

INTERNATIONAL STANDARD



GROUP SAFETY PUBLICATION

**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**

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CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references	8
3 Terms and definitions	8
4 Test conditions — Test environment	8
5 Test apparatus	9
5.1 Test equipment.....	9
5.2 Test wall and mounting	12
5.3 Source of heat	14
5.3.1 Burner	14
5.3.2 Flow meters and flow rates	14
5.3.3 Verification	16
5.4 Shock-producing device.....	16
5.5 Positioning of source of heat.....	16
5.6 Continuity checking arrangements for electric power and control cables with rated voltage up to and including 600 V/1 000 V.....	16
5.7 Fuses.....	16
6 Test specimen (electric power and control cables with rated voltage up to and including 600 V/1 000 V).....	17
6.1 Test specimen preparation.....	17
6.2 Test specimen mounting	17
7 Test procedure (electric power and control cables with rated voltage up to and including 600 V/1 000 V).....	18
7.1 Test equipment and arrangement.....	18
7.2 Electrical connections.....	18
7.3 Flame and shock application.....	19
7.4 Electrification	19
8 Performance requirements (electric power and control cables with rated voltage up to and including 600 V/1 000 V).....	20
8.1 Flame application time	20
8.2 Acceptance criteria	20
9 Retest procedure	20
10 Test report (electric power and control cables with rated voltage up to and including 600 V/1 000 V).....	20
11 Cable marking	21
Annex A (normative) Verification procedure for the source of heat	22
A.1 Measuring equipment.....	22
A.2 Procedure	22
A.3 Evaluation.....	22
A.4 Further verification.....	23
A.5 Verification report	23
Annex B (informative) Guidance on the choice of recommended test apparatus.....	24
B.1 Burner and venturi	24
B.2 Test wall material.....	24
Influence of draughts in the test chamber.....	

Guidance on provision of a suitable test chamber	
Bibliography.....	26
Figure 1 – Schematic diagram of test configuration	10
Figure 2 – Plan view of fire test equipment	11
Figure 3 – End elevation of fire test equipment (not to scale)	12
Figure 4 – Typical rubber bush (hardness: 50-60 shore A) for fastening wall.....	13
Figure 5 – Burner face	14
Figure 6 – Schematic diagram of an example of a burner control system using rotameters	15
Figure 7 – Example of method of mounting a sample for test	17
Figure 8 – Basic circuit diagram – Electric power and control cables with rated voltage up to 600 V/1 000 V	19
Figure A.1 – Temperature measuring arrangement	22

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**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**

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 60331-2 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 with 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 60331-2;
- improved description of the test environment;
- 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 figure illustrating method of mounting of the sample regarding bending radius;
- 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
20/1783A/FDIS	20/1793/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 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

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 not 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 not greater than 20 mm overall diameter.

NOTE Cables of larger diameter ~~should~~ are intended to be tested using the apparatus, procedure and requirements of IEC 60331-1.

~~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/1000 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 60331-2.

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 standard.

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 the 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 m³, 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

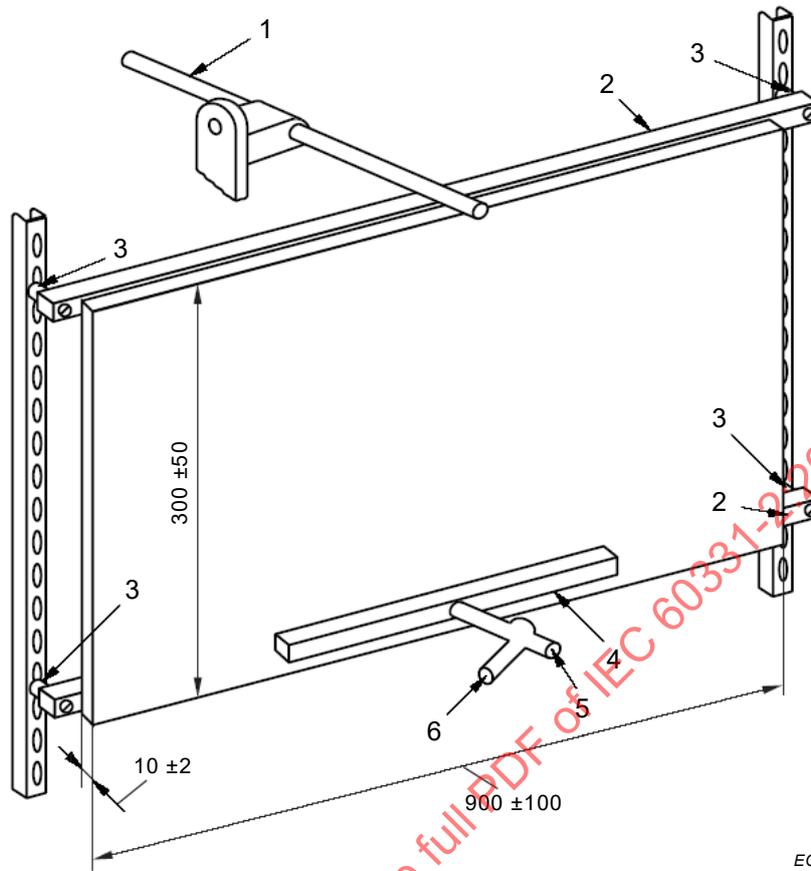
The test equipment shall consist of the following:

- a) a test wall onto which the cable is mounted, comprising a board manufactured from heat-resistant, non-combustible material ~~with~~ suitable for the temperatures involved fastened to steel supports and mounted on 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.

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Dimensions in millimetres



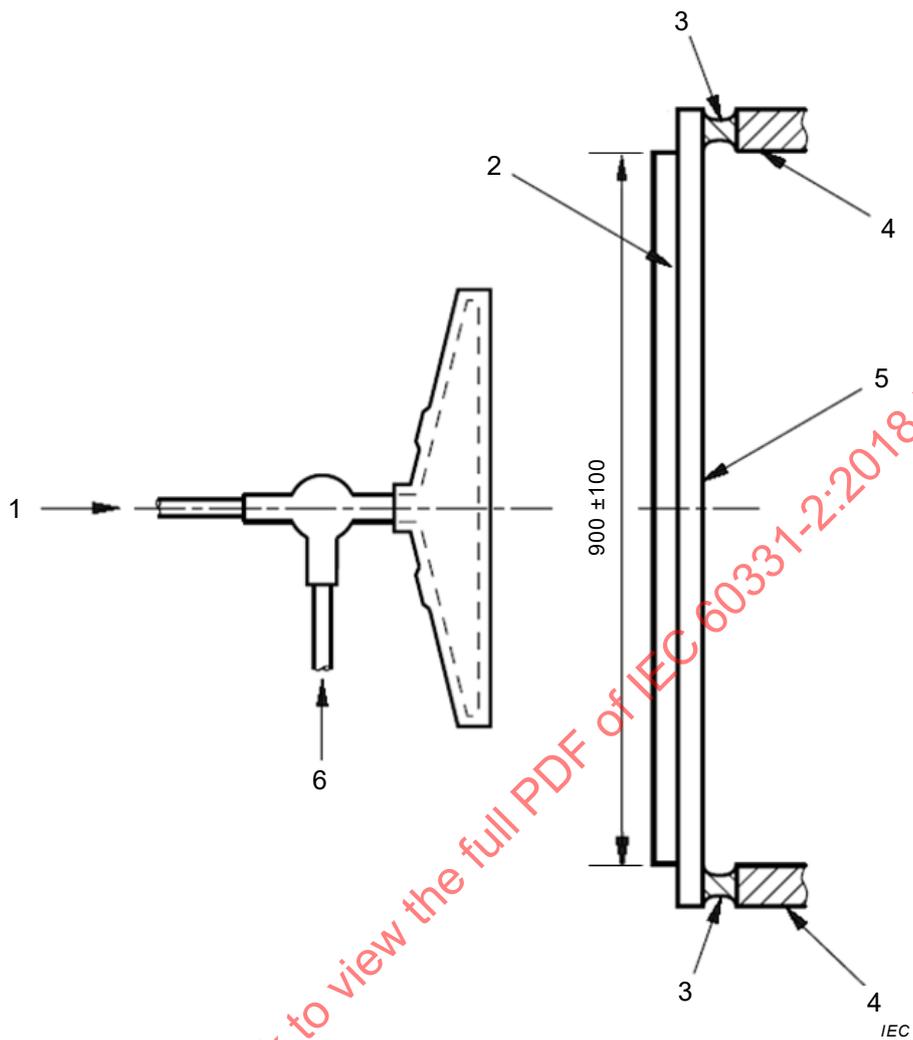
Key

- | | | | |
|---|------------------------|---|--------------------|
| 1 | shock-producing device | 4 | ribbon gas burner |
| 2 | steel support | 5 | air inlet pipe |
| 3 | rubber bush | 6 | propane inlet pipe |

