IEC 60331-1

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REDLINE VERSION

INTERNATIONAL STANDARD

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GROUP SAFETY PUBLICATION

Tests for electric cables under fire conditions – Circuit integrity – Part 1: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter exceeding 20 mm

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Part 1: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter exceeding 20 mm

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 60331-1 has been prepared by IEC technical committee 20: Electric cables.

This second edition cancels and replaces the first edition published in 2009. It constitutes a technical revision.

The significant technical changes with respect to the previous edition are as follows:

– extension of the scope to include metallic data and telecom cables and optical fibre cables, although details for the specific point of failure, continuity checking arrangement, test sample, test procedure and test report relevant to metallic data and telecom cables and optical fibre cables are not given by IEC 60331-1;
– improved description of the test environment;
– modified steel test ladder with two extra vertical elements to accommodate the modified testing of single core cables without concentric metal layer and the testing of cables with a bending radius in normal use larger than approximately 400 mm;
– mandatory use of mass flow meters/controllers as the means of controlling accurately the input flow rates of fuel and air to the burner;
– improved description of the information to be included in the test report.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
20/1781A/FDIS	20/1792/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

It has the status of a group safety publication in accordance with IEC Guide 104.

A list of all parts of the IEC 60331 series, published under the title: *Tests for electric cables under fire conditions – Circuit integrity*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The "colour inside" logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

INTRODUCTION

IEC 60331 consists of the following parts under the general title: *Tests for electric cables under fire conditions – Circuit integrity:*

Part 1: *Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter exceeding 20 mm*

Part 2: *Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter not exceeding 20 mm*

Part 3: *Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV tested in a metal enclosure*

Part 11: *Apparatus – Fire alone at a flame temperature of at least 750 °C*

Part 21: *Procedures and requirements – Cables of rated voltage up to and including 0,6/1,0 kV*

Part 23: *Procedures and requirements – Electric data cables*

Part 25: *Procedures and requirements – Optical fibre cables*

NOTE 1 Parts 21, 23 and 25 relate to fire-only conditions at a flame temperature of at least 750 °C.

NOTE 2 Parts 11, 21, 23 and 25 are no longer subject to maintenance. IEC 60331 Parts 1 and 2 are the recommended test procedures

Since its first edition (1970), IEC 60331 has been extended and has introduced a range of test apparatus in order that a test may be carried out on large and small power, control, data and optical fibre cables.

Successful tests carried out in accordance with this standard will enable an identification to be marked on the product.

TESTS FOR ELECTRIC CABLES UNDER FIRE CONDITIONS – CIRCUIT INTEGRITY –

Part 1: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter exceeding 20 mm

1 Scope

~~This part of IEC 60331 specifies the test apparatus and procedure and gives the performance requirements, including recommended flame application times, for low voltage power cables of rated voltage up to and including 0,6/1,0 kV and control cables with a rated voltage which are required to maintain circuit integrity when subject to fire and mechanical shock under specified conditions. It is intended for use when testing cables of greater than 20 mm overall diameter.~~

This part of IEC 60331 specifies the test method for cables which are required to maintain circuit integrity when subject to fire and mechanical shock under specified conditions.

This document is applicable to cables of rated voltage not exceeding 600 V/1 000 V, including those of rated voltage below 80 V, metallic data and telecom cables and optical fibre cables.

It is intended for use when testing cables of greater than 20 mm overall diameter.

~~NOTE~~ Cables of smaller diameter ~~should~~ are intended to be tested using the apparatus, procedure and requirements of IEC 60331-2.

~~This standard describes the means of test specimen preparation, the continuity checking arrangements, the electrical testing procedure, the method of burning the cables and the method of shock production, and gives requirements for evaluating test results.~~

This document includes details for the specific point of failure, continuity checking arrangement, test sample, test procedure and test report relevant to electric power and control cables with rated voltage up to and including 600 V/1 000 V. Details for the specific point of failure, continuity checking arrangement, test sample, test procedure and test report relevant to metallic data and telecom cables and optical fibre cables are not given by IEC 60331-1.

~~NOTE~~ Although the scope is restricted to cables with rated voltage up to and including 0,6/1,0 kV, the procedure ~~may~~ can be used, with the agreement of the manufacturer and the purchaser, for cables with rated voltage up to and including 1,8/3 (3,3) kV, provided that suitable fuses are used.

Annex A provides the method of verification of the burner and control system used for the test.

Requirements are stated for an identification that may optionally be marked on the cable to signify compliance with this document.

CAUTION – The test given in this 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.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 60584-1, *Thermocouples – Part 1: ~~Reference tables~~ EMF specifications and tolerances*

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*

~~IEC Guide 104, *The preparation of safety publications and the use of basic safety publications and group safety publications*~~

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
circuit integrity
ability of an electric cable to continue to operate in a designated manner whilst subjected to a specified flame source for a specified period of time under specified conditions

3.2
draught-free environment
space in which the results of tests are not significantly affected by the local air speed

4 ~~Test conditions –~~ Test environment

The test shall be carried out in a draught-free environment within a suitable chamber, of minimum volume ~~10~~ 20 m^3, with facilities for disposing of any noxious gases resulting from the burning. Sufficient ventilation shall be available to sustain the flame for the duration of the test. Air inlets and the exhaust chimney should be located in such a way that the burner flame remains stable during the verification procedure and test. If necessary, the burner shall be shielded from any draughts by the use of draught shields. Windows may be installed in the walls of the chamber in order to observe the behaviour of the cable during the test. Fume exhaust should be achieved by means of natural draught through a chimney located at least 1 m from the burner. A damper may be used for adjustment of ventilation conditions.

~~NOTE Guidance on the choice of suitable chambers is given in Annex B.~~

NOTE Experience has shown a chamber similar to the "3 m cube" specified in IEC 61034-1 to be suitable.

The chamber and test apparatus shall be at a temperature of between 10 °C and 40 °C at the start of each test.

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

~~NOTE The test given in this 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.~~

5 Test apparatus

5.1 Test equipment

The test equipment shall consist of the following:

a) a test ladder, on to which the test specimen is mounted, comprising a steel framework fastened to a rigid support as described in 5.2;

b) a source of heat comprising a horizontally mounted ribbon burner as described in 5.3;

c) a shock-producing device as described in 5.4;

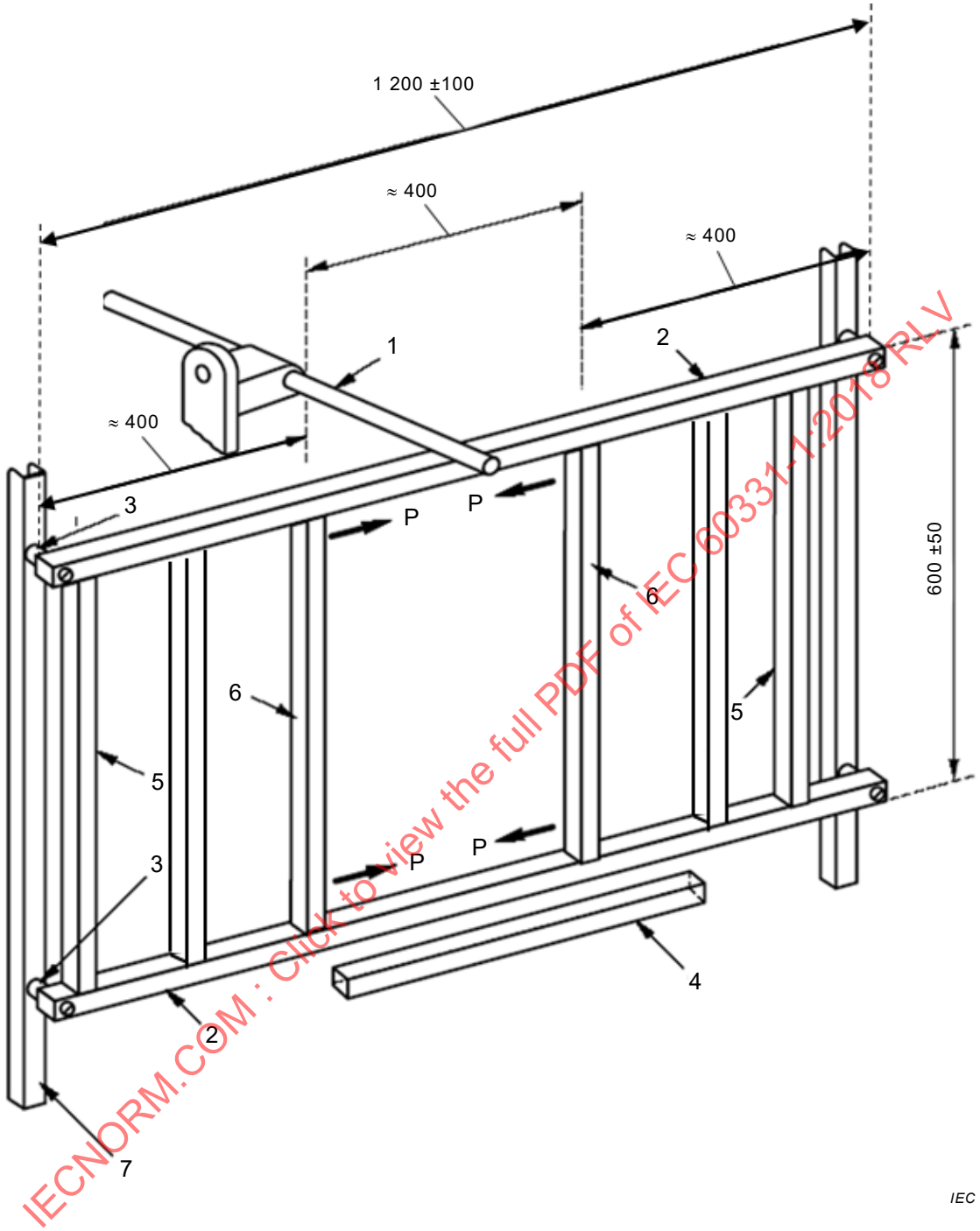
d) a test wall equipped with thermocouples for verification of the source of heat as described in Annex A;

e) a continuity checking arrangement as described in 5.6;

f) fuses as described in 5.7.

A general arrangement of the test equipment is shown in Figure 1, Figure 2 and Figure 3.

Dimensions in millimetres

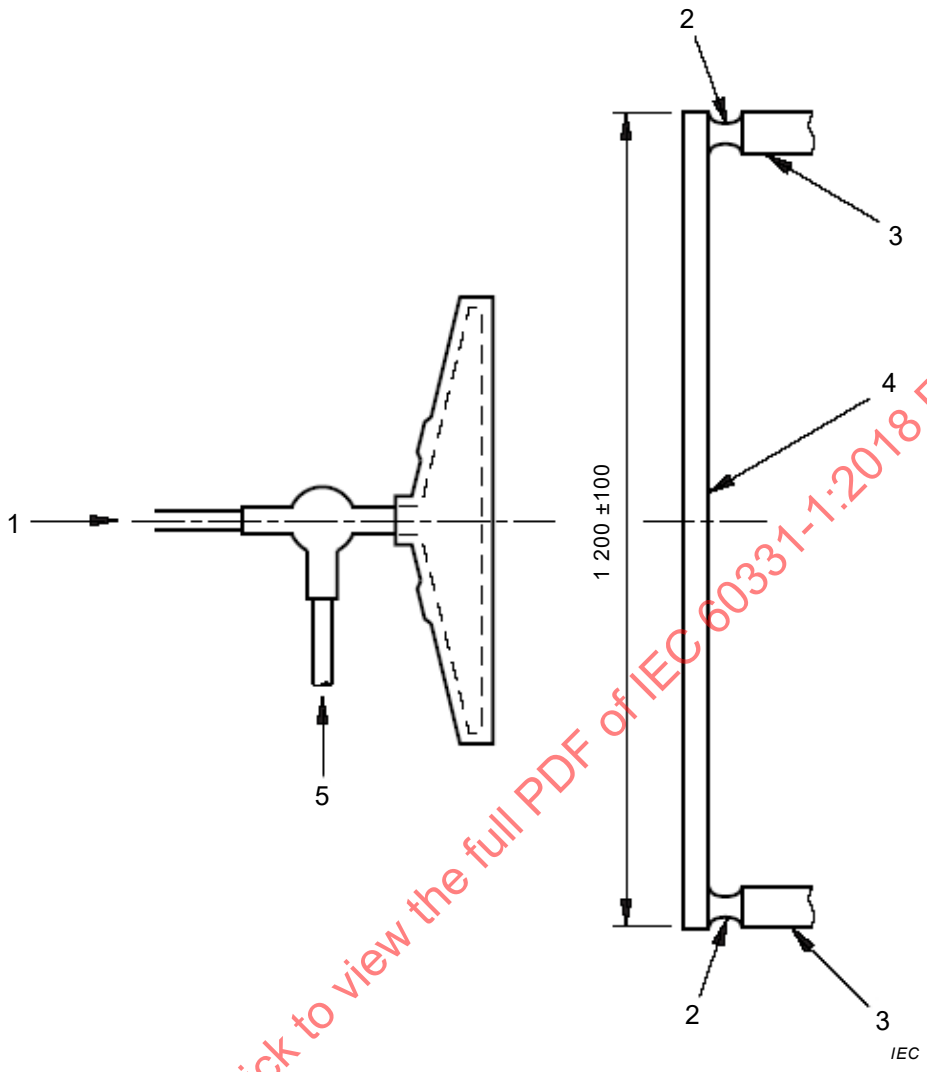


Key

1	shock producing device	5	fixed vertical elements of test ladder
2	steel test ladder	6	adjustable vertical elements of test ladder
3	rubber bush	7	rigid support framework
4	ribbon gas burner	P	plane of adjustment

Figure 1 – Schematic diagram of test configuration

Dimensions in millimetres

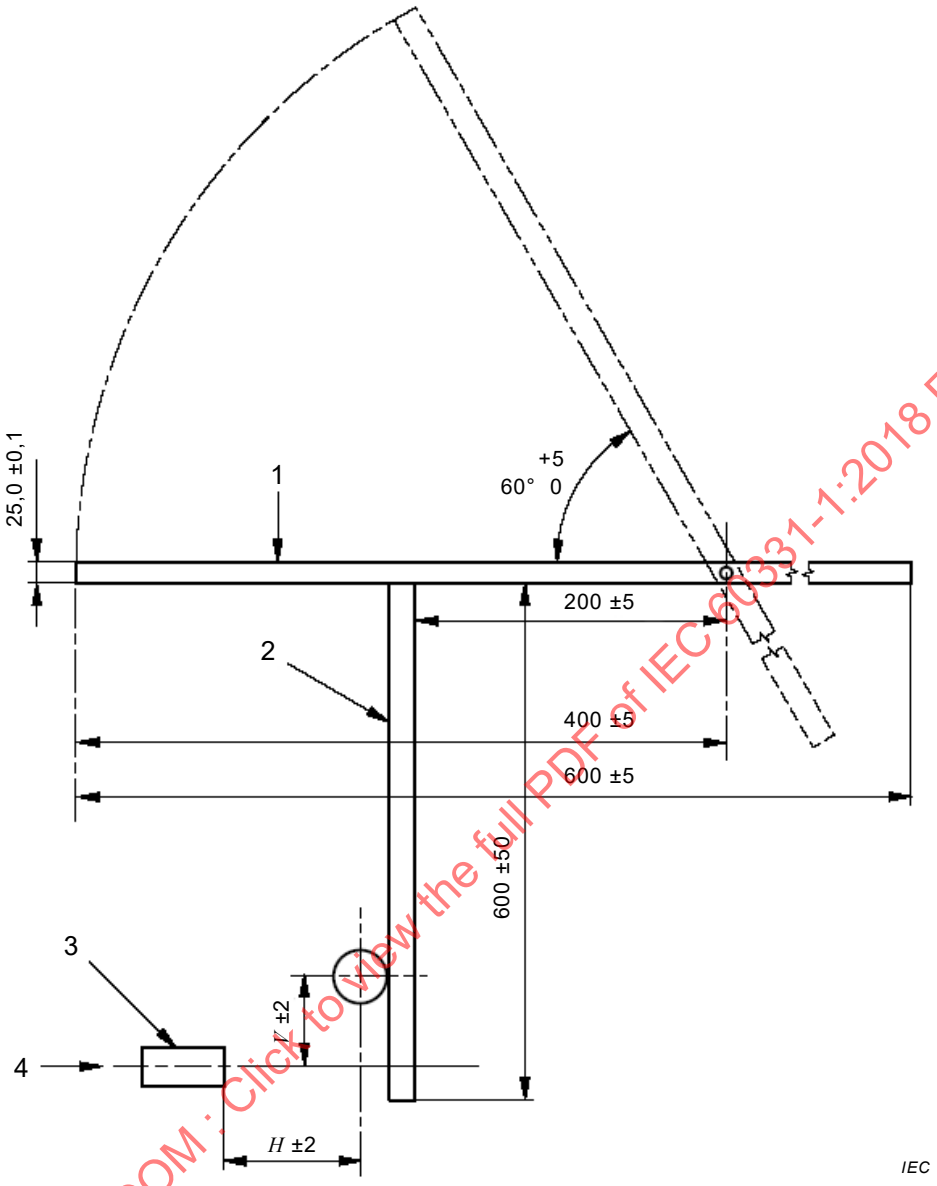


Key

1	entry for air	4	horizontal steel test ladder
2	rubber bush	5	entry for propane gas
3	rigid support framework		

Figure 2 – Plan view of fire test equipment

Dimensions in millimetres



Key

1	shock producing device	*H*	horizontal distance ~~of metal enclosure centre line~~ from burner face to the centre of the test specimen
2	steel test ladder	*V*	vertical distance ~~of metal enclosure centre line~~ from centre line of burner to the centre of the test specimen
3	gas burner		
4	centre line of burner face		

Figure 3 – End elevation of fire test equipment (not to scale)

5.2 Test ladder and mounting

The test ladder shall consist of a steel framework as shown in Figure 1. The ~~two~~ four central vertical elements of the ladder shall be adjustable in order to accommodate different sizes of cable under test. 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~~ 24 ± 1) kg. Ballast, if required, shall be placed on the steel supports.

