During the test a current is passed through all cores of the cable and this is provided by a three-phase star-connected transformer or three single-phase transformers (or one single-phase transformer if testing a single-core cable) of sufficient capacity to maintain the test voltage up to the maximum leakage current allowable, i.e. to 3 A. At the opposite end of the cable a lamp (with ballast resistor if necessary) is connected to each core with a power rating such that each core carries a current of approximately 0.25 A at the rated voltage of the cable.

D.4.1.4 *Shock producing device*

The shock producing device consists of a mild steel round bar 25 mm ± 5 % in diameter and 600 mm ± 5 % long. The rod is freely pivoted about an axis parallel to the wall, which is in the same horizontal plane as, and 200 mm away from, the upper edge of the wall. The axis divides the rod into two unequal sections of length 200 mm and 400 mm respectively, the longer section impacting the wall. Once every 30 ± 2 s the rod drops under its own weight from an angle of 60° to the horizontal to strike the top of the wall at its midpoint (see Figure 7).

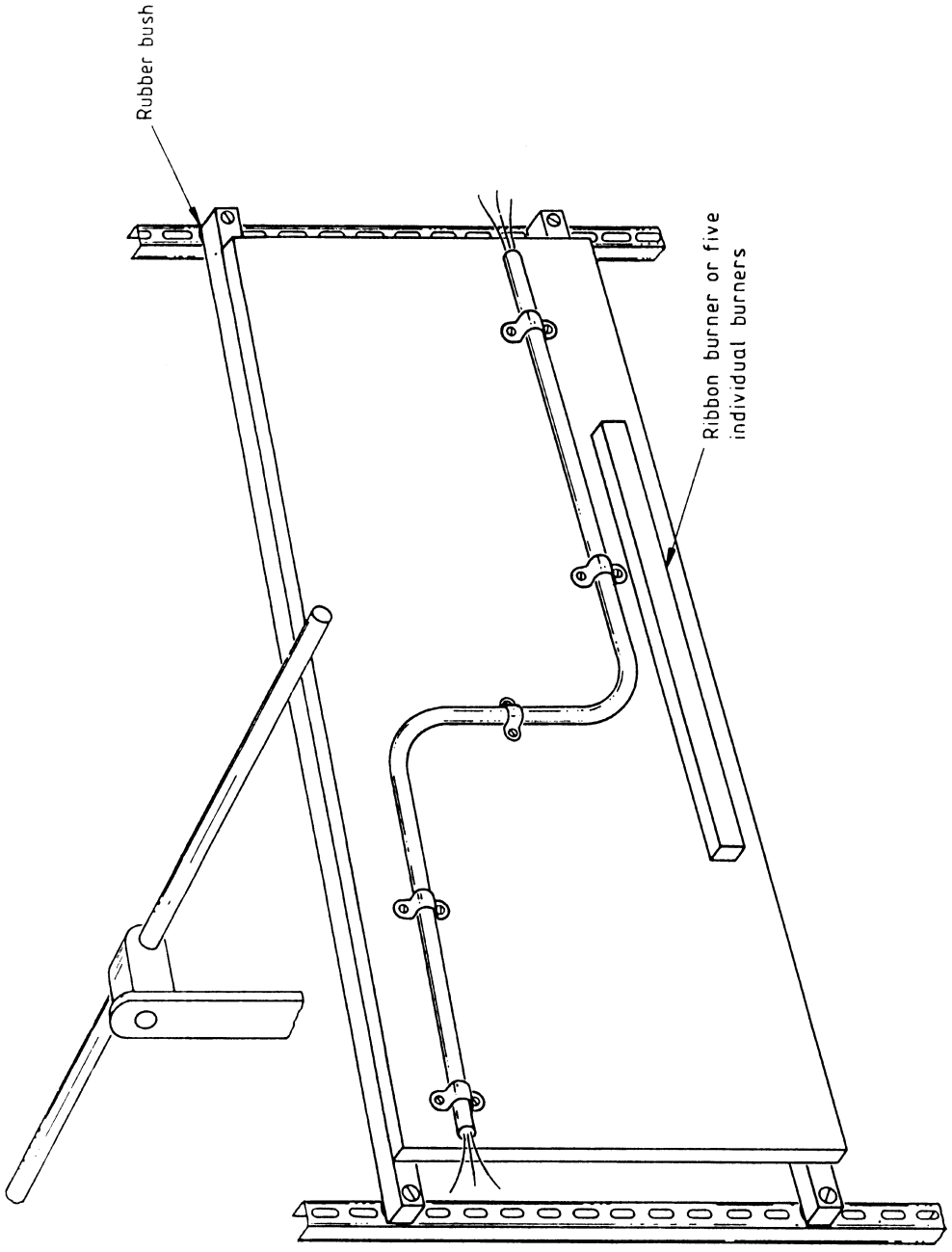
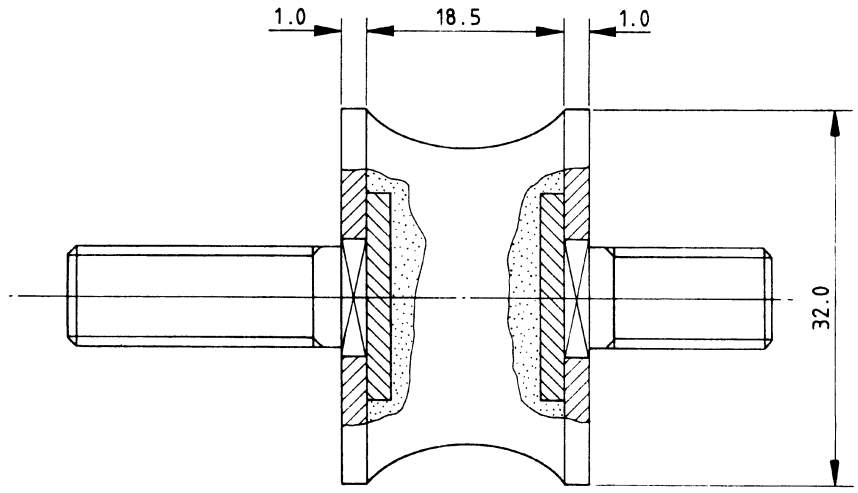