Figure 1 – Schematic diagram of test configuration

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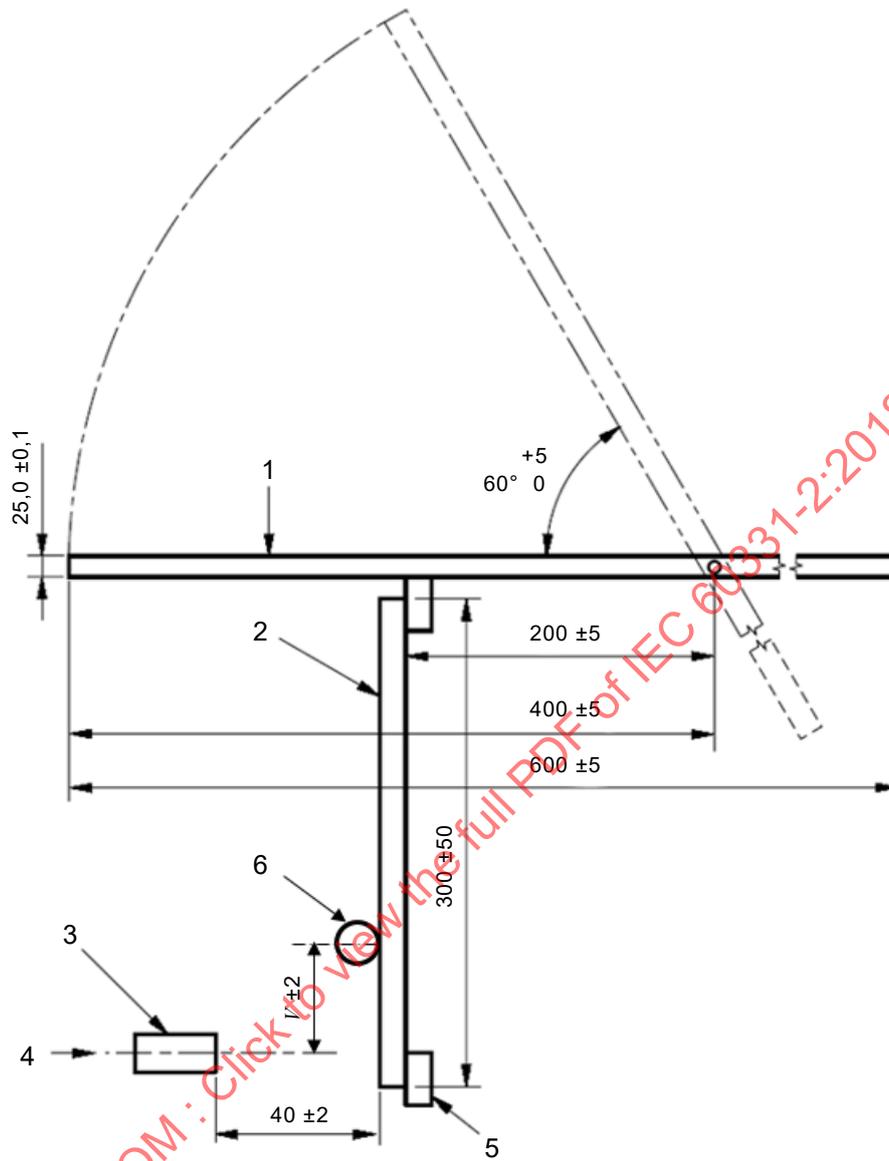
Dimensions in millimetres

**Key**

- | | | | |
|---|---------------|---|------------------------------------|
| 1 | entry for air | 4 | support framework |
| 2 | board | 5 | horizontal steel support for board |
| 3 | rubber bush | 6 | entry for propane gas |

Figure 2 – Plan view of fire test equipment

Dimensions in millimetres



IEC

Key

- | | | | |
|-----------|---|---|----------------------------|
| 1 | shock-producing device | 4 | centre line of burner face |
| 2 | board | 5 | support framework |
| 3 | gas burner | 6 | test sample |
| <i>l'</i> | Vertical distance from centre line of burner to the centre of the test specimen | | |

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

5.2 Test wall and mounting

The test wall shall consist of a board of heat-resistant, non-combustible and non-metallic material fastened rigidly to two horizontal steel supports, one at the top of the board and the other at the bottom, as shown in Figure 1. Vertical supports may also be used. The board shall be (900 ± 100) mm long, (300 ± 50) mm high and (10 ± 2) mm thick and the total mass of the test wall (i.e. board and steel supports) shall be (10,0 ± 0,5) kg. Ballast, if required, shall be placed on the steel supports.

In case of dispute, a new board should be used for each test.

NOTE 1 Supports made from square section steel tube approximately 25 mm x 25 mm and approximately 1 m long have been found to be suitable.

NOTE The top support should be fastened to the board so that its upper face is slightly above the upper edge of the board, so that the shock-producing device impacts on the support and not the board.

Each horizontal support shall have a mounting hole at each end, not more than 100 mm from the edge of the board, the exact position and diameter being determined by the particular supporting bush and supporting framework used. The test wall shall be fastened to a rigid support by four bonded rubber bushes of hardness 50–60 Shore A fitted between the horizontal steel supports of the wall 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.

In order to check the mounting of the wall, the static deflection following application of a mass to the centre of the upper support of the wall shall periodically be measured.

The values of mass and deflection shall comply with the following:

Mass kg	Deflection mm
25,0 ± 0,2	1,5 ± 0,3

Dimensions in millimetres

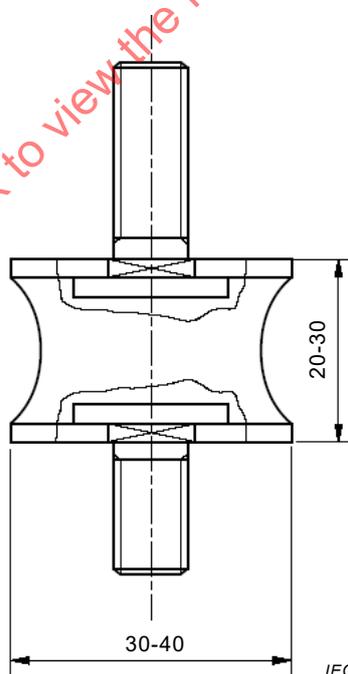


Figure 4 – Typical rubber bush (hardness: 50-60 shore A) for fastening wall

5.3 Source of heat

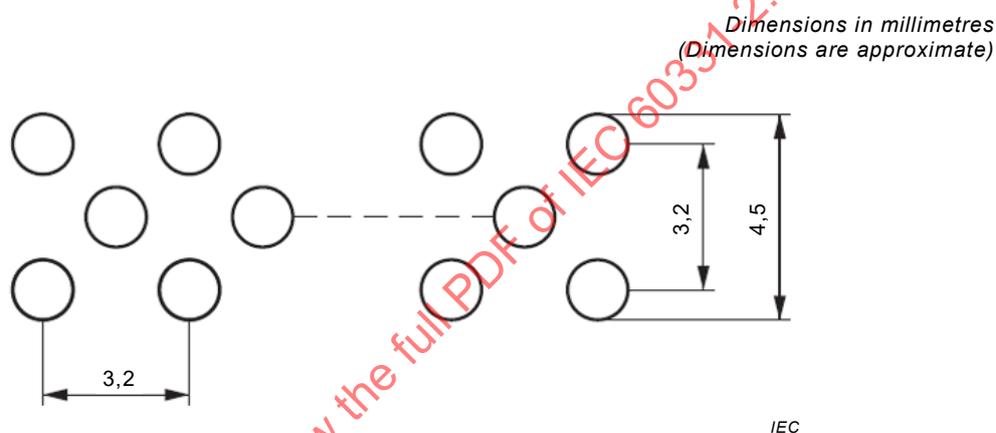
5.3.1 Burner

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.



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 purpose 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: (80 ± 4) l/min at reference conditions (1 bar and 20 °C) or (1600 ± 80) mg/s;~~

~~— propane: (5,0 ± 0,2) l/min at reference conditions (1 bar and 20 °C) or (160 ± 6) mg/s.~~

Propane: (160 ± 6) mg/s

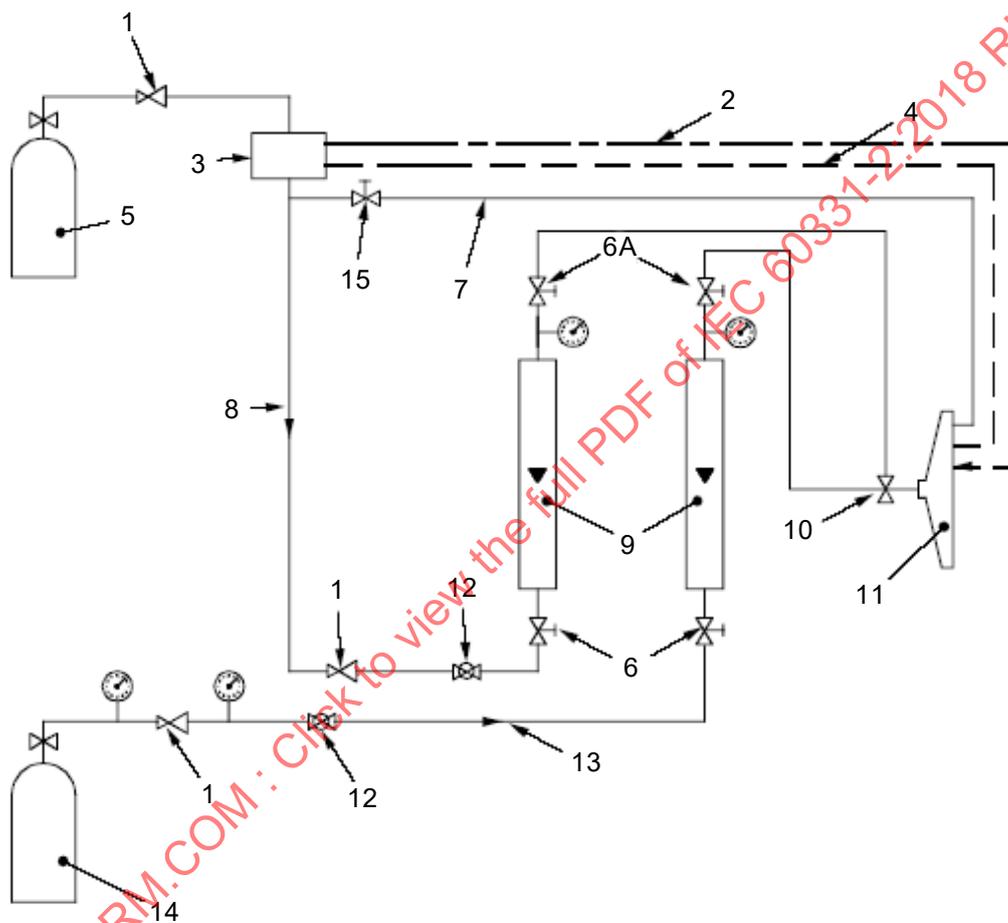
NOTE 1 This is approximately equivalent to a volume flow rate of (5,0 ± 0,2) litres/min at reference conditions (1 bar and 20 °C).