NOTE 1 Angle iron approximately 45 mm wide and 6 mm thick, with suitable slots cut to allow for fixing of the bolts or saddles, has been found to be a suitable material for construction of the ladder.

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

NOTE 2 A typical rubber bush, which has been found to be suitable, is shown in Figure 4.

Dimensions in millimetres

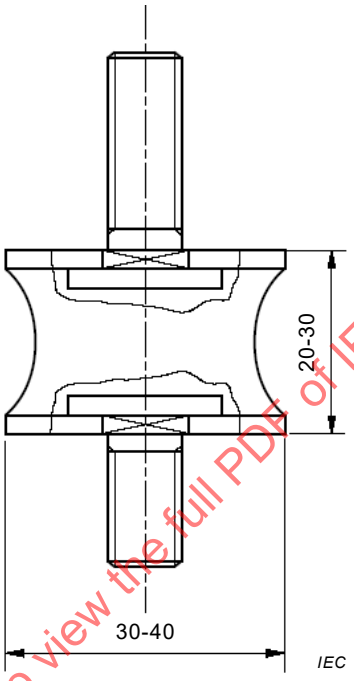


Figure 4 – Typical rubber bush for supporting the test ladder

5.3 Source of heat

5.3.1 Burner

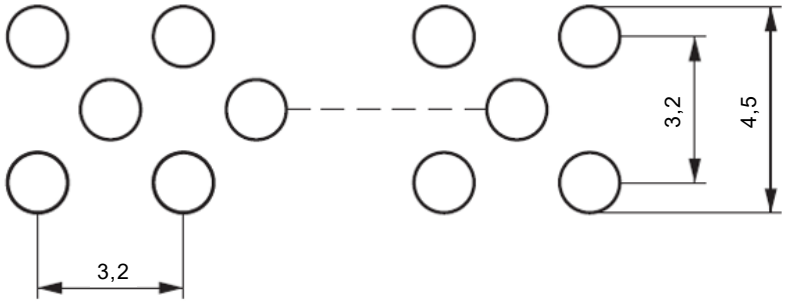
The source of heat shall be a ribbon type propane gas burner with a nominal burner face length of 500 mm (outer distance between outer holes) with a venturi mixer. The nominal burner face width shall be 10 mm. The face of the burner shall have three staggered rows of drilled holes, nominally 1,32 mm in diameter and drilled at centres 3,2 mm from one another, as shown in Figure 5.

A centre-feed burner is recommended.

~~Additionally,~~ A row of small holes milled on each side of the burner plate, to serve as pilot holes for keeping the flame burning, is permitted.

Guidance on the choice of a recommended burner system is given in Annex B.

Dimensions in millimetres
(Dimensions are approximate)



NOTE Round holes, 1,32 mm in diameter, on centres 3,2 mm from one another, staggered in three rows and centred on the face of the burner. Nominal burner face length 500 mm.

Figure 5 – Burner face

5.3.2 Flow meters and flow rates

Mass flow meters/controllers ~~should~~ shall be used as the means of controlling accurately the input flow rates of fuel and air to the burner.

~~NOTE Rotameter type flow meters may be used as an alternative, but are not recommended. Guidance on their use, and the application of appropriate correction factors is given in IEC 60331-11:1999, Annex C.~~

~~NOTE Figure 6 shows an example of a rotameter type system.~~

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

The mass flow rates used for the test shall be as follows:

~~– air: (160 ± 8) l/min at reference conditions (1 bar and 20 °C) or (3 267 ± 163) mg/s ;~~

~~– propane: (10 ± 0,4) l/min at reference conditions (1 bar and 20 °C) or (319 ± 13) mg/s ;.~~

Propane: (320 ± 13) mg/s

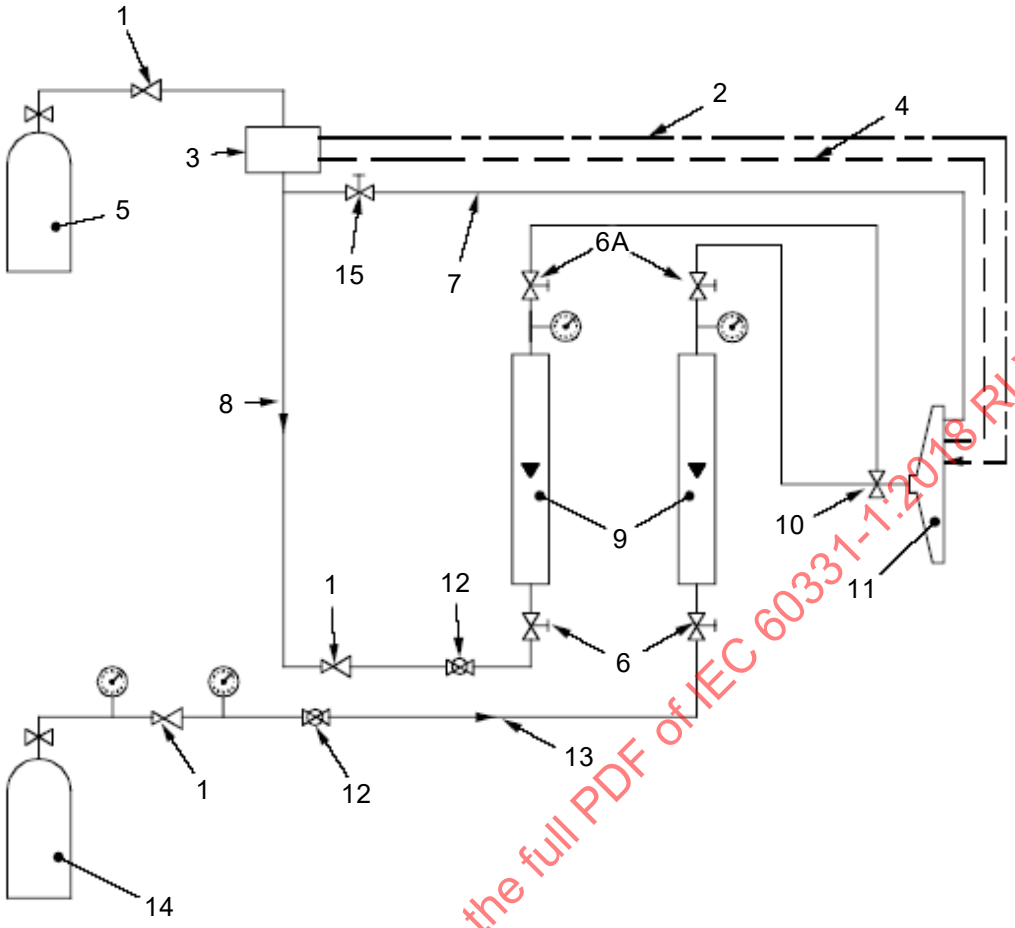
NOTE 1 This is approximately equivalent to a volume flow rate of (10,0 ± 0,4) litres/min at reference conditions (1 bar and 20 °C).

~~NOTE~~ The purity of the propane is not defined. Industrial grades that contain impurities are allowed provided that the calibration requirements are achieved.

Air: (3 270 ± 163) mg/s

NOTE 2 This is approximately equivalent to a volume flow rate of (160 ± 8) litres/min at reference conditions (1 bar and 20 °C).

A schematic diagram of an example of a burner control system is given in Figure 6.



Key

1	regulator	9	mass flow meters
2	piezoelectric igniter	10	venturi mixer
3	flame failure device	11	burner
4	control thermocouples	12	ball valve
5	propane cylinder	13	air flow
6	screw valve (6A = alternative position)	14	compressed air cylinder
7	pilot feed	15	screw valve on pilot feed
8	gas flow		

Figure 6 – Schematic diagram of an example of a burner control system ~~using rotameters~~

5.3.3 Verification

The burner and control system shall be subject to verification following the procedure given in Annex A.

5.4 Shock producing device

The shock-producing device shall consist of a mild steel round bar (25,0 ± 0,1) mm in diameter and (600 ± 5) mm long. The bar shall be freely pivoted about an axis parallel to the test ladder, which shall be in the same horizontal plane as, and (200 ± 5) mm away from, the upper edge of the ladder. The axis shall divide the bar into two unequal lengths, the longer length being (400 ± 5) mm which shall impact the ladder. The bar shall drop under its own

weight from an angle of $(60^{+5}_{0})°$ to the horizontal to strike the upper edge of the ladder at its midpoint as shown in Figure 1 and Figure 3.

5.5 Positioning of source of heat

The burner face shall be positioned in the test chamber so that it is at least 200 mm above the floor of the chamber, or any solid mounting block, and at least 500 mm from any chamber wall.

By reference to the centre point of the test specimen (cable) to be tested, the burner shall be positioned centrally at a horizontal distance of $(H \pm 2)$ mm from the burner face to the centre of the test specimen and at a vertical distance of $(V \pm 2)$ mm from the burner horizontal central plane to the centre of the test specimen, as shown in Figure 3.

The exact burner location to be used during cable testing shall be determined using the verification procedure given in Annex A, where the values of H and V to be used shall be determined.

~~NOTE~~ The burner should be rigidly fixed to the framework during testing so as to prevent movement relative to the test specimen.

5.6 Continuity checking arrangements for electric power and control cables with rated voltage up to and including 600 V/1 000 V

During the test, a current for continuity checking shall be passed through all conductors of the test specimen. This shall be provided by a three-phase star connected or single-phase transformer(s) of sufficient capacity to maintain the test voltage up to the maximum leakage current allowable.

NOTE 1 ~~Due~~ Note ~~should be taken of~~ the fuse characteristics when determining the power rating of the transformer.

This current shall be achieved by connecting, at the other end of the test specimen, a suitable load and an indicating device (e.g. lamp) to each conductor, or group of conductors.

NOTE 2 A current of 0,25 A at the test voltage, through each conductor or group of conductors, has been found to be suitable.

5.7 Fuses

Fuses used in the test procedure in Clause 7 shall ~~be of type DII,~~ comply~~ing~~ with IEC 60269-3 Fuse System A-D Type DII, 2A. Alternatively, a circuit-breaker with equivalent characteristics may be used.

Where a circuit-breaker is used, its equivalent characteristics shall be demonstrated by reference to the characteristic curve shown in IEC 60269-3.

The test method using fuses shall be the reference method in the case of dispute.

6 Test specimen (electric power and control cables with rated voltage up to and including 600 V/1 000 V)

6.1 Test specimen preparation

A cable sample at least 4,5 m long shall be available from the cable length for test. Each individual test specimen to be tested shall consist of a piece of cable, taken from the cable sample, not less than 1 500 mm long with approximately 100 mm of sheath or outer covering removed at each end.

At each end of the test specimen each conductor shall be suitably prepared for electrical connections, and, if there is more than one conductor, the exposed conductors shall be spread apart to avoid contact with each other.

6.2 Test specimen mounting

6.2.1 Single core cables with concentric metal layer and multicore cables

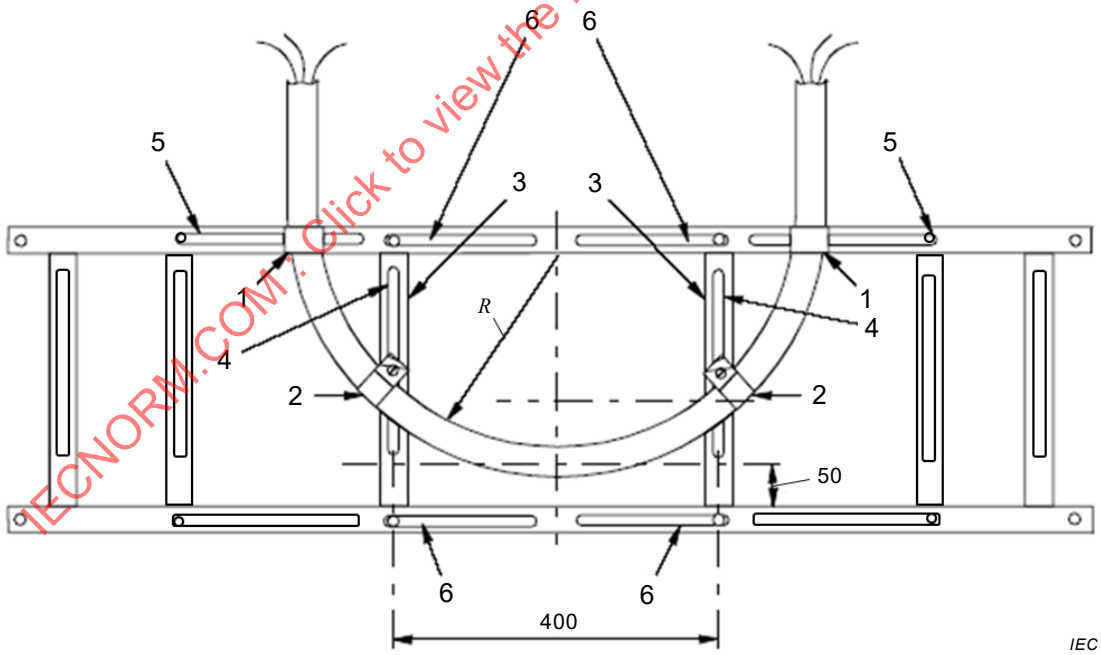
The test specimen shall be bent to form an approximate arc of a circle. The internal radius of the bend shall be the manufacturer's declared minimum bending radius in normal use.

The test specimen shall be mounted centrally on the test ladder, as shown in Figure 7, using metal clips which shall be earthed. Two U-bolts on the upper horizontal element of the ladder are recommended, but P-clips made of metal strip (20 ± 2) mm wide for cables from 20 mm up to 50 mm in diameter, and (30 ± 3) mm wide for larger cables shall be used on the two central vertical elements. The P-clips shall be formed so as to have approximately the same diameter as the test specimen under test.

If the test specimen is too small to be mounted on the central vertical elements when in the position shown in Figure 7, the two central vertical elements shall be equally moved towards the centre so that the specimen may be mounted as shown in Figure 8.

If the bending radius in normal use is too large to mount the cable as shown in Figure 7 on the slots for the U-bolt (key 5 in Figure 7), the test specimen shall be mounted as shown in Figure 9, using P-clips, which shall be earthed, on the four central vertical elements.