Figure 7 — Rig for test for resistance to fire with mechanical shock



All dimensions are in millimetres.

Figure 8 — Typical rubber bush for fastening wall for test for resistance to fire with mechanical shock

D.4.1.5 *Source of heat*

The source of heat shall be a burner assembly similar to that described in **D.3.1.4**, but adjustable so that a nominal flame temperature over the range 650 °C to 950 °C can be obtained at the specified thermocouple position, as shown in Figure 9. The burner assembly is positioned so that its centre is in line with the vertical section of the cable sample.

A thermocouple not more than 2 mm in diameter suitable for the temperature (e.g. platinum-iridium) is mounted on the wall in the position shown in Figure 9, to measure the flame temperature. The thermocouple shall protrude through the wall such that the tip of the thermocouple is between 8 mm and 10 mm from the wall.

The heat flow rate is measured by the following procedure. Fit a thermocouple at one end of a mild steel rod 3 mm ± 5 % in diameter and more than 300 mm long, so that the temperature at the end of the rod can be measured. Hold the end with the thermocouple attached in the flame so that the end of the rod is between 40 mm and 50 mm from the burner. The heat flow rate shall be such that when the flame temperature is 950 °C, the temperature of the steel rod reaches 400 °C in not less than 10 s and not more than 20 s, and when the flame temperature is 650 °C, the temperature of the steel rod reaches 400 °C in not less than 20 s and not more than 40 s.

D.4.2 ***Flame temperature for test***

The flame temperature used for the test shall be selected from the following categories:

category X 650 ± 40 °C

category Y 750 ± 40 °C

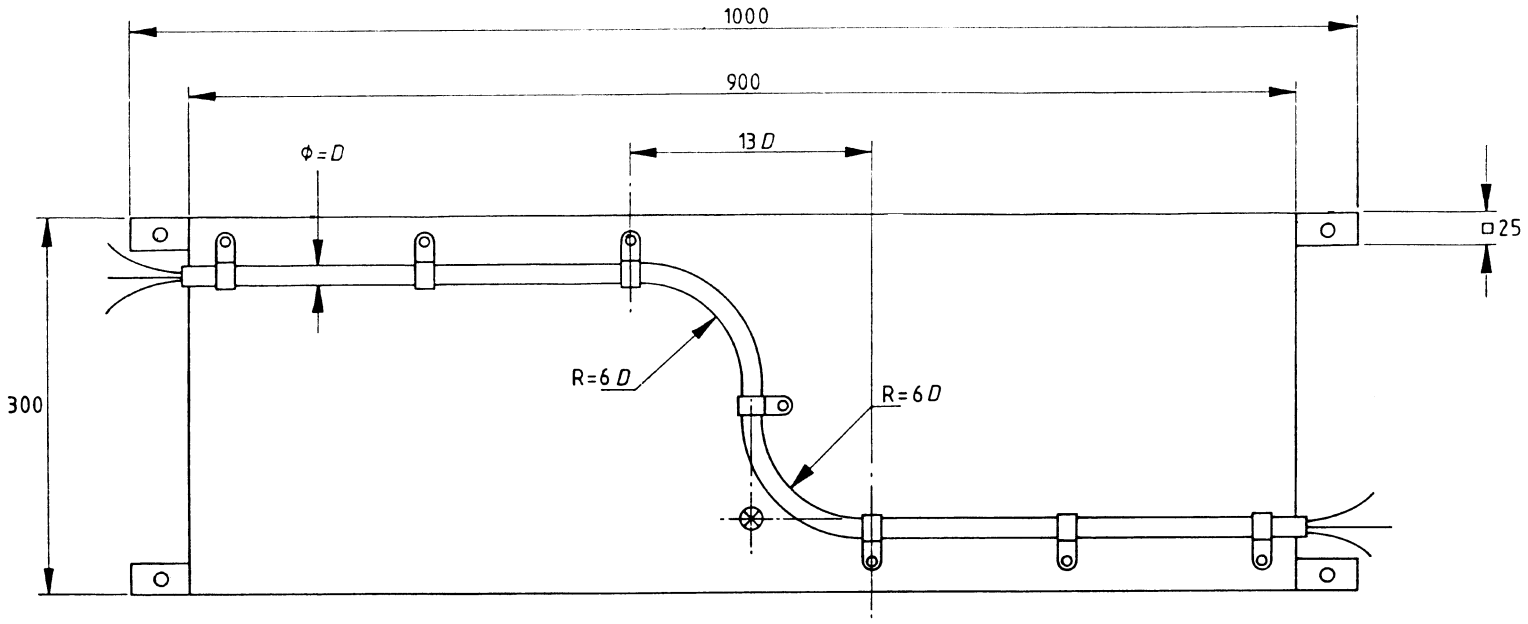
category Z 950 ± 40 °C

D.4.3 ***Sample***

The sample to be tested shall be a piece of the completed cable not less than 1 200 mm long with 100 mm of sheath and outer coverings removed from each end. At the ends of the cable the conductors shall be suitably prepared for electrical connections in accordance with the manufacturer's recommendations.

The cable shall be bent to form two approximately equal horizontal lengths with a double bend in the middle. The internal radius of each bend shall be approximately 6*D* where *D* is the overall diameter of the cable. Each bend turns the cable through 90° so that the cable describes a Z shape, the centre of each bend being in the same horizontal plane and separated by 13*D* as shown in Figure 9.

The cable shall be mounted on the wall using copper P clips, as recommended by the manufacturer for wall-mounting the particular cable under test. The clips shall support the cable between the two bends where the cable is vertical, at the points where the cable becomes horizontal adjacent to each bend and at equal distances along the horizontal sections, the space between adjacent clips being between 150 mm and 200 mm.



Key

⊗ Thermocouple

D Is the overall diameter of the cable

Tolerance on all dimensions ± 5 %.

All dimensions are in millimetres.