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

Air: $(1\,600 \pm 80)$ mg/s

NOTE 2 This is approximately equivalent to a volume flow rate of (80 ± 4) 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.



IEC

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 be a mild steel round bar ($25,0 \pm 0,1$) mm in diameter and (600 ± 5) mm long. The bar shall be freely pivoted about an axis parallel to the test wall, which shall be in the same horizontal plane as, and (200 ± 5) mm away from, the upper edge of the wall. The axis shall divide the bar into two unequal lengths, the longer length being (400 ± 5) mm which shall impact the wall. The bar shall drop under its own weight from an angle of $(60^{+5}_0)^\circ$ to the horizontal to strike the upper steel support of the wall 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 cable to be tested, the burner shall be positioned centrally at a horizontal distance of (40 ± 2) mm from the burner face to the test wall and at a vertical distance of $(V \pm 2)$ mm from the burner horizontal central plane to the central horizontal plane of the test specimen, as shown in Figure 3 and Figure A.1.

The exact burner location to be used during cable testing shall be determined using the verification procedure given in Annex A, where the value of 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 ~~sample~~ 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,~~ complying 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~~ 3,6 m long shall be available from the cable length for test. Each individual test specimen to be tested shall be a piece of cable, taken from the cable sample, not less than 1 200 mm long with approximately 100 mm of sheath or outer covering removed at each end.

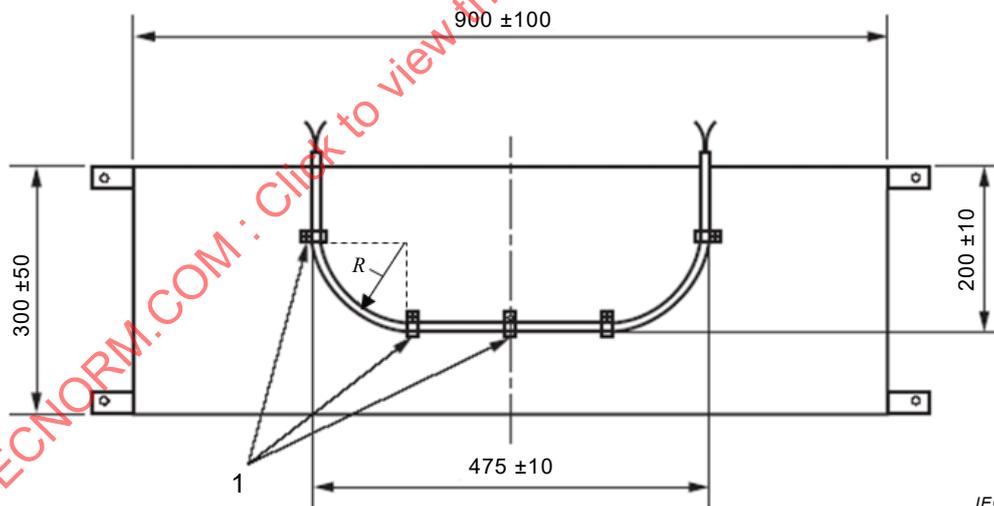
At each end of the test specimen, each conductor shall be suitably prepared for electrical connections, and, if there is more than one conductor, the exposed conductors shall be spread apart to avoid contact with each other.

6.2 Test specimen mounting

The test specimen shall be bent to form an approximate “U” shape. The internal radius of each bend shall be the manufacturer’s declared minimum bending radius in normal use and the overall distance between the vertical portions of the cable shall be (475 ± 10) mm as shown in Figure 7.

The test specimen shall be mounted centrally on the wall using metal clips which shall be earthed. The lower edge of the cable shall be (200 ± 10) mm below the top of the test wall. P-clips made of metal strip (10 ± 1) mm wide shall support the test specimen at ~~either~~ both ends of the radiused section and in the centre as shown in Figure 7. The P-clips shall be formed so as to have approximately the same diameter as the cable under test.

Dimensions in millimetres



Key

- 1 metal clips
- R minimum bending radius of cables in normal use

Figure 7 – Example of method of mounting a sample for test

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 wall and adjust the burner to the correct position relative to the 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 metallic 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 8. Where a metallic sheath, armour or screen acts as a neutral or protective conductor, it shall be connected, as shown in the circuit diagram in Figure 8, 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 8). 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 8).

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.

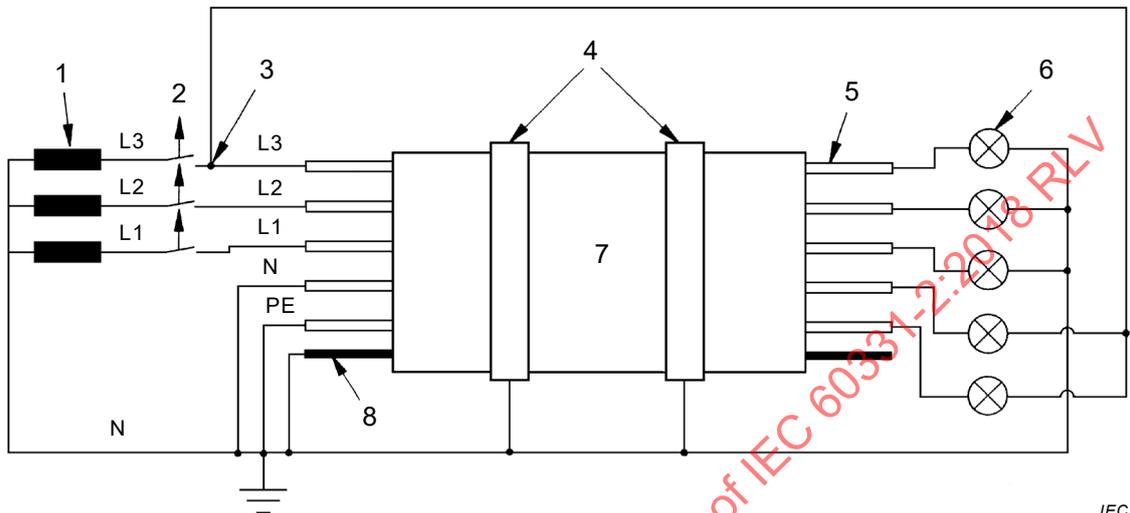
NOTE The above test procedure connects the neutral conductor to earth. This may not be appropriate if the cable is designed for use on a system where neutral is not earthed. If required by the cable standard it is permissible for the neutral conductor to be tested as if it were a phase conductor. Where a metallic 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 8).



Key

L1, L2, L3	phase conductors (L2, L3 if present)		
N	neutral conductor (if present)		
PE	protective earth (if present)		
1	Transformer	5	test conductor or group
2	fuse (2 A)	6	load and indicating device (e.g. lamp)
3	connection to phase L1 (or L2 or L3)	7	test specimen
4	metal clips	8	metal screen (if present)

Figure 8 – Basic circuit diagram – Electric power and control cables with rated voltage up to 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 wall 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 wall 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 V/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 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 standard;
- 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. type of test wall, 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 standard, it shall be marked with the number of this standard and the duration of flame application, as follows: "IEC 60331-2 (XX)" where XX shall be the duration in minutes. The marking shall be in addition to any requirement of the cable standard.

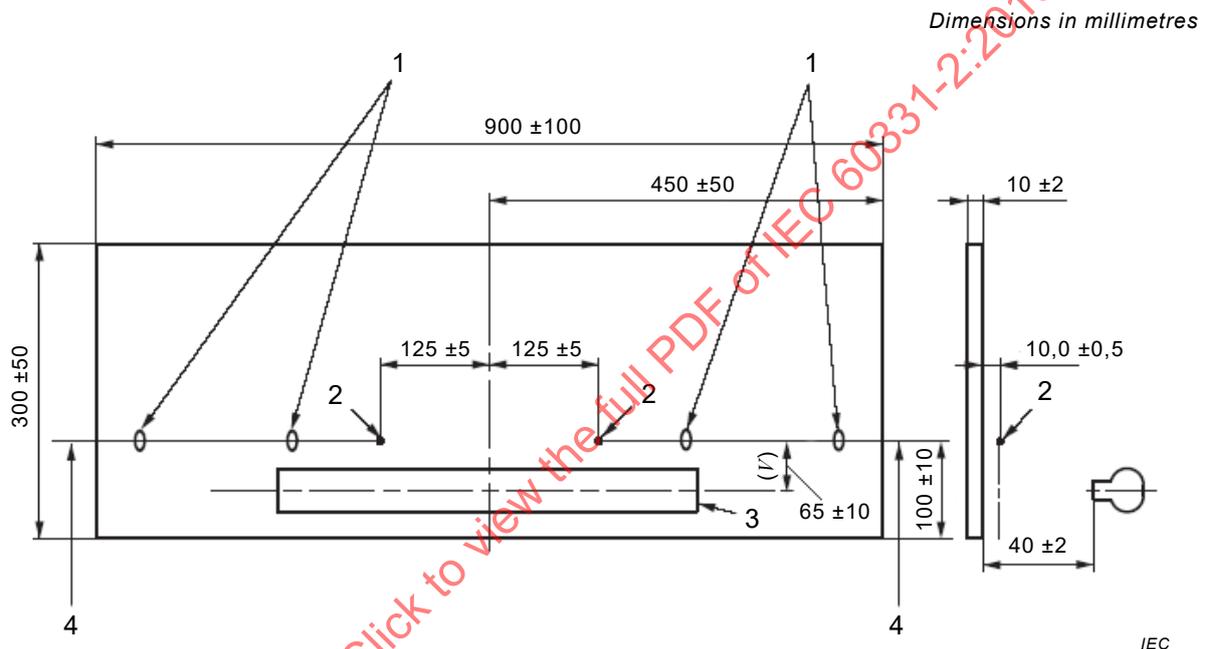
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Annex A (normative)

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 ~~(see conforming to IEC 60584-1)~~, mounted on the test wall as shown in Figure A.1. The thermocouple tips shall be $(10,0 \pm 0,5)$ 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.