Dimensions in millimetres
(dimensions are approximate)

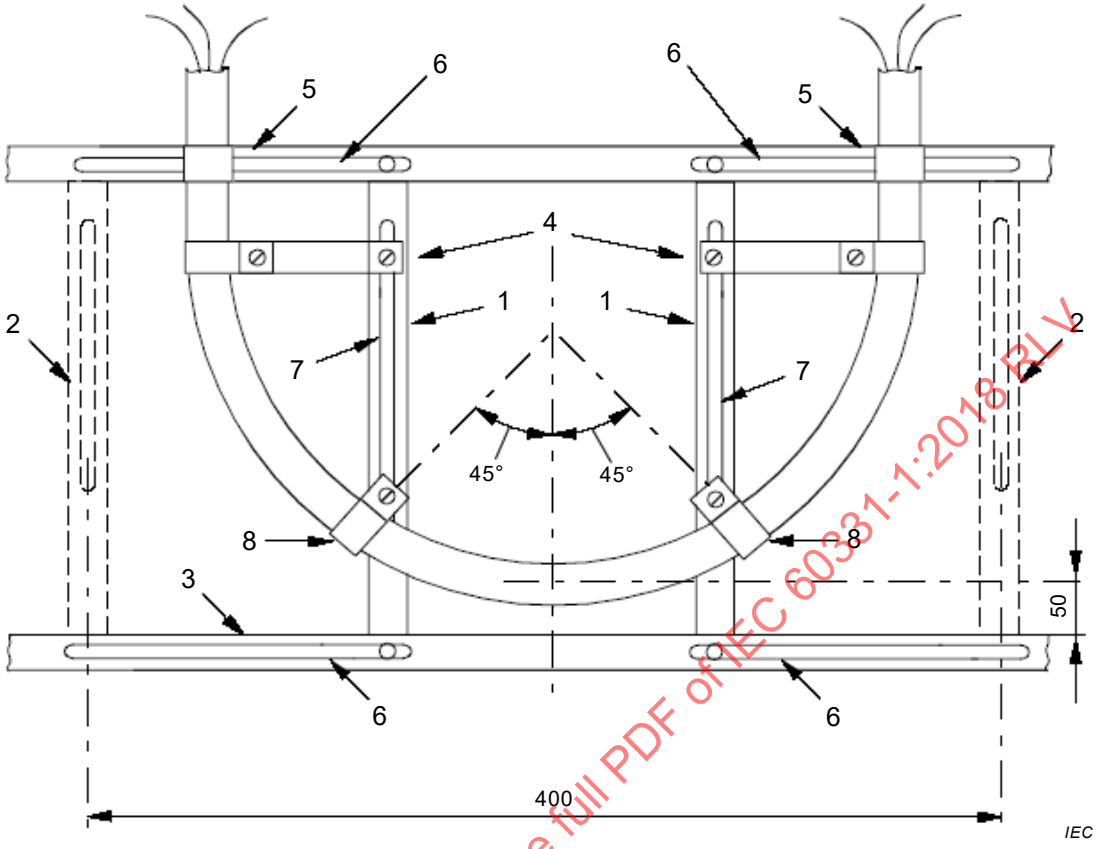


Key

1	U-bolt	5	slot for U-bolt
2	P-clip	6	slot for movement of adjustable vertical elements
3	adjustable vertical elements	*R*	minimum bending radius of cable in normal use
4	slot for P-clip fixing		

Figure 7 – Example of method of mounting a larger diameter test specimen for test (with a bending radius between approximately 200 and 400 mm)

Dimensions in millimetres
(dimensions are approximate)

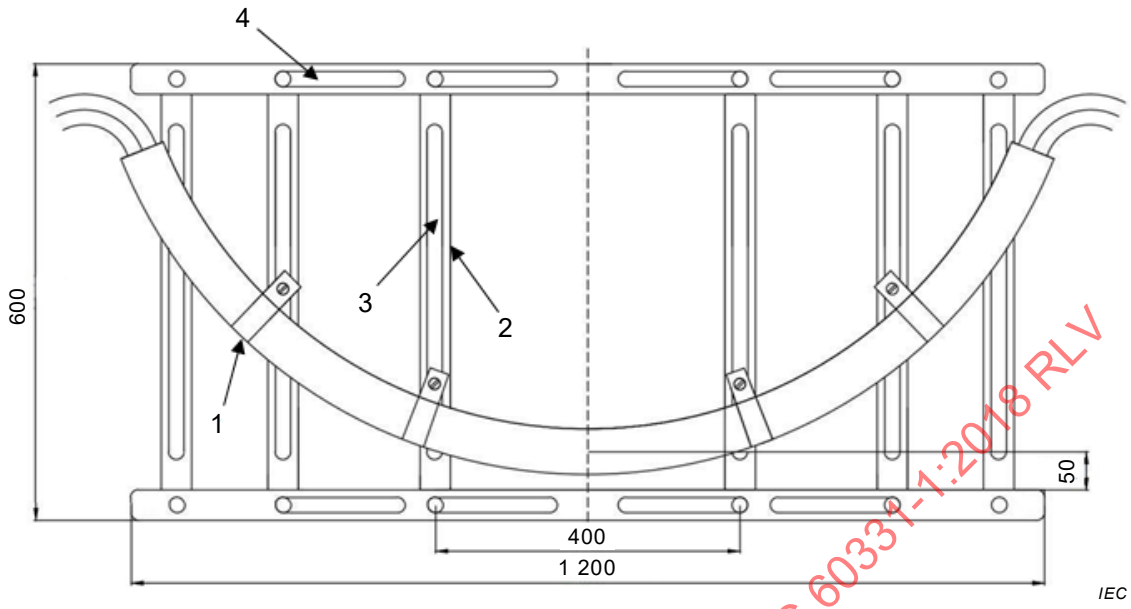


Key

1	adjustable position of vertical elements	5	U-bolt
2	normal position of vertical elements	6	slot for movement of adjustable vertical elements
3	lower horizontal element of test ladder	7	slot for P-clip fixing
4	additional clip to maintain cable arc (if required)	8	P-clip

Figure 8 – Detailed section of adjustable position of vertical ladder elements for mounting a smaller diameter test specimen for test (with a maximum bending radius of approximately 200 mm)

Dimensions in millimetres
(dimensions are approximate)



Key

1	P-clip	3	slot for P-clip fixing
2	adjustable vertical elements	4	slot for movement of adjustable vertical elements

Figure 9 – Example of method of mounting test specimen with a bending radius in normal use larger than approximately 400 mm

6.2.2 Single core cables without concentric metal layer

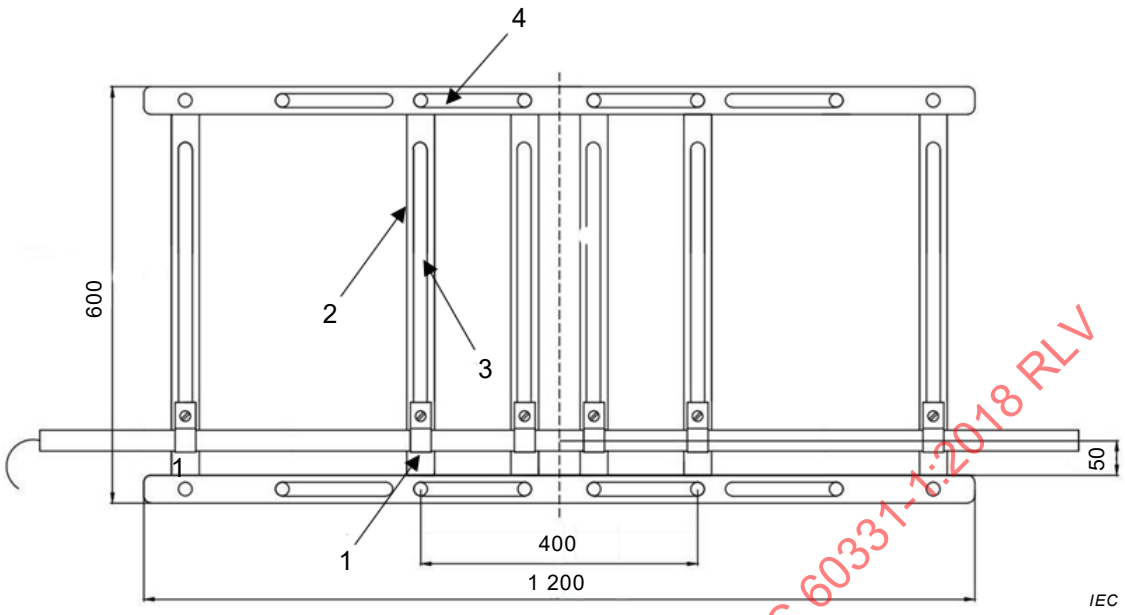
The test specimen shall be mounted straight centrally on the test ladder using four vertical elements, as shown in Figure 10, using metal clips which shall be earthed to fix the cable to these vertical elements.

The width of the metal clips shall be in accordance with 6.2.1.

NOTE Testing of a straight test specimen is appropriate for single core cables without concentric metal layer, as bending will not affect the performance for this type of cable, as internal forces such as in multicore cables will not occur.

The P-clips shall be formed so as to have approximately the same diameter as the test specimen under test.

Dimensions in millimetres
(dimensions are approximate)



Key

1	P-clip	3	slot for P-clip fixing
2	adjustable vertical elements	4	slot for movement of adjustable vertical elements

Figure 10 – Method of mounting test specimen of a single core cable without concentric metal layer

7 Test procedure (electric power and control cables with rated voltage up to and including 600 V/1 000 V)

7.1 Test equipment and arrangement

The test procedure defined in this clause shall be carried out using the apparatus detailed in Clause 5.

Mount the test specimen on the test ladder and adjust the burner to the correct position relative to the test specimen in accordance with 5.5.

7.2 Electrical connections

At the transformer end of the test specimen, earth the neutral conductor, if present, and any protective conductors. Any metal screens, drain wire or metall~~ic~~ layer shall be interconnected and earthed. 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 11. Where a metall~~ic~~ sheath, armour or screen acts as a neutral or protective conductor, it shall be connected, as shown in the circuit diagram in Figure 11, as for a neutral or protective conductor.

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

For multicore cables that have four or more conductors (excluding any neutral or protective conductors), the conductors shall be divided into three roughly equal groups, ensuring that adjacent conductors are, as far as possible, in different groups.

For multipair cables, the conductors shall be divided into two equal groups, ensuring that the a-core of each pair is connected to one phase and the b-core of each pair is connected to another phase (L1 and L2 in Figure 11). Quads shall be treated as two pairs.

For multi-triple cables, the conductors shall be divided into three equal groups, ensuring that the a-core of each triple is connected to one phase, the b-core of each triple to another phase and the c-core of each triple to the third phase of the transformer (L1, L2 and L3 in Figure 11).

Connect the conductors of each group in series and connect each group to a separate phase of the transformer output with a 2 A fuse or circuit-breaker with equivalent characteristics in each phase.

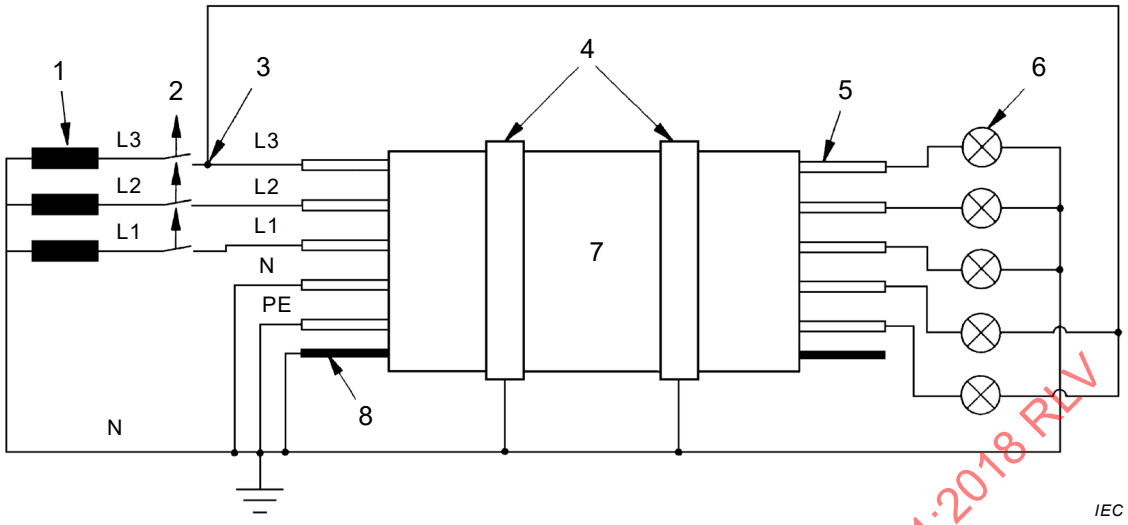
~~NOTE~~ The above test procedure connects the neutral conductor to earth. This may not be appropriate if the cable is designed for use on a system where neutral is not earthed. If required by the cable standard, it is permissible for the neutral conductor to be tested as if it were a phase conductor. Where a metal~~lic~~ sheath, armour or screen acts as a neutral conductor, it shall always be connected to earth. Any such variations in methodology should be included in the test report.

~~NOTE~~ For cable constructions not specifically identified above, the test voltage should be applied, as far as is practicable, to ensure that adjacent conductors are connected to different phases.

~~NOTE~~ In certain cases, for example when testing a control cable using a three-phase transformer, it may not be possible to apply a test voltage between conductors and from conductor to earth equal to the rated voltage simultaneously. In such cases, either the test voltage between conductors, or the test voltage from conductor to earth shall be equal to the rated voltage, such that both the test voltage between conductors and the test voltage from conductor to earth is equal to or higher than the rated voltage.

At the end of the test specimen remote from the transformer:

– connect each phase conductor, or group of conductors, to one terminal of the load and indicating device (as described in 5.6), the other terminal being earthed;
– connect the neutral conductor and any protective conductor to one terminal of the load and indicating device (as described in 5.6), the other terminal being connected to L1 (or L2 or L3) at the transformer end (see Figure 11).



Key

L1, L2, L3	phase conductor (L2, L3 if present)
N	neutral conductor (if present)
PE	protective conductor (if present)

1	transformer	5	test conductor or group
2	fuse, 2 A	6	load and indicating device
3	L1 or L2 or L3	7	test specimen
4	metal clips	8	metal screen (if present)

Figure 11 – Basic circuit diagram – Electric power and control cables with rated voltage up to and including 600 V/1 000 V

7.3 Flame and shock application

Ignite the burner and adjust the propane and air flow rates to those obtained during the verification procedure (see Annex A).

Immediately after igniting the burner, activate the shock-producing device and start the test duration timer. The shock-producing device shall impact the ladder after 5 min ± 10 s from activation and subsequently at 5 min ± 10 s intervals. After each impact, the impacting bar shall be raised from the test ladder no more than 20 s after the impact.

7.4 Electrification

Immediately after starting the test duration timer, switch on the electricity supply and adjust the voltage to the rated voltage of the cable (subject to a minimum voltage of 100 V AC), i.e. the test voltage between conductors shall equal the rated voltage between conductors, and the test voltage from conductor to earth shall equal the rated voltage from conductor to earth.

The test shall continue for the flame application time given in 8.1, after which the flame shall be extinguished.

8 Performance requirements (electric power and control cables with rated voltage up to and including 600/1 000 V)

8.1 Flame application time

The flame application time shall be as specified in the relevant cable standard. In the absence of such a standard, a flame and impact application time of 30 min, 60 min, 90 min or 120 min shall be chosen.

8.2 Acceptance criteria

With reference to the test procedure given in Clause 7, the cable possesses the characteristics for providing circuit integrity so long as during the course of the test

– the voltage is maintained, i.e. no fuse fails or circuit-breaker is interrupted,

– a conductor does not rupture, i.e. the lamp is not extinguished.

Failure by either one of the criteria listed shall be sufficient to show a failure for that cable.

9 Retest procedure

In the event of a failure, as judged by the requirements of the relevant standard, two further test specimens, taken from the same cable sample, shall be tested. If both comply, the test shall be deemed successful.

10 Test report (electric power and control cables with rated voltage up to and including 600 V/1 000 V)

The test report shall include the following information:

a) the number of this document;

b) a full description of the cable tested;

c) the manufacturer of the cable tested;

d) the test voltage and actual applied electrical connections, in accordance with Paragraphs 7 to 9 of 7.2;

e) any option used in the test procedure (i.e. failure detection method);

f) the type and disposition of clips supporting cable sample;

g) the actual cable bending radius used for the test;

h) the method used for temperature monitoring during the verification procedure;

i) the point of failure mechanism (i.e. voltage not maintained or conductor rupture);

j) the actual performance requirement applied (by reference to Clause 8);

k) the flame application time;

l) the chamber volume and temperature at the start of the test.

11 Cable marking

If a cable is required to be marked to signify compliance with this document, it shall be marked with the number of this document and the duration of flame application, as follows: “IEC 60331-1 (XX)” where XX shall be the duration in minutes. The marking shall be in addition to any requirement of the cable standard.