Figure 9 — Cable mounting for test for resistance to fire with mechanical shock

D.4.4
Procedure

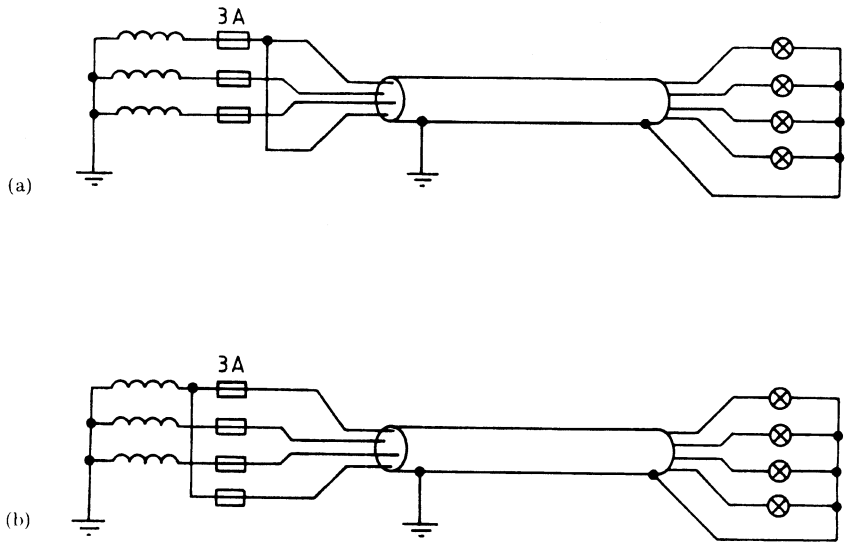
Check that the wall and shock producing device are mounted as described in **D.4.1.2** and **D.4.1.4** and that the cable sample and thermocouple are mounted on to the wall in accordance with Figure 8 and Figure 9.

Connect the transformer or transformers to the conductors at one end of the cable, excluding any conductor that is specifically identified as intended for use as a neutral or protective conductor. For single, twin or three conductor cables, connect each conductor to be connected to a separate phase of the transformer output with a 3 A fuse or circuit breaker in each phase. For cables with more than three conductors to be connected, divide the conductors into three groups, ensuring that adjacent conductors are in different groups, as far as possible. Connect the conductors in each group in parallel and connect each group to a separate phase of the transformer output, with a 3 A fuse or circuit breaker in each phase. Alternatively, place a 3 A fuse or circuit breaker in series with each conductor; in the case of dispute this alternative shall be the reference method. An example of the alternative circuit arrangements for a four conductor cable is shown in Figure 10, where Figure 10(b) shows the reference method. At the transformer output and if there is only one conductor to be connected, use a single-phase transformer. At the transformer end of the sample, earth the neutral conductor, the protective conductor, and any drain wire and metallic layer. At the other end of the cable connect one terminal of a lamp as described in **D.4.1.3** to each phase conductor and the other terminal to the neutral conductor if there is one, or otherwise to the protective conductor if there is one, or otherwise to any metallic layer.

Switch on the electricity supply and adjust the voltage between phases to the rated voltage U (or in the case of a single-core cable, to the rated voltage to earth U_0).

Start the shock producing device and ignite the burners. Continue the test for 15 min.

NOTE For cables with rated voltages other than specified in **4.2**, the test voltage should be the rated voltage (see scope).



NOTE. This figure shows circuit arrangements for a four-core cable without an identified neutral or protective conductor and with a bare metallic sheath.

Figure 10 — Alternative circuit arrangements

List of references (see clause 2)

Normative references

BSI standards publications

BRITISH STANDARDS INSTITUTION, London

BS 4066, *Tests on electric cables under fire conditions.*
BS 4066-1:1980, *Method of test on a single vertical insulated wire or cable.*
BS 4727, *Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms.*
BS 4727-2, *Terms particular to power engineering.*
BS 4727:Group 08:1986, *Electric cable terminology.*
BS 6207:1991, *Specification for mineral-insulated copper-sheathed cables with copper conductors.*
BS 6360:1991, *Specification for conductors in insulated cables and cords.*
BS 6469, *Insulating and sheathing materials of electric cables.*
BS 6469-1, *Methods of test for general application.*
BS 6469-1.4:1992, *Tests at low temperature.*

Informative references

IEC standards publication

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC), Geneva. (All publications are available from BSI Sales.)

IEC 331:1970, *Fire-resisting characteristics of electric cables*[2)].

[2)] Referred to in the foreword only.

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