Key

- | | | | |
|---|-----------------------|---|--------------------------------------|
| 1 | thermocouple supports | 3 | burner |
| 2 | thermocouple tip | 4 | 1,5 mm type K sheathed thermocouples |

V vertical distance of thermocouple tip from centre line of burner

Figure A.1 – Temperature measuring arrangement

A.2 Procedure

Position the burner (40 ± 2) mm horizontally from the wall and (65 ± 10) 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 vertical distance (V) between burner and 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 standard.

A.5 Verification report

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

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Annex B (informative)

Guidance on the choice of recommended test apparatus¹

B.1 Burner and venturi

A commercially available burner face meeting the recommendations of this standard 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.

Pemfab
30 Indel Avenue
PO Box 227
Rancocas
NJ 08073-0227
USA

www.amgasfur.com or www.pemfab.com

The recommended burner and venturi are available from:

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

B.2 Test wall material

Examples of materials which have been found to be suitable for the wall are:

- i) Tenmat Limited, UK – Sindanyo H61
- ii) Frenzelit-Werke, Germany – Isoplan 1100
- iii) Skamol, Denmark – Skamolox V-1100 Mk.2
- iv) Elit, France – Monolax 500

~~B.3 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.4 Guidance on provision of a suitable test chamber~~

~~The chamber must 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.~~

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.

~~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.~~

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Bibliography

IEC 60331-1, *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*

~~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*

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

**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**

**Essais pour câbles électriques soumis au feu – intégrité des circuits –
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**

CONTENTS

CONTENTS	2
FOREWORD	4
INTRODUCTION	6
1 Scope	7
2 Normative references	7
3 Terms and definitions	8
4 Test environment	8
5 Test apparatus	8
5.1 Test equipment	8
5.2 Test wall and mounting	11
5.3 Source of heat	13
5.3.1 Burner	13
5.3.2 Flow meters and flow rates	14
5.3.3 Verification	15
5.4 Shock-producing device	15
5.5 Positioning of source of heat	16
5.6 Continuity checking arrangements for electric power and control cables with rated voltage up to and including 600 V/1 000 V	16
5.7 Fuses	16
6 Test specimen (electric power and control cables with rated voltage up to and including 600 V/1 000 V)	16
6.1 Test specimen preparation	16
6.2 Test specimen mounting	17
7 Test procedure (electric power and control cables with rated voltage up to and including 600 V/1 000 V)	17
7.1 Test equipment and arrangement	17
7.2 Electrical connections	17
7.3 Flame and shock application	19
7.4 Electrification	19
8 Performance requirements (electric power and control cables with rated voltage up to and including 600 V/1 000 V)	20
8.1 Flame application time	20
8.2 Acceptance criteria	20
9 Retest procedure	20
10 Test report (electric power and control cables with rated voltage up to and including 600 V/1 000 V)	20
11 Cable marking	20
Annex A (normative) Verification procedure for the source of heat	21
A.1 Measuring equipment	21
A.2 Procedure	21
A.3 Evaluation	21
A.4 Further verification	22
A.5 Verification report	22

Annex B (informative) Guidance on the choice of recommended test apparatus.....	23
B.1 Burner and venturi	23
B.2 Test wall material.....	23
Bibliography.....	24
Figure 1 – Schematic diagram of test configuration.....	9
Figure 2 – Plan view of fire test equipment	10
Figure 3 – End elevation of fire test equipment (not to scale).....	11
Figure 4 – Typical rubber bush (hardness: 50-60 shore A) for fastening wall.....	13
Figure 5 – Burner face	14
Figure 6 – Schematic diagram of an example of a burner control system	15
Figure 7 – Example of method of mounting a sample for test	17
Figure 8 – Basic circuit diagram – Electric power and control cables with rated voltage up to 600 V/1 000 V	19
Figure A.1 – Temperature measuring arrangement	21

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**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**

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 60331-2 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 with 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 60331-2;
- improved description of the test environment;
- 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 figure illustrating method of mounting of the sample regarding bending radius;
- 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
20/1783A/FDIS	20/1793/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 stability date indicated on the IEC website 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.

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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

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 not greater than 20 mm overall diameter.

Cables of larger diameter are intended to be tested using the apparatus, procedure and requirements of IEC 60331-1.

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/1000 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 60331-2.

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 standard.

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 the 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 m³, 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.

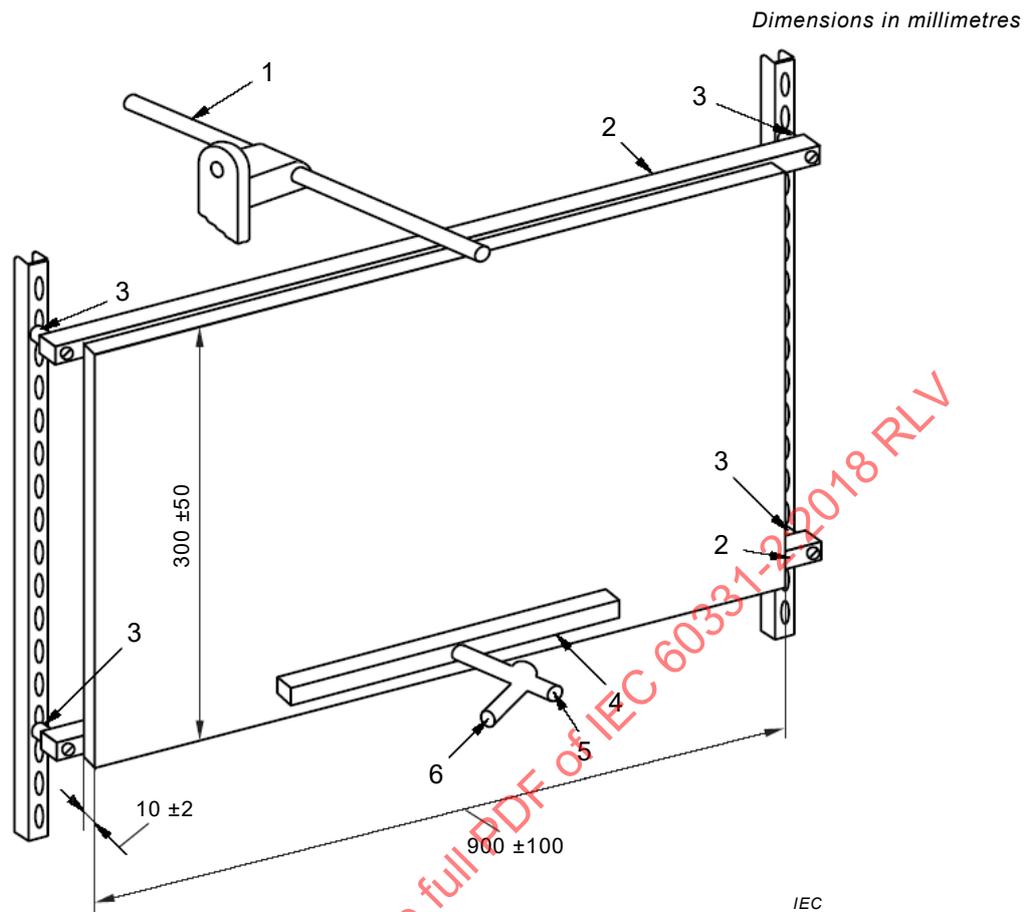
5 Test apparatus

5.1 Test equipment

The test equipment shall consist of the following:

- a) a test wall onto which the cable is mounted, comprising a board manufactured from heat-resistant, non-combustible material suitable for the temperatures involved fastened to steel supports and mounted on 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.