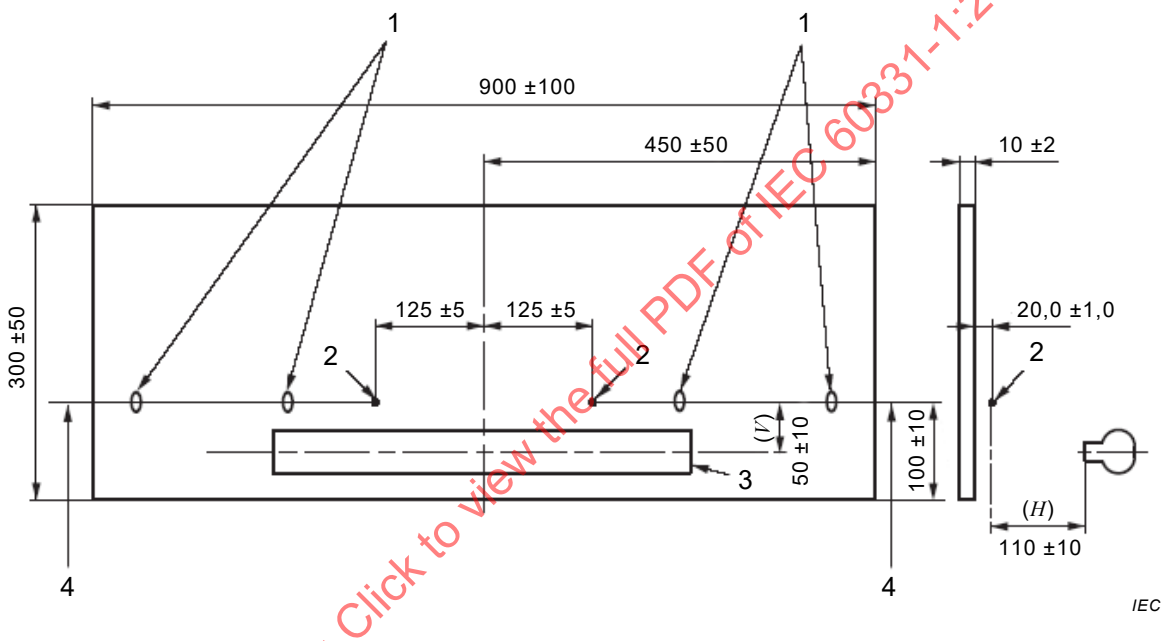
Annex A
(normative)

Verification procedure for the source of heat

A.1 Measuring equipment

The flame temperature shall be measured using two 1,5 mm mineral insulated, stainless steel sheathed thermocouples type K ~~to~~ in conformance with IEC 60584-1, mounted on the test wall as shown in Figure A.1. The thermocouple tips shall be (20,0 ± 1,0) mm in front of the test wall. The horizontal line of the thermocouples shall be (100 ± 10) mm above the bottom of the wall. The wall shall consist of a board of heat-resistant, non-combustible and non-metallic material (900 ± 100) mm long, (300 ± 50) mm high and (10 ± 2) mm thick.

Dimensions in millimetres



Key

1	thermocouple supports
2	thermocouple tip
3	burner
4	1,5 mm type K sheathed thermocouples
H	horizontal distance of thermocouple tip from burner face
V	vertical distance of thermocouple tip from centre line of burner

Figure A.1 – Temperature measuring arrangement

A.2 Procedure

Position the burner 100 mm to 120 mm horizontally from the thermocouple (H) and 40 mm to 60 mm vertically below the centre line of the thermocouples (V) as shown in Figure A.1.

Ignite the burner and adjust the gas and air supplies to those given in 5.3.

Monitor the temperature as recorded by the thermocouples over a period of 10 min to ensure conditions are stable.

A.3 Evaluation

The verification procedure shall be considered satisfactory if:

a) the arithmetic mean of the averaged readings for each of the two thermocouples over the 10 min falls within the requirement of $(830\ ^{+40}_{0})$ °C and

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

At least one measurement shall be made every 30 s in order to obtain the average.

~~NOTE~~ The actual method of obtaining the average thermocouple reading over the period is not specified, but it is recommended that a recorder with averaging facilities is used in order to damp the variability caused by point measurement.

If the verification is not successful, the flow rates shall be altered within the tolerances given in 5.3 and a further verification carried out.

A.4 Further verification

If the verification of Clause A.3 is not successful, the distances (H and V) between the burner and the thermocouples shall be altered (within the tolerance given in Clause A.2) and a further verification carried out.

If no successful verification can be achieved within the tolerances given, then the burner system shall be considered as incapable of providing the source of heat required by this document.

A.5 Verification report

The position established for successful verification (of H and V) and the flow rates used shall be recorded.

Annex B
(informative)

Guidance on the choice of recommended test apparatus (burner and venturi)[1]

A commercially available burner face meeting the recommendations of this document is the AGF burner insert 11-55, and a suitable 500 mm burner, including the specified burner face, is the AGF, reference 1857B. A recommended venturi mixer is the AGF 14-18.

The recommended burner and venturi are available from:

~~Pemfab~~
~~30 Indel Avenue~~
~~PO Box 227~~
~~Rancocas~~
~~New Jersey 08073-0227~~
~~USA~~

~~www.amgasfur.com or www.pemfab.com~~

AGF Burner, Inc.
www.agfburner.com
1955 Swarthmore Ave
Lakewood, NJ 08703-8060

~~B.2 Influence of draughts in the test chamber~~

~~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 draught shields.~~

~~B.3 Guidance on provision of a suitable test chamber~~

~~The chamber shall have a sufficient volume such 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 IEC 61034-1 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 cable during the test. Fume exhaust should be by means of a chimney located at least 1 m from the burner. A damper may be used for adjustment of ventilation conditions.~~

~~Air inlet to the chamber should be made through orifices located near the base of the chamber. Air inlets and an exhaust chimney should be located in such a way that the burner flame remains stable during the verification procedure and test.~~

[1] This information is given for the convenience of users of this International Standard and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Bibliography

IEC 60331-2, *Tests for electric cables under fire conditions – Circuit integrity – Part 2: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter not exceeding 20 mm*

~~IEC 60331-11:1999, *Tests for electric cables under fire conditions – Circuit integrity – Part 11: Apparatus – Fire alone at a flame temperature of at least 750 °C*~~

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

IEC 60331-1

Edition 2.0 2018-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Tests for electric cables under fire conditions – circuit integrity – Part 1: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter exceeding 20 mm

Essais pour câbles électriques soumis au feu – intégrité des circuits – Partie 1: Méthode d'essai au feu avec chocs pour les câbles de tension assignée au plus égale à 0,6/1,0 kV et de diamètre externe supérieur à 20 mm, à une température d'au moins 830 °C

IEC 60331-1:2018-03(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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TESTS FOR ELECTRIC CABLES UNDER FIRE CONDITIONS – CIRCUIT INTEGRITY –

Part 1: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter exceeding 20 mm

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60331-1 has been prepared by IEC technical committee 20: Electric cables.

This bilingual version (2018-11) corresponds to the monolingual English version, published in 2018-03.

This second edition cancels and replaces the first edition published in 2009. It constitutes a technical revision.

The significant technical changes with respect to the previous edition are as follows:

– extension of the scope to include metallic data and telecom cables and optical fibre cables, although details for the specific point of failure, continuity checking arrangement, test sample, test procedure and test report relevant to metallic data and telecom cables and optical fibre cables are not given by IEC 60331-1;
– improved description of the test environment;
– modified steel test ladder with two extra vertical elements to accommodate the modified testing of single core cables without concentric metal layer and the testing of cables with a bending radius in normal use larger than approximately 400 mm;
– mandatory use of mass flow meters/controllers as the means of controlling accurately the input flow rates of fuel and air to the burner;
– improved description of the information to be included in the test report.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
20/1781A/FDIS	20/1792/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

The French version of this document has not been voted upon.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

It has the status of a group safety publication in accordance with IEC Guide 104.

A list of all parts of the IEC 60331 series, published under the title: *Tests for electric cables under fire conditions – Circuit integrity*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

IEC 60331 consists of the following parts under the general title: *Tests for electric cables under fire conditions – Circuit integrity:*

Part 1: *Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter exceeding 20 mm*

Part 2: *Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter not exceeding 20 mm*

Part 3: *Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV tested in a metal enclosure*

Part 11: *Apparatus – Fire alone at a flame temperature of at least 750 °C*

Part 21: *Procedures and requirements – Cables of rated voltage up to and including 0,6/1,0 kV*

Part 23: *Procedures and requirements – Electric data cables*

Part 25: *Procedures and requirements – Optical fibre cables*

NOTE 1 Parts 21, 23 and 25 relate to fire-only conditions at a flame temperature of at least 750 °C.

NOTE 2 Parts 11, 21, 23 and 25 are no longer subject to maintenance. IEC 60331 Parts 1 and 2 are the recommended test procedures.

Since its first edition (1970), IEC 60331 has been extended and has introduced a range of test apparatus in order that a test may be carried out on large and small power, control, data and optical fibre cables.

Successful tests carried out in accordance with this standard will enable an identification to be marked on the product.

TESTS FOR ELECTRIC CABLES UNDER FIRE CONDITIONS – CIRCUIT INTEGRITY –

Part 1: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter exceeding 20 mm

1 Scope

This part of IEC 60331 specifies the test method for cables which are required to maintain circuit integrity when subject to fire and mechanical shock under specified conditions.

This document is applicable to cables of rated voltage not exceeding 600 V/1 000 V, including those of rated voltage below 80 V, metallic data and telecom cables and optical fibre cables.

It is intended for use when testing cables of greater than 20 mm overall diameter.

Cables of smaller diameter are intended to be tested using the apparatus, procedure and requirements of IEC 60331-2.

This document includes details for the specific point of failure, continuity checking arrangement, test sample, test procedure and test report relevant to electric power and control cables with rated voltage up to and including 600 V/1 000 V. Details for the specific point of failure, continuity checking arrangement, test sample, test procedure and test report relevant to metallic data and telecom cables and optical fibre cables are not given by IEC 60331-1.

Although the scope is restricted to cables with rated voltage up to and including 0,6/1,0 kV, the procedure can be used, with the agreement of the manufacturer and the purchaser, for cables with rated voltage up to and including 1,8/3 (3,3) kV, provided that suitable fuses are used.

Annex A provides the method of verification of the burner and control system used for the test.

Requirements are stated for an identification that may optionally be marked on the cable to signify compliance with this document.

CAUTION – The test given in this 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.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 60584-1, *Thermocouples – Part 1: EMF specifications and tolerances*

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 document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
circuit integrity
ability of an electric cable to continue to operate in a designated manner whilst subjected to a specified flame source for a specified period of time under specified conditions

3.2
draught-free environment
space in which the results of tests are not significantly affected by the local air speed

4 Test environment

The test shall be carried out in a draught-free environment within a suitable chamber, of minimum volume 20 m^3, with facilities for disposing of any noxious gases resulting from the burning. Sufficient ventilation shall be available to sustain the flame for the duration of the test. Air inlets and the exhaust chimney should be located in such a way that the burner flame remains stable during the verification procedure and test. If necessary, the burner shall be shielded from any draughts by the use of draught shields. Windows may be installed in the walls of the chamber in order to observe the behaviour of the cable during the test. Fume exhaust should be achieved by means of natural draught through a chimney located at least 1 m from the burner. A damper may be used for adjustment of ventilation conditions.

NOTE Experience has shown a chamber similar to the "3 m cube" specified in IEC 61034-1 to be suitable.

The chamber and test apparatus shall be at a temperature of between 10 °C and 40 °C at the start of each test.

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

5 Test apparatus

5.1 Test equipment

The test equipment shall consist of the following:

a) a test ladder, on to which the test specimen is mounted, comprising a steel framework fastened to a rigid support as described in 5.2;

b) a source of heat comprising a horizontally mounted ribbon burner as described in 5.3;

c) a shock-producing device as described in 5.4;

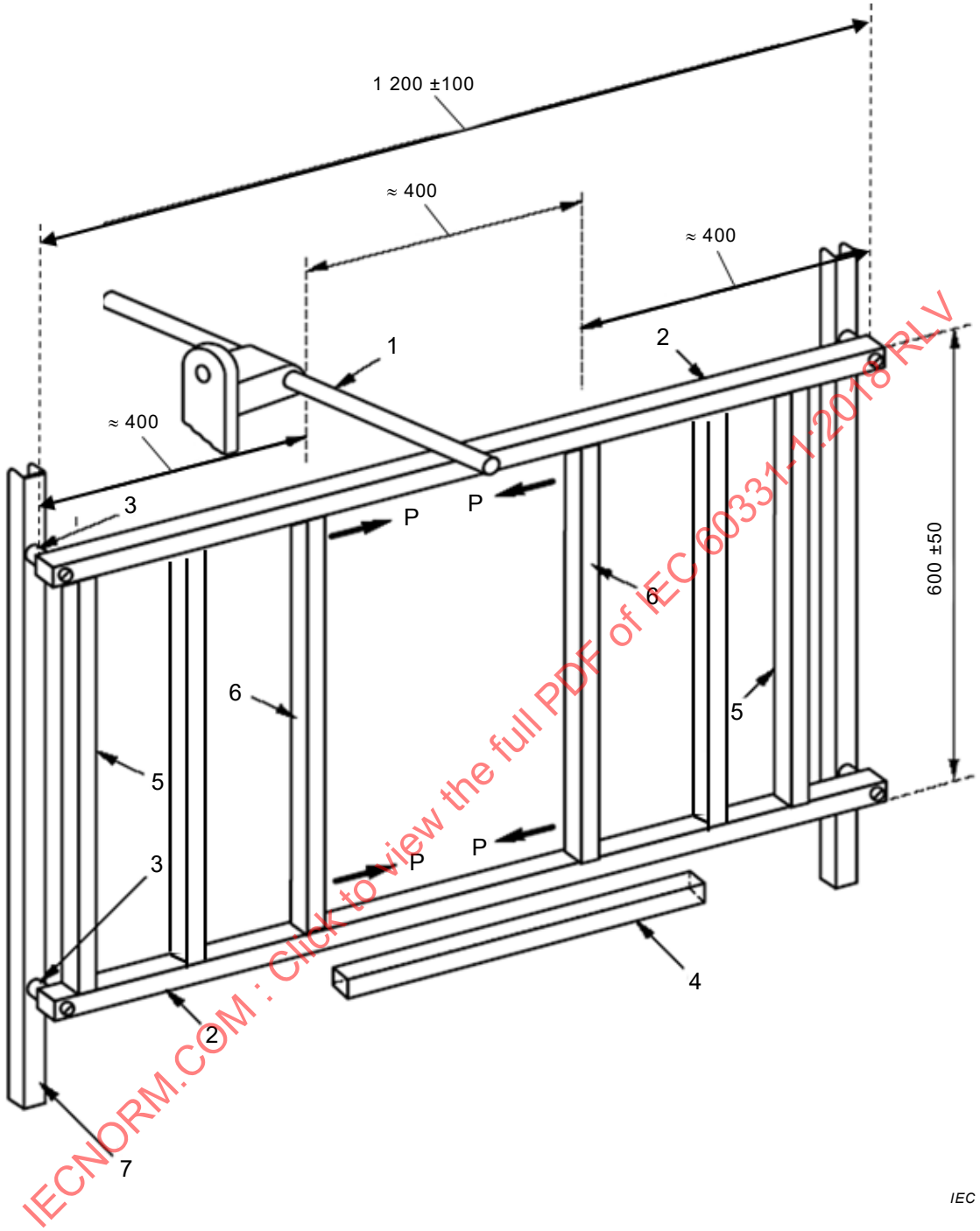
d) a test wall equipped with thermocouples for verification of the source of heat as described in Annex A;

e) a continuity checking arrangement as described in 5.6;

f) fuses as described in 5.7.

A general arrangement of the test equipment is shown in Figure 1, Figure 2 and Figure 3.