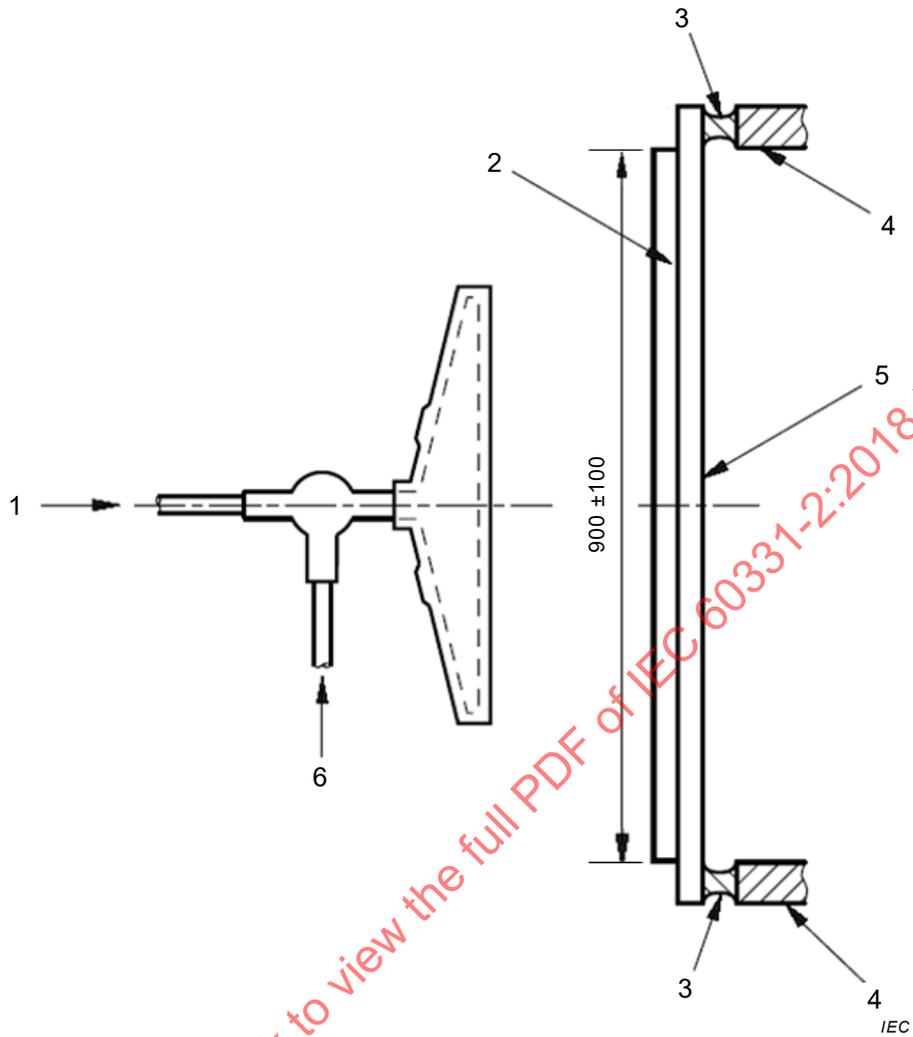
A general arrangement of the test equipment is shown in Figure 1, Figure 2 and Figure 3.

**Key**

- | | | | |
|---|------------------------|---|--------------------|
| 1 | shock-producing device | 4 | ribbon gas burner |
| 2 | steel support | 5 | air inlet pipe |
| 3 | rubber bush | 6 | propane inlet pipe |

Figure 1 – Schematic diagram of test configuration

Dimensions in millimetres



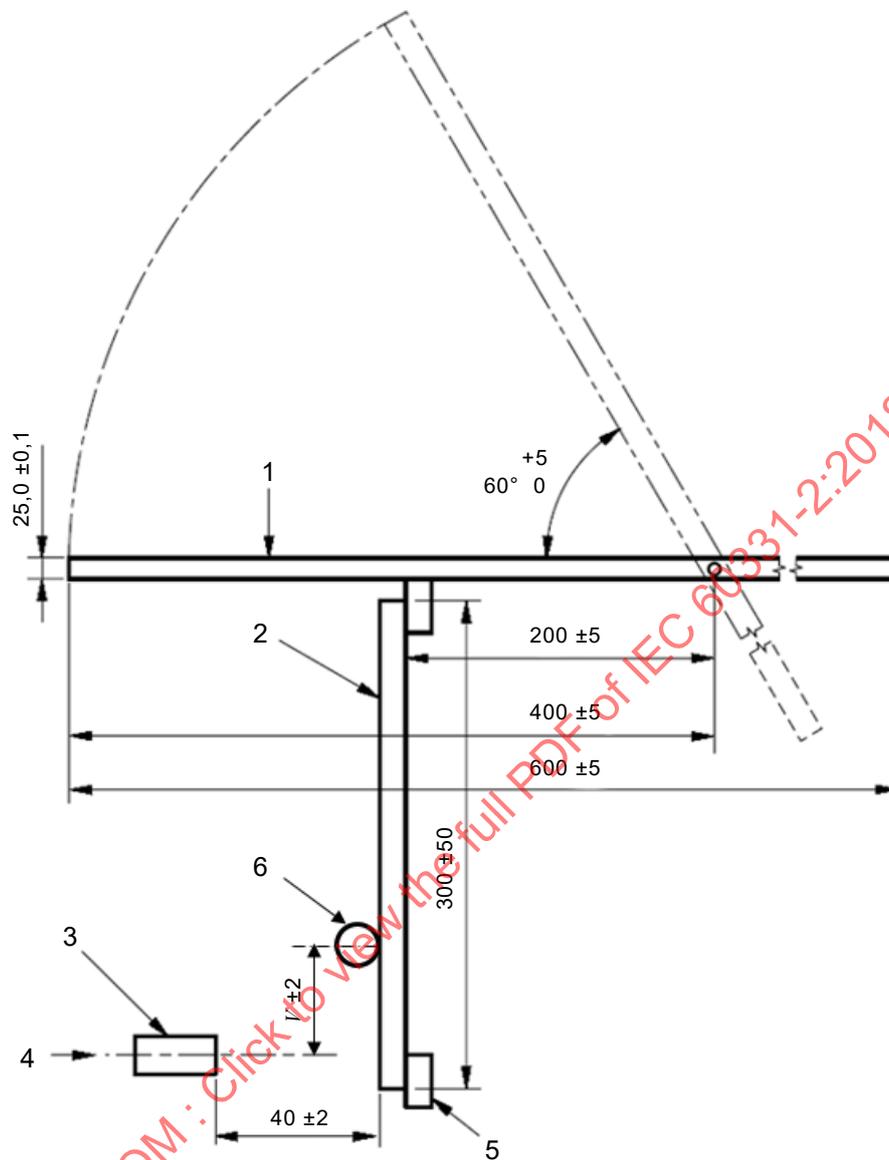
Key

- | | | | |
|---|---------------|---|------------------------------------|
| 1 | entry for air | 4 | support framework |
| 2 | board | 5 | horizontal steel support for board |
| 3 | rubber bush | 6 | entry for propane gas |

Figure 2 – Plan view of fire test equipment

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IEC



IEC

Key

- | | | | |
|---|---|---|----------------------------|
| 1 | shock-producing device | 4 | centre line of burner face |
| 2 | board | 5 | support framework |
| 3 | gas burner | 6 | test sample |
| V | Vertical distance from centre line of burner to the centre of the test specimen | | |

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

5.2 Test wall and mounting

The test wall shall consist of a board of heat-resistant, non-combustible and non-metallic material fastened rigidly to two horizontal steel supports, one at the top of the board and the other at the bottom, as shown in Figure 1. Vertical supports may also be used. The board shall be (900 ± 100) mm long, (300 ± 50) mm high and (10 ± 2) mm thick and the total mass of the test wall (i.e. board and steel supports) shall be $(10,0 \pm 0,5)$ kg. Ballast, if required, shall be placed on the steel supports.

In case of dispute, a new board should be used for each test.

NOTE 1 Supports made from square section steel tube approximately 25 mm x 25 mm and approximately 1 m long have been found to be suitable.

The top support should be fastened to the board so that its upper face is slightly above the upper edge of the board, so that the shock-producing device impacts on the support and not the board.

Each horizontal support shall have a mounting hole at each end, not more than 100 mm from the edge of the board, the exact position and diameter being determined by the particular supporting bush and supporting framework used. The test wall shall be fastened to a rigid support by four bonded rubber bushes of hardness 50–60 Shore A fitted between the horizontal steel supports of the wall 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.

In order to check the mounting of the wall, the static deflection following application of a mass to the centre of the upper support of the wall shall periodically be measured.

The values of mass and deflection shall comply with the following:

Mass kg	Deflection mm
25,0 ± 0,2	1,5 ± 0,3

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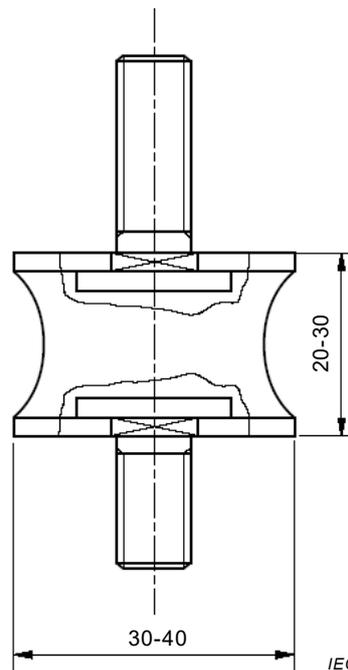
Dimensions in millimetres

Figure 4 – Typical rubber bush (hardness: 50-60 shore A) for fastening wall

5.3 Source of heat

5.3.1 Burner

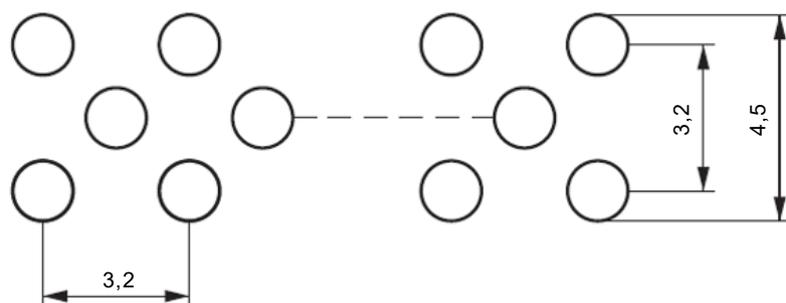
The source of heat shall be a ribbon type propane gas burner with a nominal burner face length of 500 mm (outer distance between outer holes) with a venturi mixer. The nominal burner face width shall be 10 mm. The face of the burner shall have three staggered rows of drilled holes, nominally 1,32 mm 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)*