Dimensions in millimetres

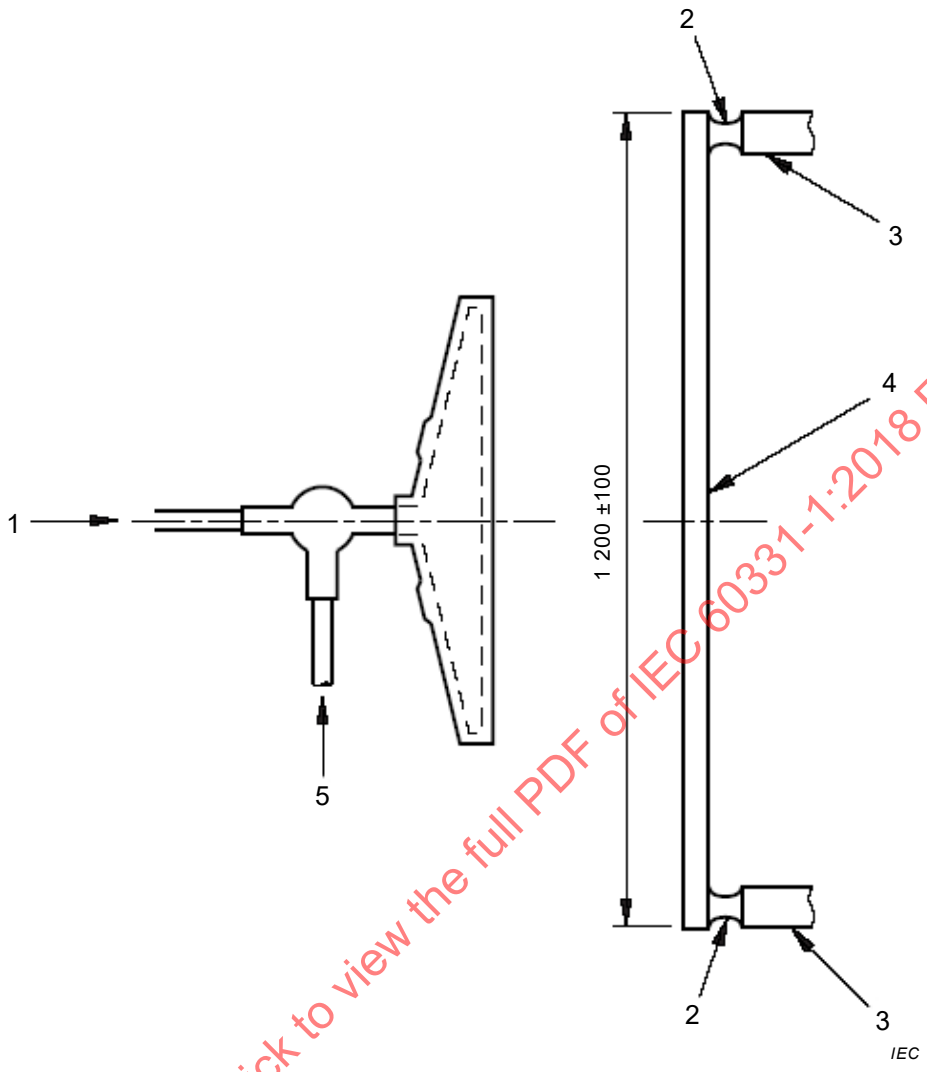


Key

1	shock producing device	5	fixed vertical elements of test ladder
2	steel test ladder	6	adjustable vertical elements of test ladder
3	rubber bush	7	rigid support framework
4	ribbon gas burner	P	plane of adjustment

Figure 1 – Schematic diagram of test configuration

Dimensions in millimetres

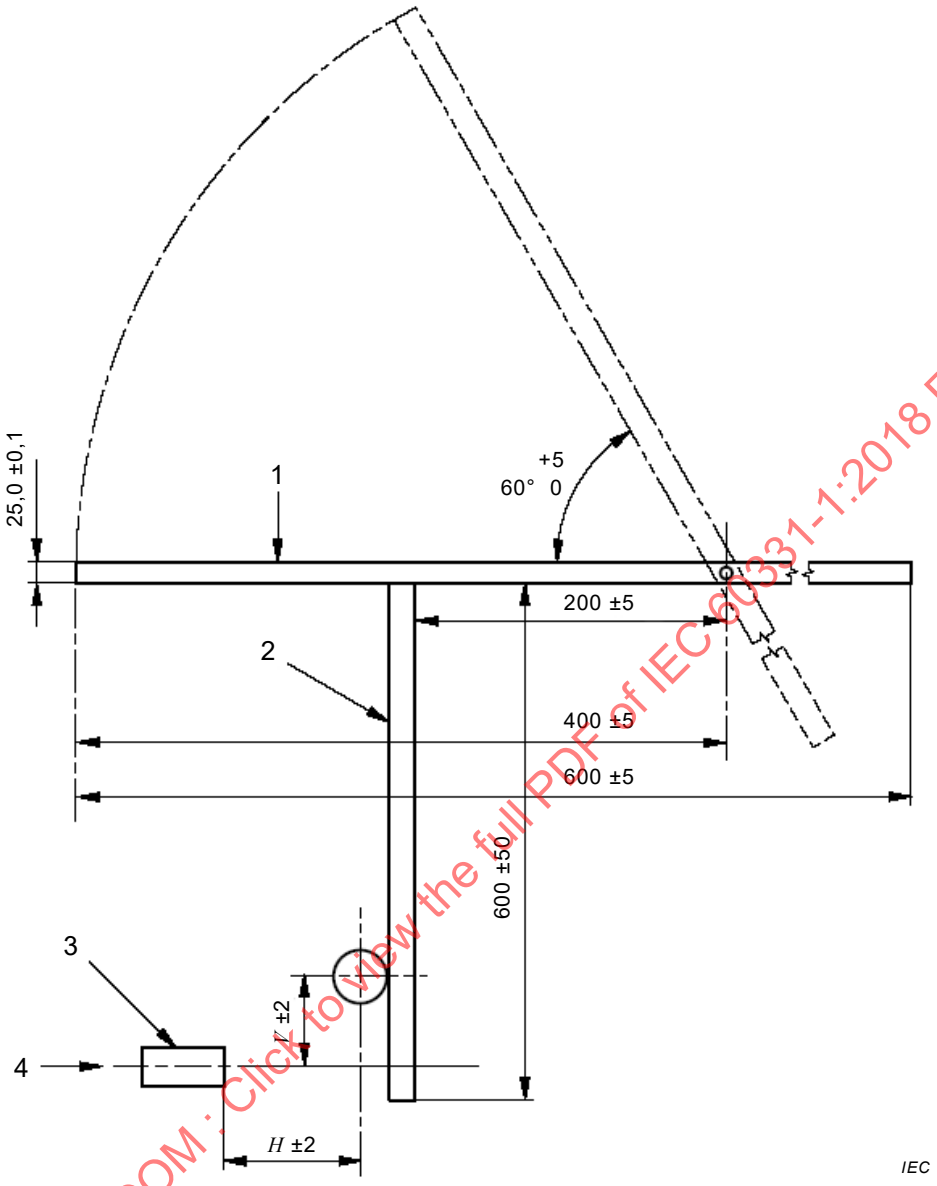


Key

1	entry for air	4	horizontal steel test ladder
2	rubber bush	5	entry for propane gas
3	rigid support framework		

Figure 2 – Plan view of fire test equipment

Dimensions in millimetres



Key

1	shock producing device	*H*	horizontal distance from burner face to the centre of the test specimen
2	steel test ladder	*V*	vertical distance from centre line of burner to the centre of the test specimen
3	gas burner		
4	centre line of burner face		

Figure 3 – End elevation of fire test equipment (not to scale)

5.2 Test ladder and mounting

The test ladder shall consist of a steel framework as shown in Figure 1. The four central vertical elements of the ladder shall be adjustable in order to accommodate different sizes of cable under test. 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 (24 ± 1) kg. Ballast, if required, shall be placed on the steel supports.

NOTE 1 Angle iron approximately 45 mm wide and 6 mm thick, with suitable slots cut to allow for fixing of the bolts or saddles, has been found to be a suitable material for construction of the ladder.

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

NOTE 2 A typical rubber bush, which has been found to be suitable, is shown in Figure 4.

Dimensions in millimetres

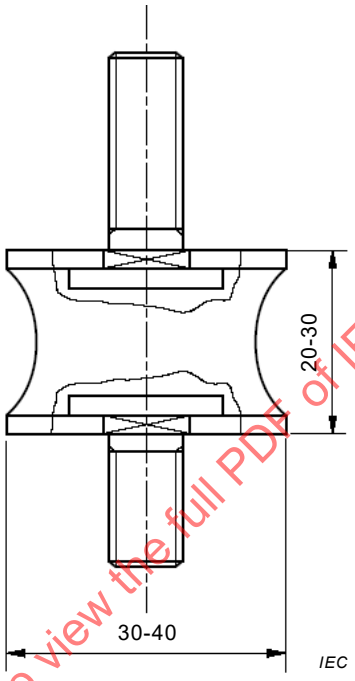


Figure 4 – Typical rubber bush for supporting the test ladder

5.3 Source of heat

5.3.1 Burner

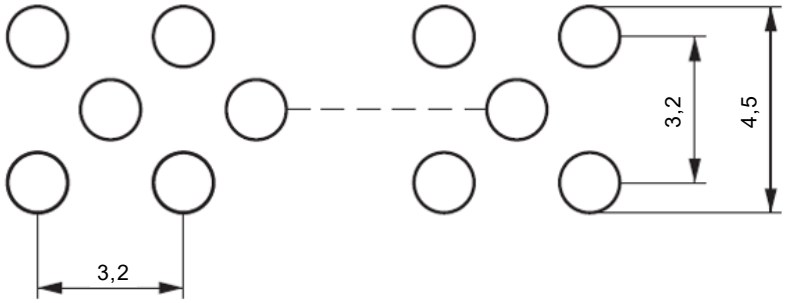
The source of heat shall be a ribbon type propane gas burner with a nominal burner face length of 500 mm (outer distance between outer holes) with a venturi mixer. The nominal burner face width shall be 10 mm. The face of the burner shall have three staggered rows of drilled holes, nominally 1,32 mm in diameter and drilled at centres 3,2 mm from one another, as shown in Figure 5.

A centre-feed burner is recommended.

A row of small holes milled on each side of the burner plate, to serve as pilot holes for keeping the flame burning, is permitted.

Guidance on the choice of a recommended burner system is given in Annex B.

Dimensions in millimetres
(Dimensions are approximate)



NOTE Round holes, 1,32 mm in diameter, on centres 3,2 mm from one another, staggered in three rows and centred on the face of the burner. Nominal burner face length 500 mm.

Figure 5 – Burner face

5.3.2 Flow meters and flow rates

Mass flow meters/controllers shall be used as the means of controlling accurately the input flow rates of fuel and air to the burner.

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

The mass flow rates used for the test shall be as follows:

Propane: (320 ± 13) mg/s

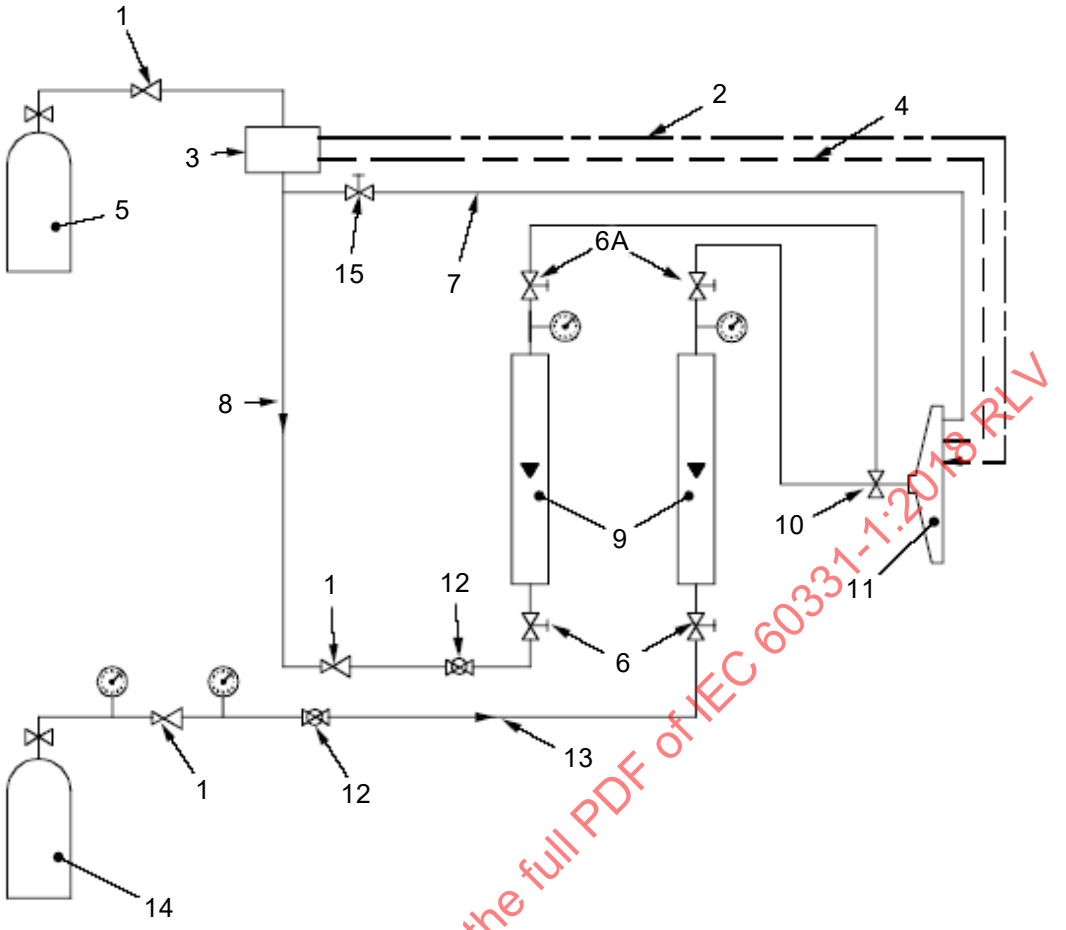
NOTE 1 This is approximately equivalent to a volume flow rate of (10,0 ± 0,4) litres/min at reference conditions (1 bar and 20 °C).

The purity of the propane is not defined. Industrial grades that contain impurities are allowed provided that the calibration requirements are achieved.

Air: (3 270 ± 163) mg/s

NOTE 2 This is approximately equivalent to a volume flow rate of (160 ± 8) litres/min at reference conditions (1 bar and 20 °C).

A schematic diagram of an example of a burner control system is given in Figure 6.



Key

1	regulator	9	mass flow meters
2	piezoelectric igniter	10	venturi mixer
3	flame failure device	11	burner
4	control thermocouples	12	ball valve
5	propane cylinder	13	air flow
6	screw valve (6A = alternative position)	14	compressed air cylinder
7	pilot feed	15	screw valve on pilot feed
8	gas flow		

Figure 6 – Schematic diagram of an example of a burner control system

5.3.3 Verification

The burner and control system shall be subject to verification following the procedure given in Annex A.

5.4 Shock producing device

The shock-producing device shall consist of a mild steel round bar (25,0 ± 0,1) mm in diameter and (600 ± 5) mm long. The bar shall be freely pivoted about an axis parallel to the test ladder, which shall be in the same horizontal plane as, and (200 ± 5) mm away from, the upper edge of the ladder. The axis shall divide the bar into two unequal lengths, the longer length being (400 ± 5) mm which shall impact the ladder. The bar shall drop under its own weight from an angle of $(60^{+5}_{0})°$ to the horizontal to strike the upper edge of the ladder at its midpoint as shown in Figure 1 and Figure 3.

5.5 Positioning of source of heat

The burner face shall be positioned in the test chamber so that it is at least 200 mm above the floor of the chamber, or any solid mounting block, and at least 500 mm from any chamber wall.

By reference to the centre point of the test specimen (cable) to be tested, the burner shall be positioned centrally at a horizontal distance of $(H \pm 2)$ mm from the burner face to the centre of the test specimen and at a vertical distance of $(V \pm 2)$ mm from the burner horizontal central plane to the centre of the test specimen, as shown in Figure 3.

The exact burner location to be used during cable testing shall be determined using the verification procedure given in Annex A, where the values of H and V to be used shall be determined.

The burner should be rigidly fixed to the framework during testing so as to prevent movement relative to the test specimen.

5.6 Continuity checking arrangements for electric power and control cables with rated voltage up to and including 600 V/1 000 V

During the test, a current for continuity checking shall be passed through all conductors of the test specimen. This shall be provided by a three-phase star connected or single-phase transformer(s) of sufficient capacity to maintain the test voltage up to the maximum leakage current allowable.

NOTE 1 Note the fuse characteristics when determining the power rating of the transformer.

This current shall be achieved by connecting, at the other end of the test specimen, a suitable load and an indicating device (e.g. lamp) to each conductor, or group of conductors.

NOTE 2 A current of 0,25 A at the test voltage, through each conductor or group of conductors, has been found to be suitable.

5.7 Fuses

Fuses used in the test procedure in Clause 7 shall comply with IEC 60269-3 Fuse System A-D Type DII, 2A. Alternatively, a circuit-breaker with equivalent characteristics may be used.

Where a circuit-breaker is used, its equivalent characteristics shall be demonstrated by reference to the characteristic curve shown in IEC 60269-3.

The test method using fuses shall be the reference method in the case of dispute.

6 Test specimen (electric power and control cables with rated voltage up to and including 600 V/1 000 V)

6.1 Test specimen preparation

A cable sample at least 4,5 m long shall be available from the cable length for test. Each individual test specimen to be tested shall consist of a piece of cable, taken from the cable sample, not less than 1 500 mm long with approximately 100 mm of sheath or outer covering removed at each end.

At each end of the test specimen each conductor shall be suitably prepared for electrical connections, and, if there is more than one conductor, the exposed conductors shall be spread apart to avoid contact with each other.