IEC

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 purpose 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: (160 ± 6) mg/s

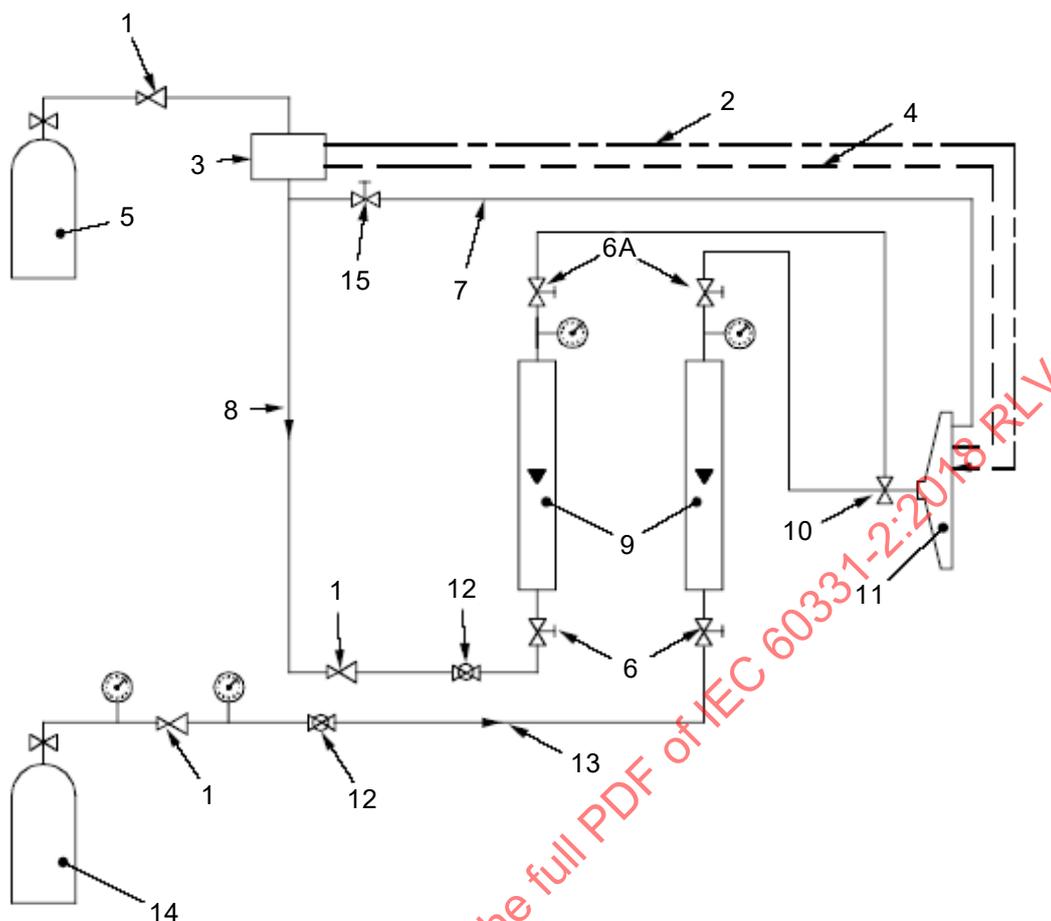
NOTE 1 This is approximately equivalent to a volume flow rate of (5,0 ± 0,2) litres/min at reference conditions (1 bar and 20 °C).

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

Air: (1 600 ± 80) mg/s

NOTE 2 This is approximately equivalent to a volume flow rate of (80 ± 4) 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.



IEC

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 be a mild steel round bar ($25,0 \pm 0,1$) mm in diameter and (600 ± 5) mm long. The bar shall be freely pivoted about an axis parallel to the test wall, which shall be in the same horizontal plane as, and (200 ± 5) mm away from, the upper edge of the wall. The axis shall divide the bar into two unequal lengths, the longer length being (400 ± 5) mm which shall impact the wall. The bar shall drop under its own weight from an angle of $(60^{+5}_0)^\circ$ to the horizontal to strike the upper steel support of the wall 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 cable to be tested, the burner shall be positioned centrally at a horizontal distance of (40 ± 2) mm from the burner face to the test wall and at a vertical distance of $(V \pm 2)$ mm from the burner horizontal central plane to the central horizontal plane of the test specimen, as shown in Figure 3 and Figure A.1.

The exact burner location to be used during cable testing shall be determined using the verification procedure given in Annex A, where the value of 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

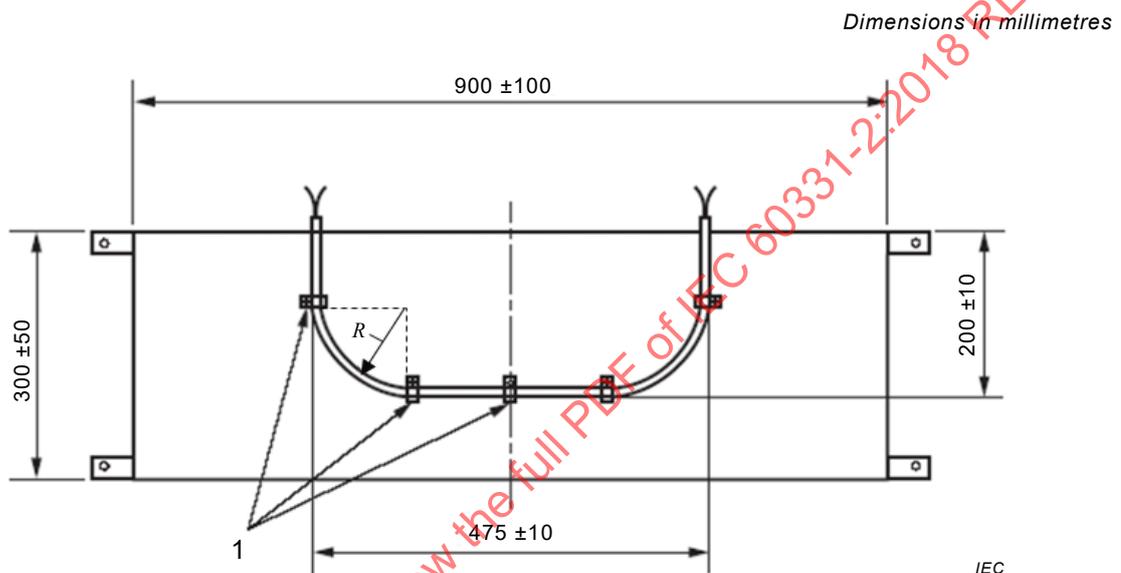
A cable sample at least 3,6 m long shall be available from the cable length for test. Each individual test specimen to be tested shall be a piece of cable, taken from the cable sample, not less than 1 200 mm long with approximately 100 mm of sheath or outer covering removed at each end.

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

The test specimen shall be bent to form an approximate “U” shape. The internal radius of each bend shall be the manufacturer’s declared minimum bending radius in normal use and the overall distance between the vertical portions of the cable shall be (475 ± 10) mm as shown in Figure 7.

The test specimen shall be mounted centrally on the wall using metal clips which shall be earthed. The lower edge of the cable shall be (200 ± 10) mm below the top of the test wall. P-clips made of metal strip (10 ± 1) mm wide shall support the test specimen at both ends of the radiused section and in the centre as shown in Figure 7. The P-clips shall be formed so as to have approximately the same diameter as the cable under test.



Key

- 1 metal clips
- R minimum bending radius of cables in normal use

Figure 7 – Example of method of mounting a sample for test

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 wall and adjust the burner to the correct position relative to the 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 8. 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 8, 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 8). 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 8).

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.

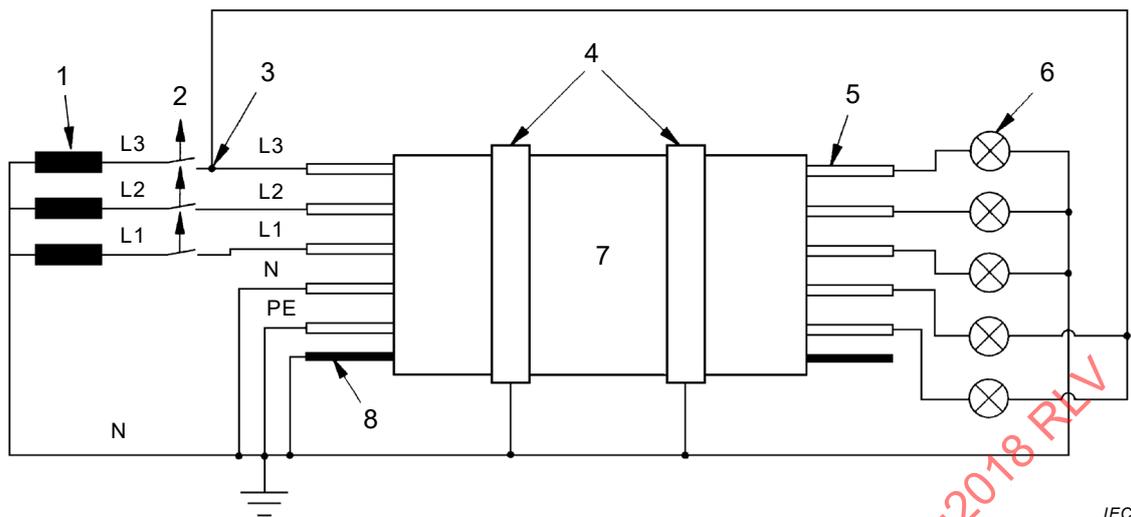
The above test procedure connects the neutral conductor to earth. This may not be appropriate if the cable is designed for use on a system where neutral is not earthed. If required by the cable standard it is permissible for the neutral conductor to be tested as if it were a phase conductor. Where a 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 8).