6.2 Test specimen mounting

6.2.1 Single core cables with concentric metal layer and multicore cables

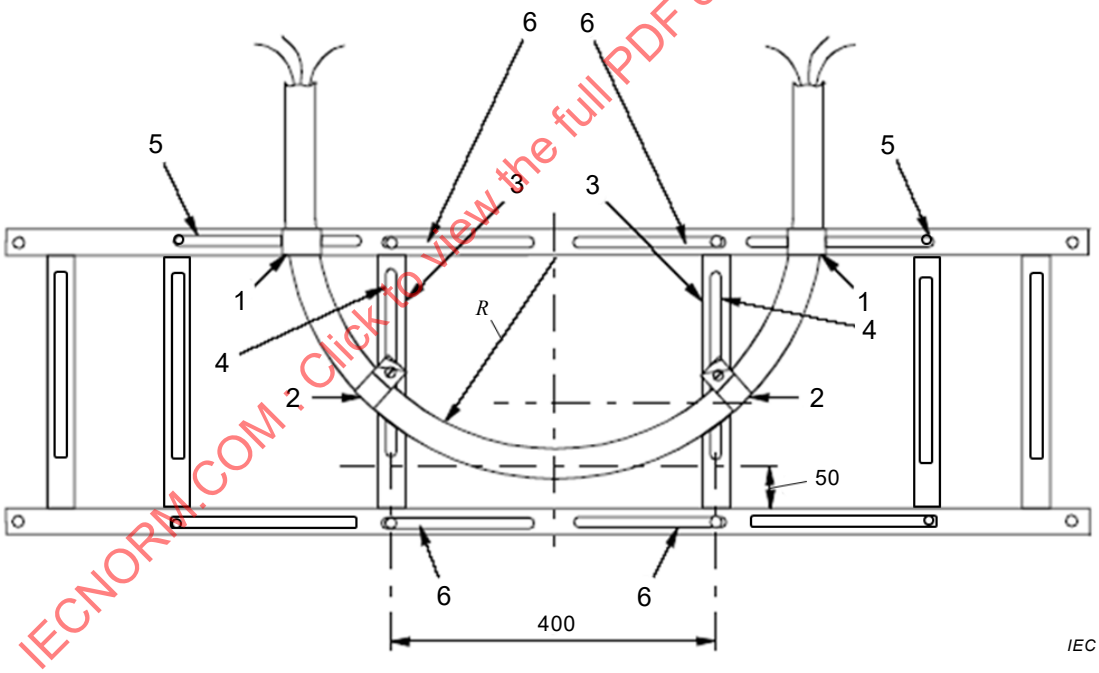
The test specimen shall be bent to form an approximate arc of a circle. The internal radius of the bend shall be the manufacturer's declared minimum bending radius in normal use.

The test specimen shall be mounted centrally on the test ladder, as shown in Figure 7, using metal clips which shall be earthed. Two U-bolts on the upper horizontal element of the ladder are recommended, but P-clips made of metal strip (20 ± 2) mm wide for cables from 20 mm up to 50 mm in diameter, and (30 ± 3) mm wide for larger cables shall be used on the two central vertical elements. The P-clips shall be formed so as to have approximately the same diameter as the test specimen under test.

If the test specimen is too small to be mounted on the central vertical elements when in the position shown in Figure 7, the two central vertical elements shall be equally moved towards the centre so that the specimen may be mounted as shown in Figure 8.

If the bending radius in normal use is too large to mount the cable as shown in Figure 7 on the slots for the U-bolt (key 5 in Figure 7), the test specimen shall be mounted as shown in Figure 9, using P-clips, which shall be earthed, on the four central vertical elements.

Dimensions in millimetres
(dimensions are approximate)

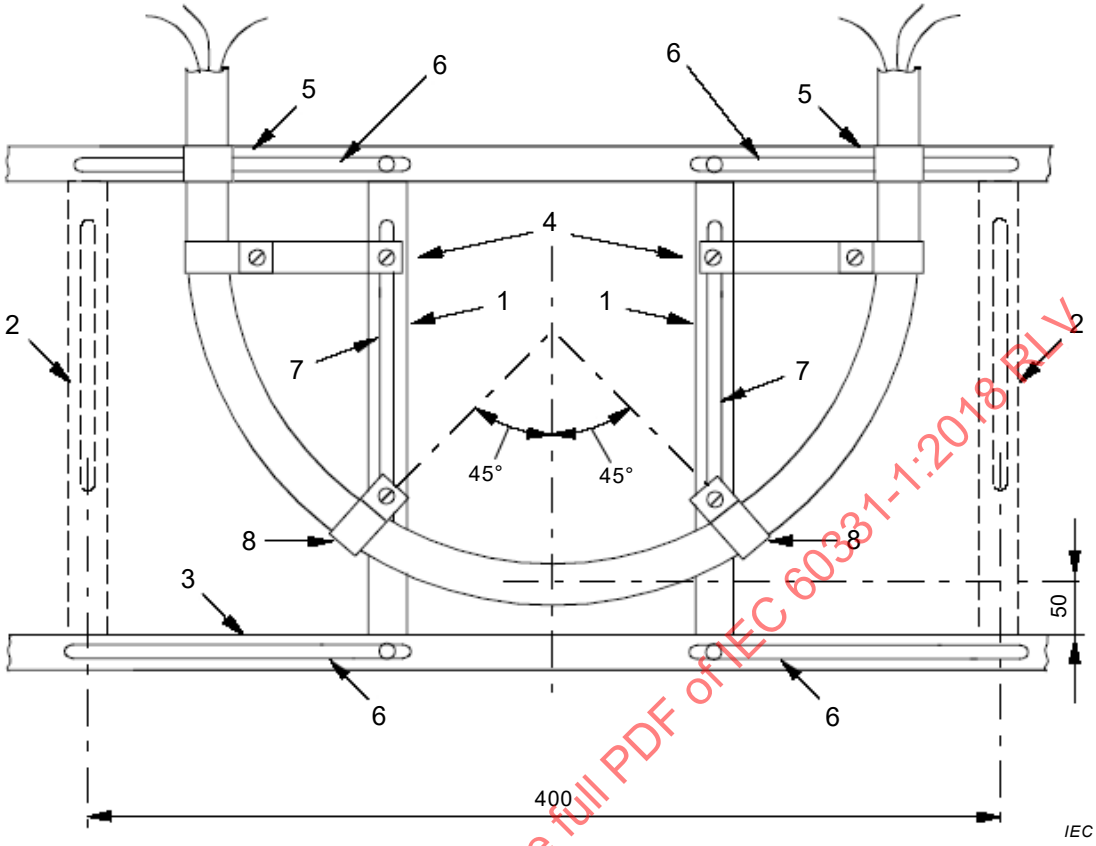


Key

1	U-bolt	5	slot for U-bolt
2	P-clip	6	slot for movement of adjustable vertical elements
3	adjustable vertical elements	*R*	minimum bending radius of cable in normal use
4	slot for P-clip fixing		

Figure 7 – Example of method of mounting a larger diameter test specimen for test (with a bending radius between approximately 200 and 400 mm)

Dimensions in millimetres
(dimensions are approximate)

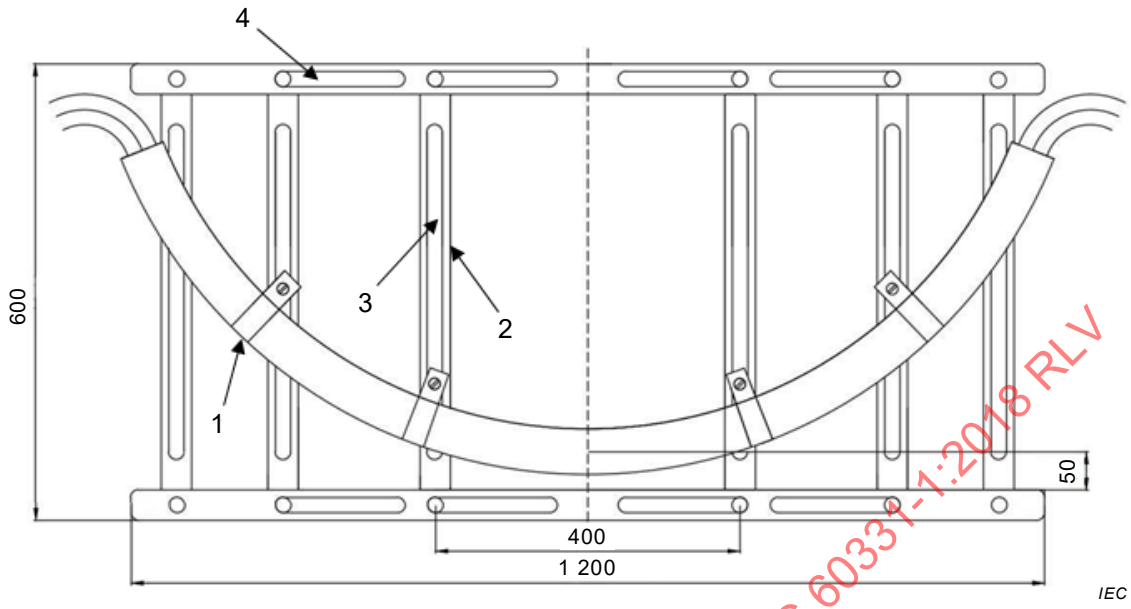


Key

1	adjustable position of vertical elements	5	U-bolt
2	normal position of vertical elements	6	slot for movement of adjustable vertical elements
3	lower horizontal element of test ladder	7	slot for P-clip fixing
4	additional clip to maintain cable arc (if required)	8	P-clip

Figure 8 – Detailed section of adjustable position of vertical ladder elements for mounting a smaller diameter test specimen for test (with a maximum bending radius of approximately 200 mm)

Dimensions in millimetres
(dimensions are approximate)



Key

1	P-clip	3	slot for P-clip fixing
2	adjustable vertical elements	4	slot for movement of adjustable vertical elements

Figure 9 – Example of method of mounting test specimen with a bending radius in normal use larger than approximately 400 mm

6.2.2 Single core cables without concentric metal layer

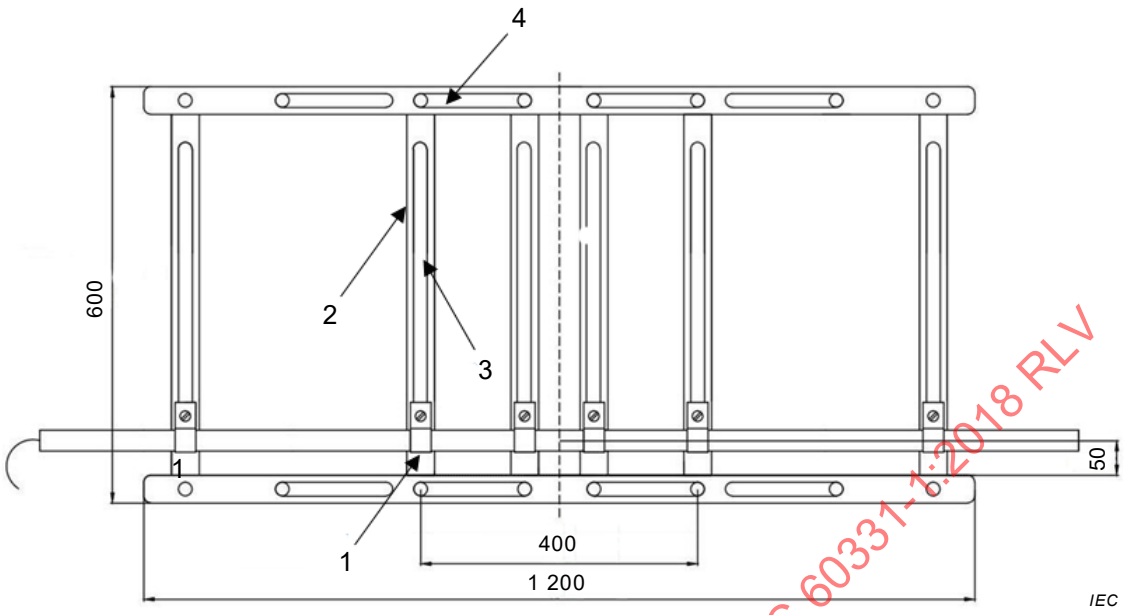
The test specimen shall be mounted straight centrally on the test ladder using four vertical elements, as shown in Figure 10, using metal clips which shall be earthed to fix the cable to these vertical elements.

The width of the metal clips shall be in accordance with 6.2.1.

NOTE Testing of a straight test specimen is appropriate for single core cables without concentric metal layer, as bending will not affect the performance for this type of cable, as internal forces such as in multicore cables will not occur.

The P-clips shall be formed so as to have approximately the same diameter as the test specimen under test.

Dimensions in millimetres
(dimensions are approximate)



Key

1	P-clip	3	slot for P-clip fixing
2	adjustable vertical elements	4	slot for movement of adjustable vertical elements

Figure 10 – Method of mounting test specimen of a single core cable without concentric metal layer

7 Test procedure (electric power and control cables with rated voltage up to and including 600 V/1 000 V)

7.1 Test equipment and arrangement

The test procedure defined in this clause shall be carried out using the apparatus detailed in Clause 5.

Mount the test specimen on the test ladder and adjust the burner to the correct position relative to the test specimen in accordance with 5.5.

7.2 Electrical connections

At the transformer end of the test specimen, earth the neutral conductor, if present, and any protective conductors. Any metal screens, drain wire or metal layer shall be interconnected and earthed. 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 11. Where a metal sheath, armour or screen acts as a neutral or protective conductor, it shall be connected, as shown in the circuit diagram in Figure 11, as for a neutral or protective conductor.

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

For multicore cables that have four or more conductors (excluding any neutral or protective conductors), the conductors shall be divided into three roughly equal groups, ensuring that adjacent conductors are, as far as possible, in different groups.

For multipair cables, the conductors shall be divided into two equal groups, ensuring that the a-core of each pair is connected to one phase and the b-core of each pair is connected to another phase (L1 and L2 in Figure 11). Quads shall be treated as two pairs.

For multi-triple cables, the conductors shall be divided into three equal groups, ensuring that the a-core of each triple is connected to one phase, the b-core of each triple to another phase and the c-core of each triple to the third phase of the transformer (L1, L2 and L3 in Figure 11).

Connect the conductors of each group in series and connect each group to a separate phase of the transformer output with a 2 A fuse or circuit-breaker with equivalent characteristics in each phase.

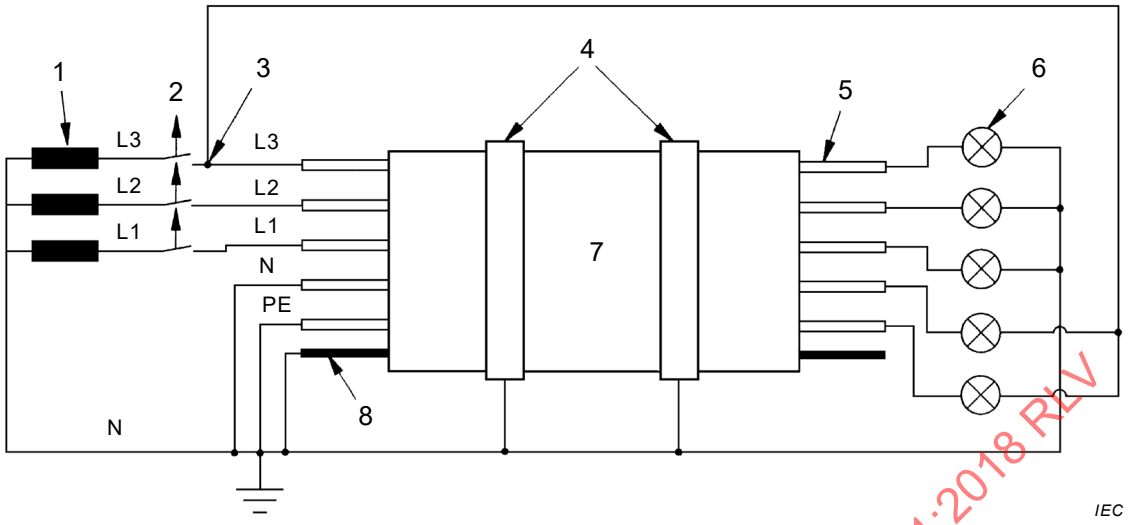
The above test procedure connects the neutral conductor to earth. This may not be appropriate if the cable is designed for use on a system where neutral is not earthed. If required by the cable standard, it is permissible for the neutral conductor to be tested as if it were a phase conductor. Where a metal sheath, armour or screen acts as a neutral conductor, it shall always be connected to earth. Any such variations in methodology should be included in the test report.

For cable constructions not specifically identified above, the test voltage should be applied, as far as is practicable, to ensure that adjacent conductors are connected to different phases.

In certain cases, for example when testing a control cable using a three-phase transformer, it may not be possible to apply a test voltage between conductors and from conductor to earth equal to the rated voltage simultaneously. In such cases, either the test voltage between conductors, or the test voltage from conductor to earth shall be equal to the rated voltage, such that both the test voltage between conductors and the test voltage from conductor to earth is equal to or higher than the rated voltage.

At the end of the test specimen remote from the transformer:

– connect each phase conductor, or group of conductors, to one terminal of the load and indicating device (as described in 5.6), the other terminal being earthed;
– connect the neutral conductor and any protective conductor to one terminal of the load and indicating device (as described in 5.6), the other terminal being connected to L1 (or L2 or L3) at the transformer end (see Figure 11).



Key

L1, L2, L3	phase conductor (L2, L3 if present)
N	neutral conductor (if present)
PE	protective conductor (if present)

1	transformer	5	test conductor or group
2	fuse, 2 A	6	load and indicating device
3	L1 or L2 or L3	7	test specimen
4	metal clips	8	metal screen (if present)

Figure 11 – Basic circuit diagram – Electric power and control cables with rated voltage up to and including 600 V/1 000 V

7.3 Flame and shock application

Ignite the burner and adjust the propane and air flow rates to those obtained during the verification procedure (see Annex A).

Immediately after igniting the burner, activate the shock-producing device and start the test duration timer. The shock-producing device shall impact the ladder after 5 min ± 10 s from activation and subsequently at 5 min ± 10 s intervals. After each impact, the impacting bar shall be raised from the test ladder no more than 20 s after the impact.

7.4 Electrification

Immediately after starting the test duration timer, switch on the electricity supply and adjust the voltage to the rated voltage of the cable (subject to a minimum voltage of 100 V AC), i.e. the test voltage between conductors shall equal the rated voltage between conductors, and the test voltage from conductor to earth shall equal the rated voltage from conductor to earth.

The test shall continue for the flame application time given in 8.1, after which the flame shall be extinguished.

8 Performance requirements (electric power and control cables with rated voltage up to and including 600/1 000 V)

8.1 Flame application time

The flame application time shall be as specified in the relevant cable standard. In the absence of such a standard, a flame and impact application time of 30 min, 60 min, 90 min or 120 min shall be chosen.

8.2 Acceptance criteria

With reference to the test procedure given in Clause 7, the cable possesses the characteristics for providing circuit integrity so long as during the course of the test

– the voltage is maintained, i.e. no fuse fails or circuit-breaker is interrupted,

– a conductor does not rupture, i.e. the lamp is not extinguished.

Failure by either one of the criteria listed shall be sufficient to show a failure for that cable.

9 Retest procedure

In the event of a failure, as judged by the requirements of the relevant standard, two further test specimens, taken from the same cable sample, shall be tested. If both comply, the test shall be deemed successful.

10 Test report (electric power and control cables with rated voltage up to and including 600 V/1 000 V)

The test report shall include the following information:

a) the number of this document;

b) a full description of the cable tested;

c) the manufacturer of the cable tested;

d) the test voltage and actual applied electrical connections, in accordance with Paragraphs 7 to 9 of 7.2;

e) any option used in the test procedure (i.e. failure detection method);

f) the type and disposition of clips supporting cable sample;

g) the actual cable bending radius used for the test;

h) the method used for temperature monitoring during the verification procedure;

i) the point of failure mechanism (i.e. voltage not maintained or conductor rupture);

j) the actual performance requirement applied (by reference to Clause 8);

k) the flame application time;

l) the chamber volume and temperature at the start of the test.

11 Cable marking

If a cable is required to be marked to signify compliance with this document, it shall be marked with the number of this document and the duration of flame application, as follows: “IEC 60331-1 (XX)” where XX shall be the duration in minutes. The marking shall be in addition to any requirement of the cable standard.

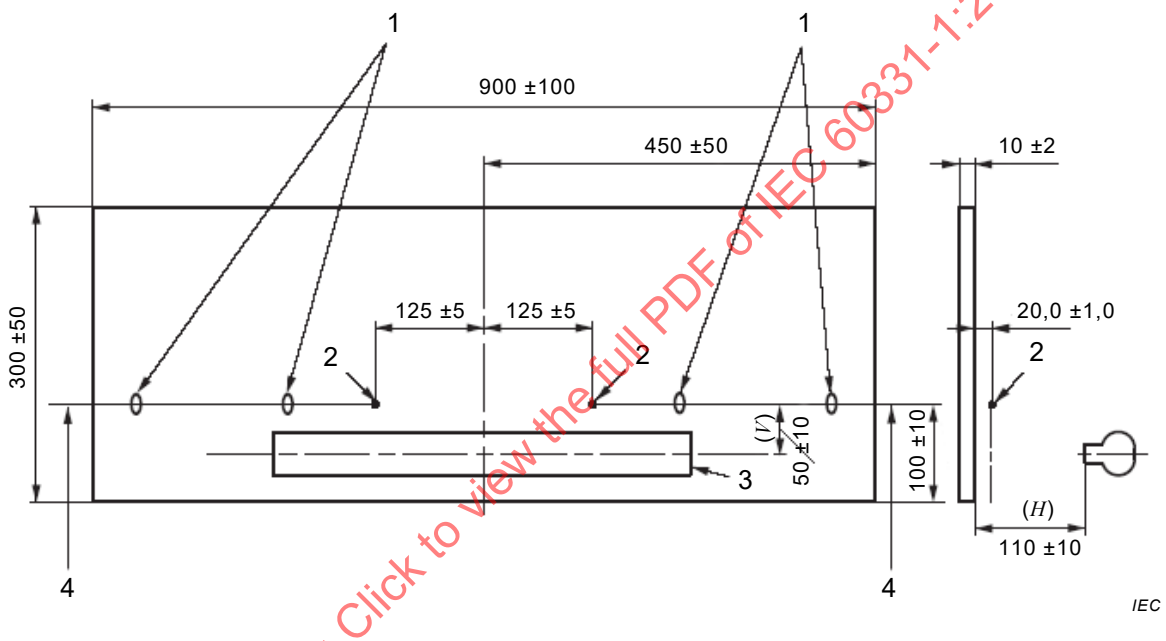
Annex A
(normative)

Verification procedure for the source of heat

A.1 Measuring equipment

The flame temperature shall be measured using two 1,5 mm mineral insulated, stainless steel sheathed thermocouples type K in conformance with IEC 60584-1, mounted on the test wall as shown in Figure A.1. The thermocouple tips shall be (20,0 ± 1,0) mm in front of the test wall. The horizontal line of the thermocouples shall be (100 ± 10) mm above the bottom of the wall. The wall shall consist of a board of heat-resistant, non-combustible and non-metallic material (900 ± 100) mm long, (300 ± 50) mm high and (10 ± 2) mm thick.

Dimensions in millimetres



Key

1	thermocouple supports
2	thermocouple tip
3	burner
4	1,5 mm type K sheathed thermocouples
H	horizontal distance of thermocouple tip from burner face
V	vertical distance of thermocouple tip from centre line of burner

Figure A.1 – Temperature measuring arrangement

A.2 Procedure

Position the burner 100 mm to 120 mm horizontally from the thermocouple (H) and 40 mm to 60 mm vertically below the centre line of the thermocouples (V) as shown in Figure A.1.

Ignite the burner and adjust the gas and air supplies to those given in 5.3.

Monitor the temperature as recorded by the thermocouples over a period of 10 min to ensure conditions are stable.

A.3 Evaluation

The verification procedure shall be considered satisfactory if:

a) the arithmetic mean of the averaged readings for each of the two thermocouples over the 10 min falls within the requirement of $(830\ ^{+40}_{0})$ °C and

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

At least one measurement shall be made every 30 s in order to obtain the average.

The actual method of obtaining the average thermocouple reading over the period is not specified, but it is recommended that a recorder with averaging facilities is used in order to damp the variability caused by point measurement.

If the verification is not successful, the flow rates shall be altered within the tolerances given in 5.3 and a further verification carried out.

A.4 Further verification

If the verification of Clause A.3 is not successful, the distances (H and V) between the burner and the thermocouples shall be altered (within the tolerance given in Clause A.2) and a further verification carried out.

If no successful verification can be achieved within the tolerances given, then the burner system shall be considered as incapable of providing the source of heat required by this document.

A.5 Verification report

The position established for successful verification (of H and V) and the flow rates used shall be recorded.

Annex B
(informative)

Guidance on the choice of recommended test apparatus (burner and venturi)[1]

A commercially available burner face meeting the recommendations of this document is the AGF burner insert 11-55, and a suitable 500 mm burner, including the specified burner face, is the AGF, reference 1857B. A recommended venturi mixer is the AGF 14-18.

The recommended burner and venturi are available from:

AGF Burner, Inc.
www.agfburner.com
1955 Swarthmore Ave
Lakewood, NJ 08703-8060

[1] This information is given for the convenience of users of this International Standard and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Bibliography

IEC 60331-2, *Tests for electric cables under fire conditions – Circuit integrity – Part 2: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter not exceeding 20 mm*

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

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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ESSAIS POUR CÂBLES ÉLECTRIQUES SOUMIS AU FEU – INTÉGRITÉ DES CIRCUITS –

Partie 1: Méthode d'essai au feu avec chocs pour les câbles de tension assignée au plus égale à 0,6/1,0 kV et de diamètre externe supérieur à 20 mm, à une température d'au moins 830 °C

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La Norme internationale IEC 60331-1 a été établie par le comité d'études 20 de l'IEC: Câbles électriques.

La présente version bilingue (2018-11) correspond à la version anglaise monolingue publiée en 2018-03.

Cette deuxième édition annule et remplace la première édition parue en 2009. Elle constitue une révision technique.

Les modifications techniques majeures par rapport à l'édition précédente sont les suivantes:

– extension du domaine d'application aux câbles métalliques de données et de télécommunications et aux câbles à fibres optiques, bien que les informations concernant le point spécifique de défaillance, le dispositif de contrôle de la continuité, l'échantillon d'essai, la procédure d'essai et le rapport d'essai pertinents pour les câbles métalliques de données et de télécommunications et pour les câbles à fibres optiques ne soient pas fournis dans l'IEC 60331-1;
– amélioration de la description de l'environnement d'essai;
– modification de l'échelle d'essai en acier avec deux éléments verticaux supplémentaires afin d'effectuer les essais modifiés sur des câbles unipolaires sans couche de métal concentrique et les essais sur des câbles de rayon de courbure en utilisation normale supérieur à environ 400 mm;
– utilisation obligatoire de débitmètres massiques/régulateurs comme moyens précis de contrôle des débits d'entrée de combustible et d'air au brûleur;
– amélioration de la description des informations à inclure dans le rapport d'essai.

Le texte anglais de cette norme est issu des documents 20/1781A/FDIS et 20/1792/RVD.

Le rapport de vote 20/1792/RVD donne toute information sur le vote ayant abouti à l'approbation de cette norme.

La version française de cette norme n'a pas été soumise au vote.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Il a le statut d'une publication fondamentale de sécurité conformément au Guide IEC 104.

Une liste de toutes les parties de la série IEC 60331, publiées sous le titre général: *Essais pour câbles électriques soumis au feu – Intégrité des circuits,* peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu de cette publication ne sera pas modifié avant la date de maintenance indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives à la publication recherchée. À cette date, la publication sera

- reconduite,
- supprimée,
- remplacée par une édition révisée, ou
- amendée.

INTRODUCTION

L'IEC 60331 comprend les parties suivantes présentées sous le titre général: *Essais pour câbles électriques soumis au feu – Intégrité des circuits:*

Partie 1: *Méthode d'essai au feu avec chocs pour les câbles de tension assignée au plus égale à 0,6/1,0 kV et de diamètre externe supérieur à 20 mm, à une température d'au moins 830 °C*

Partie 2: *Méthode d'essai au feu avec chocs pour les câbles de tension assignée au plus égale à 0,6/1,0 kV et de diamètre externe inférieur ou égal à 20 mm, à une température d'au moins 830 °C*

Partie 3: *Méthode d'essai au feu pour les câbles de tension assignée au plus égale à 0,6/1,0 kV, soumis à essai sous conduit métallique avec chocs, à une température d'au moins 830 °C*

Partie 11: *Appareillage – Incendie seul avec flamme à une température d'au moins 750 °C*

Partie 21: *Procédures et prescriptions – Câbles de tension assignée jusque et y compris 0,6/1,0 kV*

Partie 23: *Procédures et prescriptions – Câbles électriques de données*

Partie 25: *Procédures et prescriptions – Câbles à fibres optiques*

NOTE 1 Les Parties 21, 23 et 25 décrivent uniquement les conditions d'essai avec une flamme à une température d'au moins 750 °C.

NOTE 2 Les Parties 11, 21, 23 et 25 ne font plus l'objet d'une maintenance. Les Parties 1 et 2 de l'IEC 60331 comportent les procédures d'essai recommandées.

Depuis sa première édition (1970), l'IEC 60331 a été élargie afin que l'appareillage d'essai puisse être utilisé pour les essais des petits et gros câbles de puissance, de commande, de données et à fibres optiques.

Des essais satisfaisants réalisés conformément à la présente norme pourront permettre une identification sur le produit par un marquage.

ESSAIS POUR CÂBLES ÉLECTRIQUES SOUMIS AU FEU – INTÉGRITÉ DES CIRCUITS –

Partie 1: Méthode d'essai au feu avec chocs pour les câbles de tension assignée au plus égale à 0,6/1,0 kV et de diamètre externe supérieur à 20 mm, à une température d'au moins 830 °C

1 Domaine d'application

La présente partie de l'IEC 60331 spécifie la méthode d'essai pour les câbles nécessaires afin de conserver l'intégrité du circuit quand ils sont soumis à un feu et à des chocs mécaniques dans des conditions spécifiées.

Le présent document s'applique aux câbles de tension assignée au plus égale à 600 V/1 000 V, y compris les câbles de tension assignée inférieure à 80 V, les câbles métalliques de données et de télécommunications ainsi que les câbles à fibres optiques.

Elle est prévue pour être utilisée pour soumettre à l'essai des câbles de diamètre externe supérieur à 20 mm.

Pour les câbles de diamètre plus petit, l'appareillage, la procédure et les exigences de l'IEC 60331-2 sont utilisés.

Le présent document comprend des détails concernant le point spécifique de défaillance, le dispositif de contrôle de la continuité, l'échantillon d'essai, la procédure d'essai et le rapport d'essai pertinents pour les câbles électriques de puissance et de commande de tension assignée au plus égale à 600 V/1 000 V. Les détails concernant le point spécifique de défaillance, le dispositif de contrôle de la continuité, l'échantillon d'essai, la procédure d'essai et le rapport d'essai pertinents pour les câbles métalliques de données et de télécommunications ainsi que les câbles à fibres optiques ne sont pas fournis dans l'IEC 60331-1.

Bien que le domaine d'application soit limité aux câbles de tension assignée au plus égale à 0,6/1,0 kV, par accord entre le fabricant et l'acheteur, la procédure peut être utilisée pour des câbles de tension assignée au plus égale à 1,8/3 (3,3) kV à condition d'utiliser des fusibles appropriés.

L'Annexe A fournit la méthode de vérification du brûleur et le système de contrôle utilisé pour l'essai.

Les exigences sont indiquées pour une identification pouvant être éventuellement apposée par marquage sur le câble pour signifier sa conformité à la présente norme.

AVERTISSEMENT – L'essai indiqué dans la présente norme peut mettre en œuvre l'utilisation de tensions et de températures dangereuses. Il convient de prendre des précautions appropriées contre les risques de choc, de brûlure, de feu et d'explosion qui peuvent en résulter et contre toutes fumées nocives pouvant être générées.

2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60584-1, *Couples thermoélectriques – Partie 1: Spécifications et tolérances en matière de FEM*

IEC 60269-3, *Fusibles basse tension – Partie 3: Exigences supplémentaires pour les fusibles destinés à être utilisés par des personnes non qualifiées (fusibles pour usages essentiellement domestiques et analogues) – Exemples de systèmes de fusibles normalisés A à F*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

3.1
intégrité du circuit
aptitude du câble électrique à continuer de fonctionner de la façon prévue lorsqu'il est soumis à une source de flamme spécifiée pendant une durée spécifiée dans les conditions spécifiées

3.2
environnement en air calme
environnement dans lequel les résultats des essais ne sont pas affectés de manière significative par la vitesse locale de l'air

4 Environnement d'essai

L'essai doit être effectué dans un environnement en air calme, dans une chambre appropriée, d'un volume minimal de 20 m^3, pourvue de moyens d'évacuation des gaz nocifs résultant de la combustion. Une ventilation suffisante doit être disponible pour maintenir la flamme pendant la durée de l'essai. Il convient de placer les entrées d'air et la cheminée d'évacuation de sorte que la flamme du brûleur reste stable pendant la procédure de vérification et l'essai. Si nécessaire, le brûleur doit être protégé contre les courants d'air par l'utilisation de protections. Des fenêtres peuvent être installées dans les parois de la chambre de façon à observer le comportement du câble pendant l'essai. Il convient d'évacuer les fumées par tirage naturel au moyen d'une cheminée située à au moins 1 m du brûleur. Un volet d'extraction peut être utilisé pour régler les conditions de ventilation.