IEC

Key

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

1	Transformer	5	test conductor or group
2	fuse (2 A)	6	load and indicating device (e.g. lamp)
3	connection to phase L1 (or L2 or L3)	7	test specimen
4	metal clips	8	metal screen (if present)

Figure 8 – Basic circuit diagram – Electric power and control cables with rated voltage up to 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 wall after $5 \text{ min} \pm 10 \text{ s}$ from activation and subsequently at $5 \text{ min} \pm 10 \text{ s}$ intervals. After each impact, the impacting bar shall be raised from the test wall 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 V/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 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 standard;
- 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. type of test wall, 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

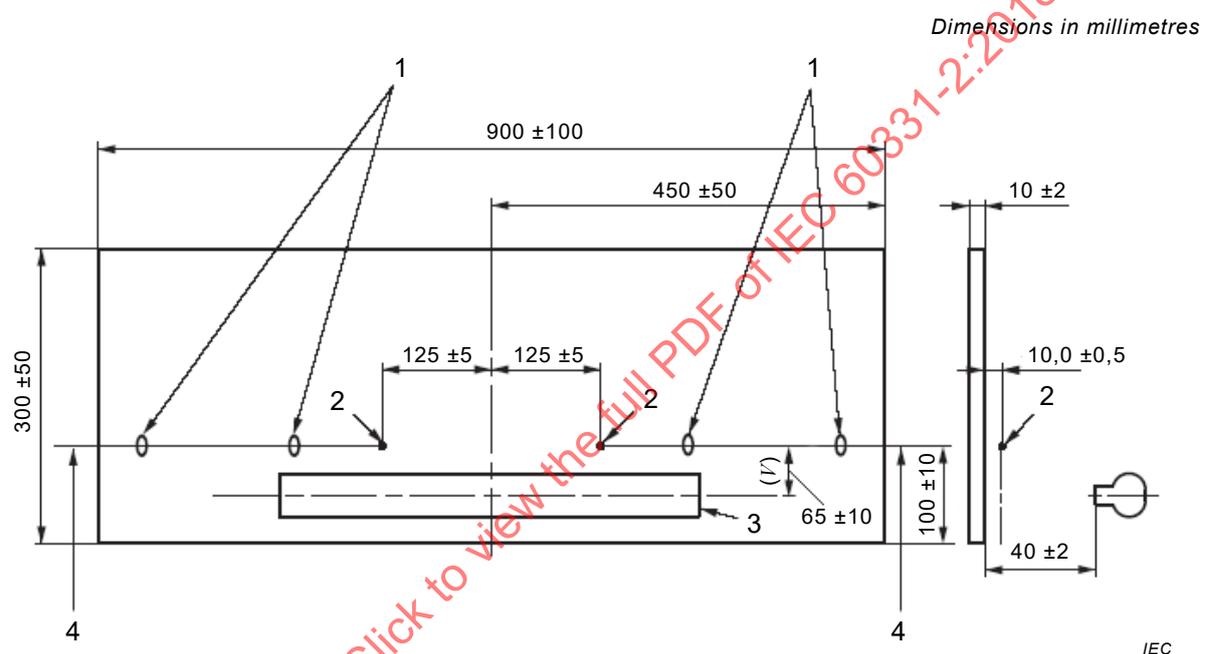
If a cable is required to be marked to signify compliance with this standard, it shall be marked with the number of this standard and the duration of flame application, as follows: "IEC 60331-2 (XX)" where XX shall be the duration in minutes. The marking shall be in addition to any requirement of the 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 conforming to IEC 60584-1, mounted on the test wall as shown in Figure A.1. The thermocouple tips shall be $(10,0 \pm 0,5)$ 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.



Key

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

Figure A.1 – Temperature measuring arrangement

A.2 Procedure

Position the burner (40 ± 2) mm horizontally from the wall and (65 ± 10) 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 vertical distance (V) between burner and 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 standard.

A.5 Verification report

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

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Annex B (informative)

Guidance on the choice of recommended test apparatus¹

B.1 Burner and venturi

A commercially available burner face meeting the recommendations of this standard 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

B.2 Test wall material

Examples of materials which have been found to be suitable for the wall are:

- i) Tenmat Limited, UK – Sindanyo H61
- ii) Frenzelit-Werke, Germany – Isoplan 1100
- iii) Skamol, Denmark – Skamolex V-1100 Mk.2
- iv) Elit, France – Monolax 500

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 60331-1, *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*

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

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SOMMAIRE

AVANT-PROPOS	28
INTRODUCTION.....	30
1 Domaine d'application	31
2 Références normatives	31
3 Termes et définitions	32
4 Environnement d'essai.....	32
5 Appareillage d'essai	32
5.1 Équipement d'essai.....	32
5.2 Paroi d'essai et son montage	36
5.3 Source de chaleur.....	38
5.3.1 Brûleur	38
5.3.2 Débitmètres et débits.....	39
5.3.3 Vérification	40
5.4 Dispositif de production de chocs.....	40
5.5 Positionnement de la source de chaleur.....	41
5.6 Dispositif de contrôle de la continuité pour les câbles électriques de puissance et de commande de tension assignée au plus égale à 600 V/1 000 V.....	41
5.7 Fusibles	41
6 Éprouvette (câbles électriques de puissance et de commande de tension assignée au plus égale à 600 V/1 000 V).....	41
6.1 Préparation de l'éprouvette	41
6.2 Montage de l'éprouvette.....	42
7 Procédure d'essai (câbles électriques de puissance et de commande de tension assignée au plus égale à 600 V/1 000 V).....	42
7.1 Équipement et disposition d'essai	42
7.2 Connexions électriques.....	43
7.3 Application de la flamme et des chocs	44
7.4 Mise sous tension	44
8 Exigences de performance (câbles électriques de puissance et de commande de tension assignée au plus égale à 600 V/1 000 V).....	45
8.1 Durée d'application de la flamme	45
8.2 Critères d'acceptation	45
9 Procédure de contre-essai.....	45
10 Rapport d'essai (câbles électriques de puissance et de commande de tension assignée au plus égale à 600 V/1 000 V).....	45
11 Marquage du câble	46
Annexe A (normative) Procédure de vérification de la source de chaleur	47
A.1 Équipement de mesure	47
A.2 Procédure	47
A.3 Évaluation.....	48
A.4 Vérification supplémentaire.....	48
A.5 Rapport de vérification.....	48
Annexe B (informative) Recommandations pour le choix de l'appareillage d'essai préconisé.....	49
B.1 Brûleur et mélangeur venturi.....	49
B.2 Matériau de la paroi d'essai	49

Bibliographie.....	50
Figure 1 – Schéma de configuration de l'essai	34
Figure 2 – Vue en plan de l'équipement d'essai au feu.....	35
Figure 3 – Vue en élévation de l'équipement d'essai au feu (non à l'échelle)	36
Figure 4 – Manchon amortisseur type en caoutchouc (dureté shore A 50-60) pour fixer le panneau d'essai	38
Figure 5 – Face avant du brûleur	39
Figure 6 – Schéma d'un exemple de montage du système de contrôle du brûleur	40
Figure 7 – Exemple de méthode de montage d'un échantillon pour l'essai	42
Figure 8 – Schéma de base du circuit électrique – Câbles électriques de puissance et de commande de tension assignée au plus égale à 600 V/1 000 V	44
Figure A.1 – Disposition du système de mesure de la température	47

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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

AVANT-PROPOS

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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 pour les câbles métalliques de données et de télécommunications et pour les câbles à fibres optiques ne soient pas données dans l'IEC 60331-2;
- amélioration de la description de l'environnement d'essai;
- 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 figure représentant la méthode de montage de l'échantillon au niveau du rayon de courbure;
- amélioration de la description des informations à inclure dans le rapport d'essai.

Le texte anglais de cette norme est issu des documents 20/1783A/FDIS et 20/1793/RVD.

Le rapport de vote 20/1793/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.

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- 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 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

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/1000 V, y compris ceux dont la tension assignée est inférieure à 80 V, aux câbles métalliques de données et de télécommunications ainsi qu'aux câbles à fibres optiques.

Elle est destinée à être utilisée pour soumettre à l'essai des câbles de diamètre externe inférieur ou égal à 20 mm.

Pour les câbles de diamètre plus grand, l'appareillage, la procédure et les exigences de l'IEC 60331-1 sont utilisés.

Le présent document inclut des 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 électriques de puissance et de commande de tension assignée au plus égale à 600 V/1000 V. 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 les câbles à fibres optiques ne sont pas données dans l'IEC 60331-2.