NOTE L'expérience a montré qu'une chambre similaire au "caisson de 3 m" spécifié dans l'IEC 61034-1 était appropriée.

La température de la chambre d'essai et de l'appareillage d'essai doit être comprise entre 10 °C et 40 °C au début de chaque essai.

Les conditions de ventilation et de protection utilisées dans la chambre au cours des procédures de vérification et d'essai du câble doivent être identiques.

5 Appareillage d'essai

5.1 Équipement d'essai

L'équipement d'essai doit être constitué des éléments suivants:

a) une échelle d'essai sur laquelle l'éprouvette d'essai est montée, comprenant un cadre en acier fixé à un support rigide comme décrit en 5.2;

b) une source de chaleur comprenant un brûleur de type à ruban monté horizontalement comme décrit en 5.3;

c) un dispositif de production de chocs comme décrit en 5.4;

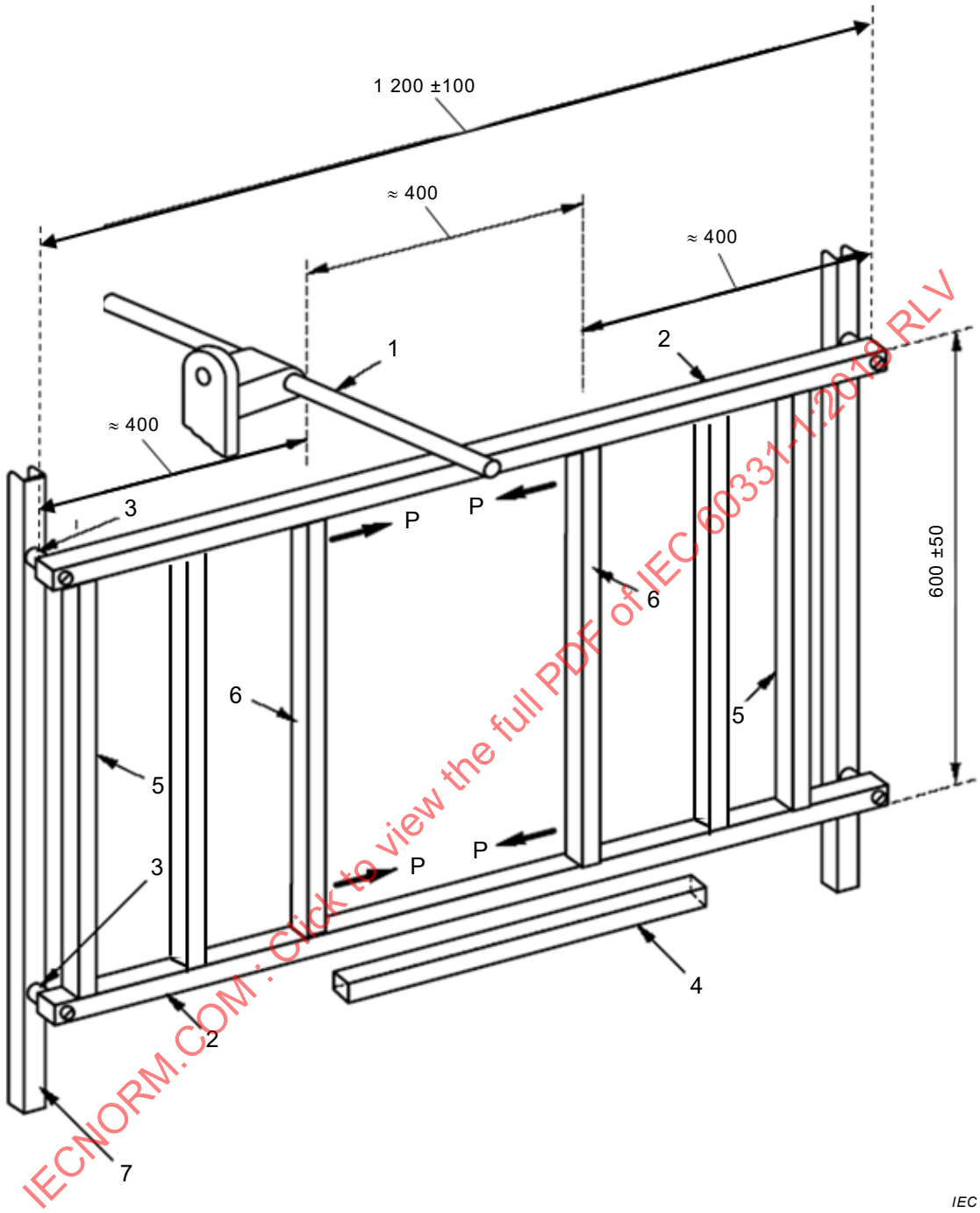
d) une paroi d'essai équipée de thermocouples pour la vérification de la source de chaleur comme décrit dans l'Annexe A;

e) un dispositif de contrôle de la continuité comme décrit en 5.6;

f) des fusibles comme décrit en 5.7.

Une disposition générale de l'équipement d'essai est représentée à la Figure 1, la Figure 2 et la Figure 3.

Dimensions en millimètres

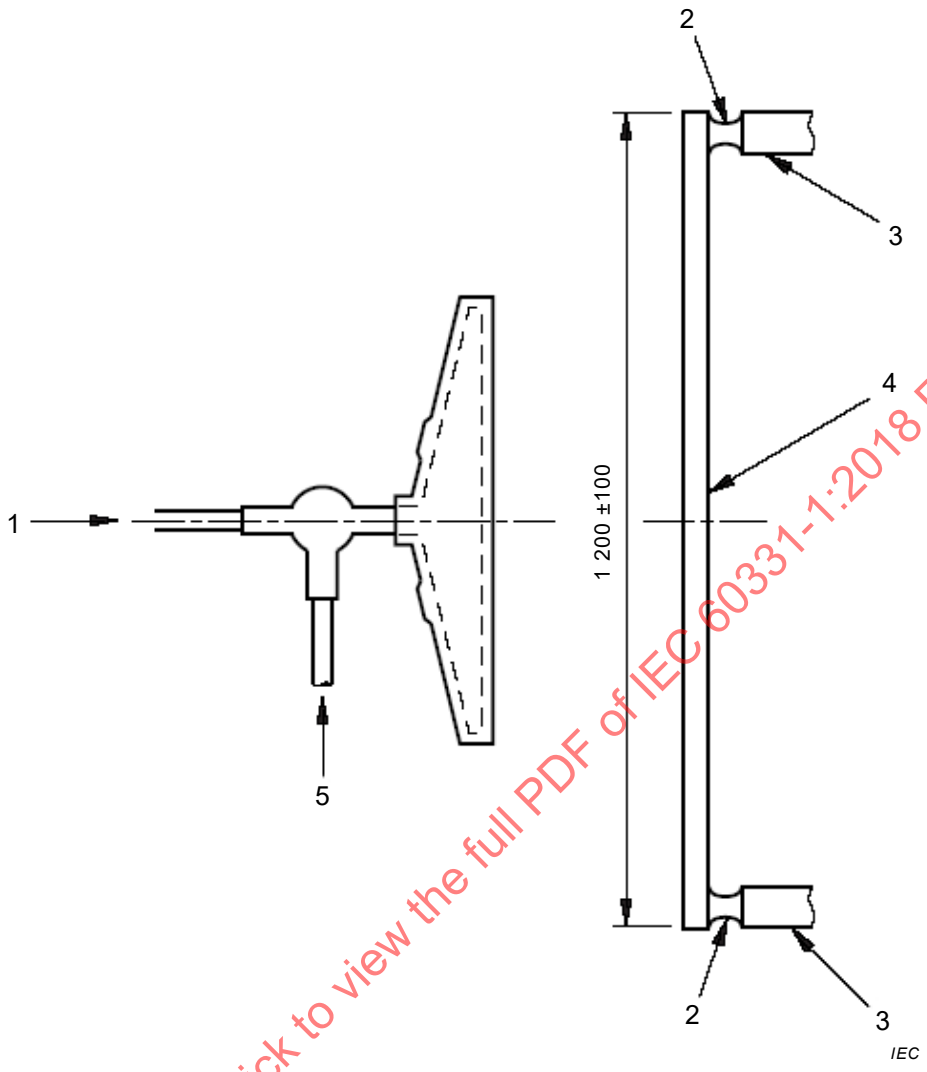


Légende

1	dispositif de production de chocs	5	éléments verticaux fixes de l'échelle d'essai
2	échelle d'essai en acier	6	éléments verticaux amovibles de l'échelle d'essai
3	manchon amortisseur en caoutchouc	7	cadre support rigide du dispositif d'essai
4	brûleur à gaz du type à ruban	P	plan d'ajustement

Figure 1 – Schéma de configuration de l'essai

Dimensions en millimètres

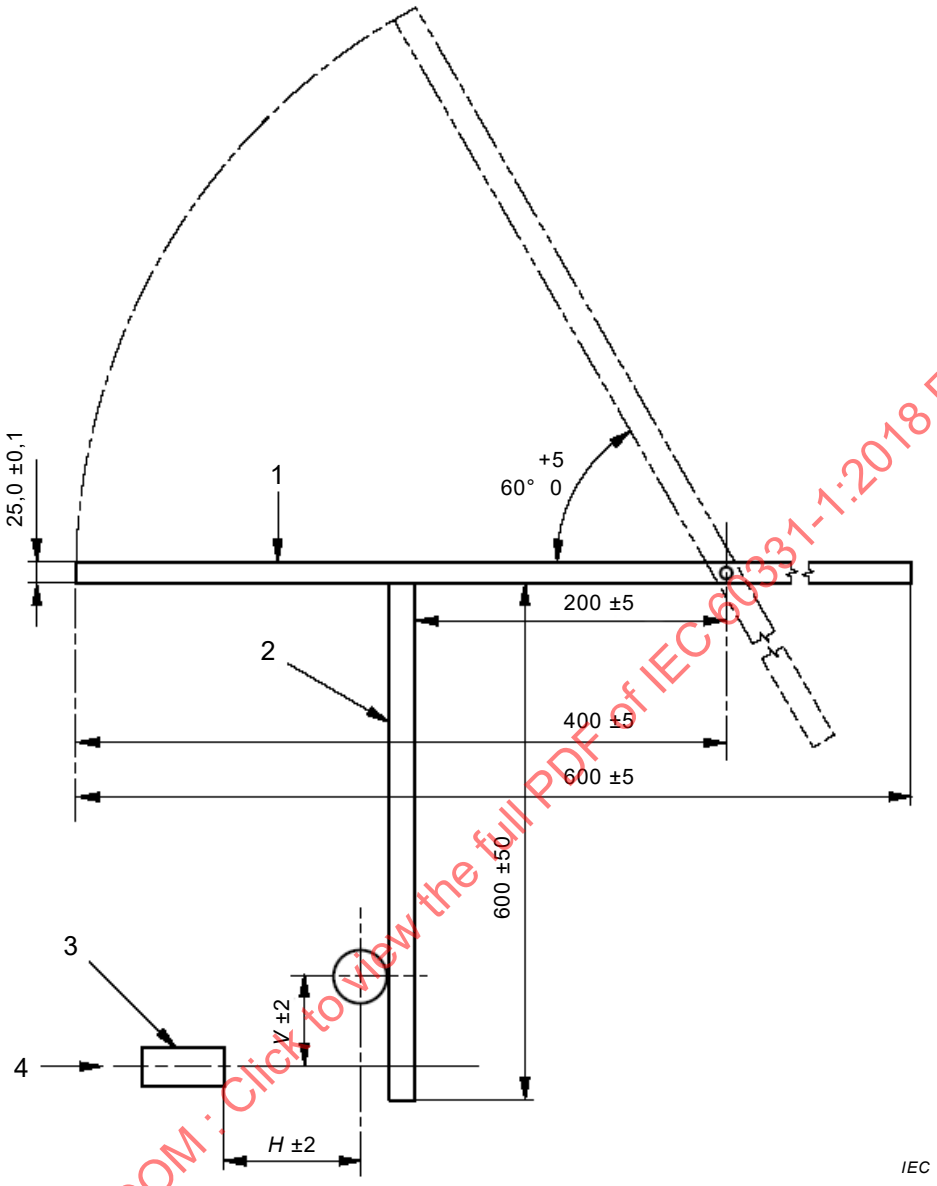


Légende

1	arrivée d'air	4	échelle d'essai horizontale en acier
2	manchon amortisseur en caoutchouc	5	arrivée du gaz propane
3	cadre support du dispositif d'essai		

Figure 2 – Vue en plan de l'équipement d'essai au feu

Dimensions en millimètres



Légende

1	dispositif de production de chocs	*H*	distance horizontale de la face du brûleur au centre de l'éprouvette d'essai
2	échelle d'essai en acier	*V*	distance verticale de l'axe central du brûleur au centre de l'éprouvette d'essai
3	brûleur à gaz		
4	axe central de la face du brûleur		

Figure 3 – Vue en élévation de l'équipement d'essai au feu (non à l'échelle)

5.2 Échelle d'essai et son montage

L'échelle d'essai doit être constituée d'un cadre en acier comme représenté à la Figure 1. Les quatre éléments centraux verticaux de l'échelle doivent être amovibles afin de les adapter aux différentes tailles de câbles en essai. L'échelle d'essai doit avoir une longueur de (1 200 ± 100) mm et une hauteur de (600 ± 50) mm, et la masse totale de l'échelle d'essai doit être de (24 ± 1) kg. Si nécessaire, un lest doit être placé sur les supports en acier.

NOTE 1 L'utilisation de cornière en acier de largeur approximative de 45 mm et d'épaisseur approximative de 6 mm, comportant des encoches appropriées afin de permettre la fixation des boulons et des pinces, s'est révélée être convenable pour la construction de l'échelle.

Chaque élément horizontal doit comporter un trou de montage situé au plus à 200 mm de chaque extrémité, la position exacte et le diamètre étant déterminés en fonction du type de manchon amortisseur et du type de cadre support utilisés. L'échelle d'essai doit être fixée à un support rigide à l'aide de quatre manchons amortisseurs en caoutchouc de dureté 50–60 Shore A placés entre les éléments horizontaux en acier de l'échelle et le cadre support, tel que représenté à la Figure 1 et la Figure 2, de façon à permettre son déplacement lors des chocs.

NOTE 2 Un manchon amortisseur type en caoutchouc, qui s'est avéré être approprié, est représenté à la Figure 4.

Dimensions en millimètres

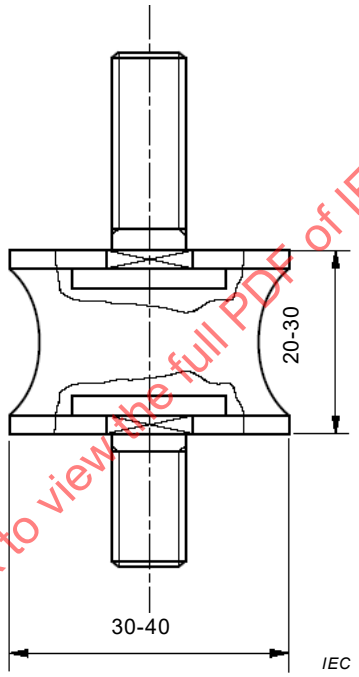


Figure 4 – Manchon amortisseur type en caoutchouc pour supporter l'échelle d'essai

5.3 Source de chaleur

5.3.1 Brûleur

La source de chaleur doit consister en un brûleur à gaz propane du type à ruban, dont la face a une longueur nominale de 500 mm (distance maximale entre les trous extérieurs), muni d'un mélangeur venturi. La largeur nominale de la face avant du brûleur doit être de 10 mm. La face du brûleur doit comporter trois rangées de trous en quinconce, de diamètre nominal de 1,32 mm et dont les centres de perçage sont espacés l'un de l'autre de 3,2 mm, comme représenté à la Figure 5.

Il est recommandé d'utiliser un brûleur à alimentation centrale.

Une rangée de petits trous disposés de chaque côté de la plaque du brûleur est autorisée afin de servir de trous pilotes pour que la flamme continue de brûler.