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

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

Des 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 ci-après, dans leur intégralité ou non, sont des références normatives indispensables à l'application 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 m³, 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

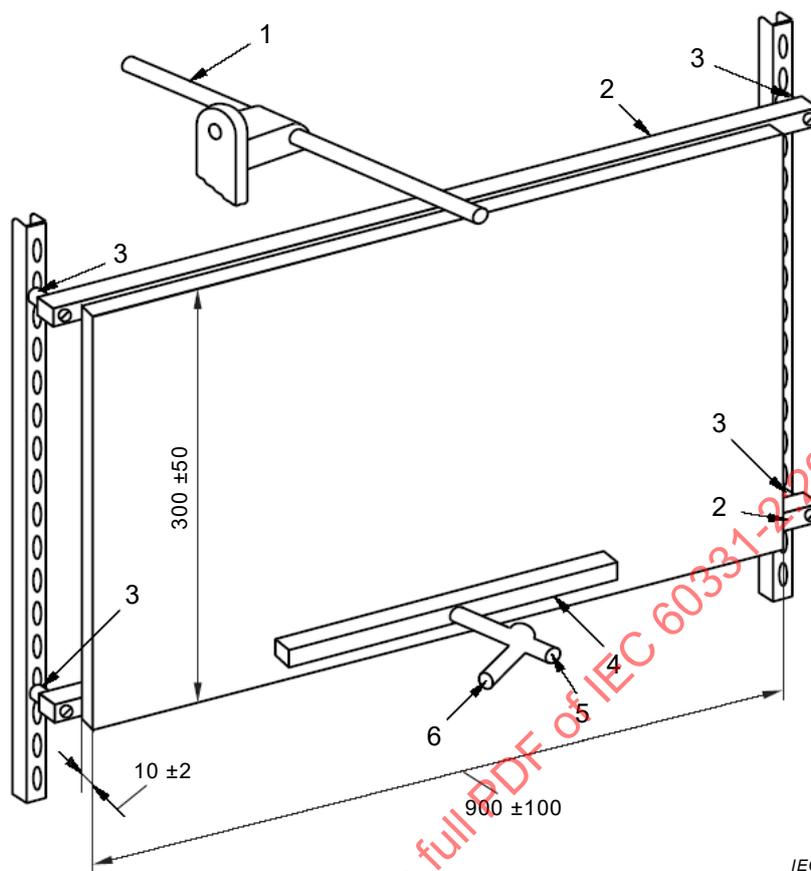
L'équipement d'essai doit être constitué des éléments suivants:

- a) une paroi d'essai sur laquelle le câble est monté, comprenant un panneau fabriqué à partir d'un matériau non combustible résistant à la chaleur, adapté aux températures utilisées, fixé sur des supports en acier et monté sur un support rigide tel que 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 en 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.

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Dimensions en millimètres



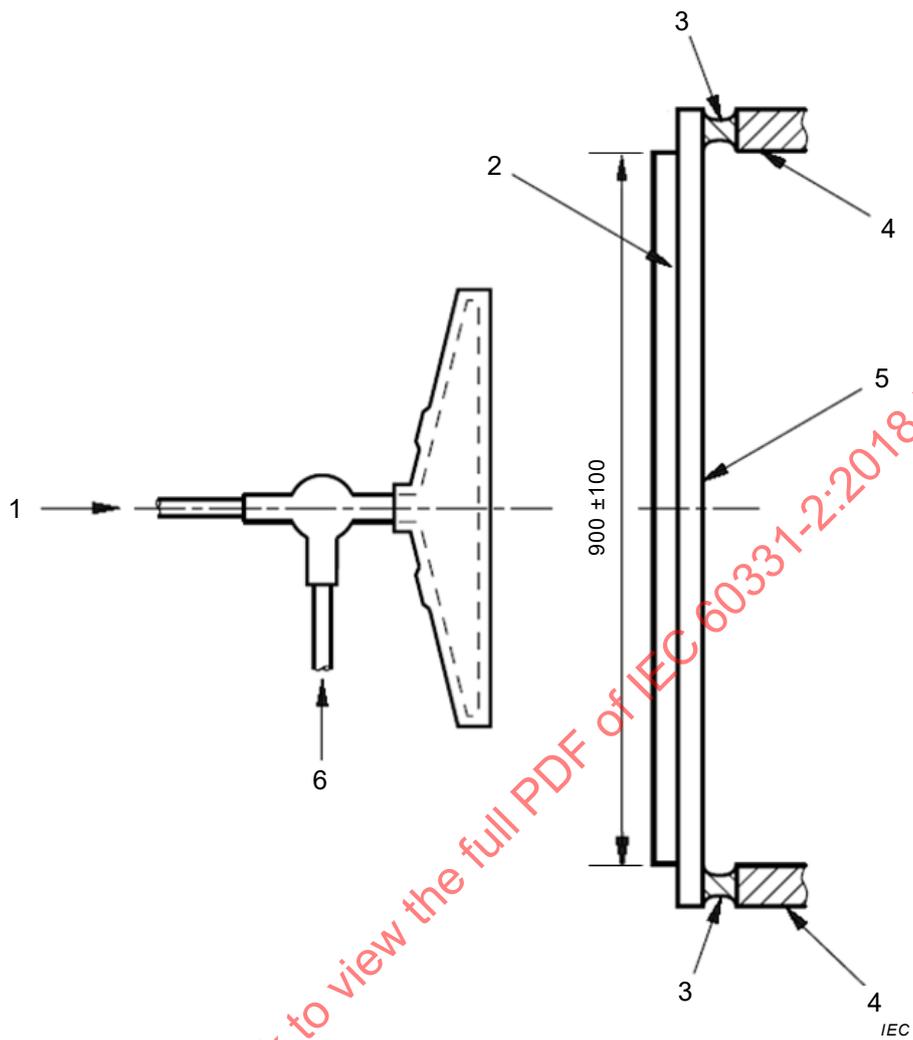
Légende

- | | | | |
|---|-------------------------------------|---|-------------------------------|
| 1 | dispositif de production de chocs | 4 | brûleur à gaz du type à ruban |
| 2 | support en acier | 5 | entrée d'air |
| 3 | manchons amortisseurs en caoutchouc | 6 | arrivée du gaz propane |

Figure 1 – Schéma de configuration de l'essai

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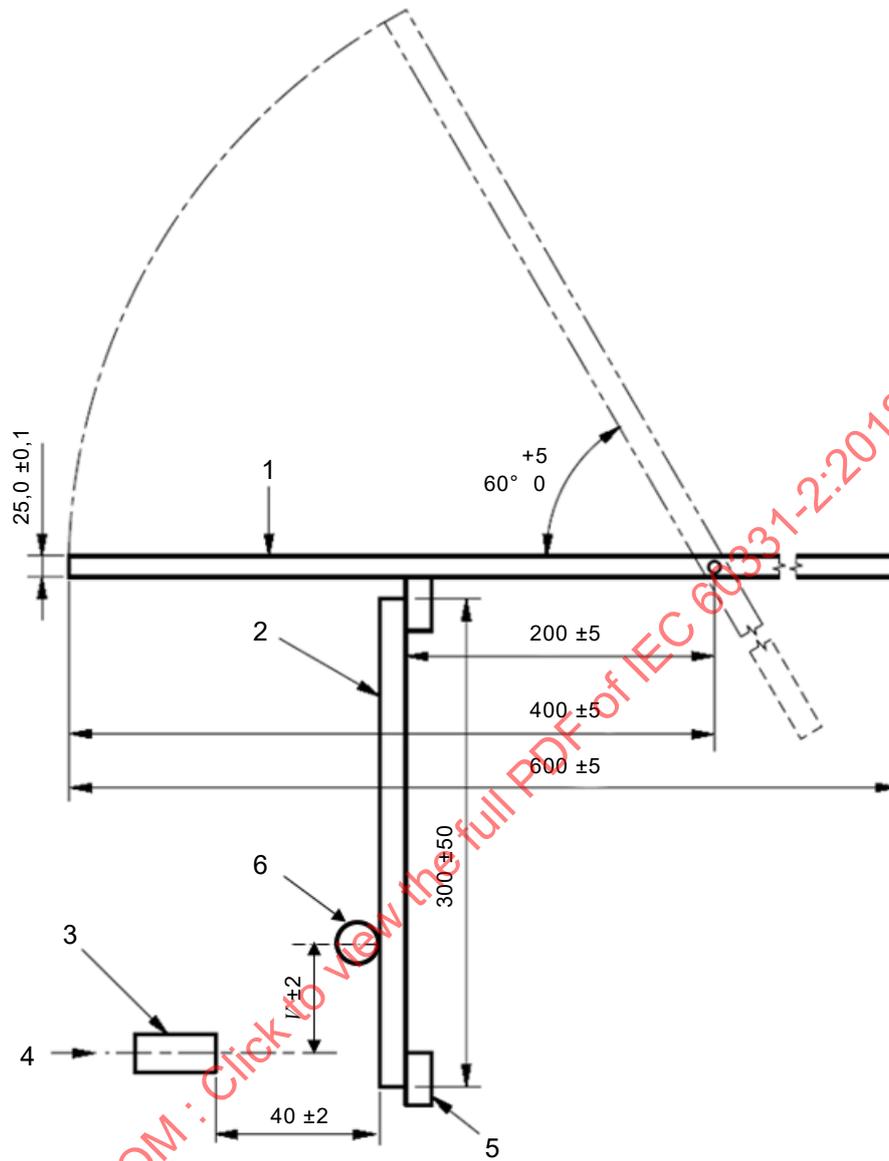
Dimensions en millimètres



Légende

1	entrée de l'air	4	support rigide du dispositif d'essai
2	panneau	5	support horizontal en acier pour le panneau
3	manchon amortisseur en caoutchouc	6	arrivée de gaz propane

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



IEC

Légende

- | | | | |
|-----------|--|---|--|
| 1 | dispositif de production de chocs mécaniques | 4 | ligne centrale de la face avant du brûleur |
| 2 | panneau | 5 | cadre support |
| 3 | brûleur à gaz | 6 | échantillon d'essai |
| <i>l'</i> | distance verticale de l'axe central du brûleur au centre de l'éprouvette d'essai | | |

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

5.2 Paroi d'essai et son montage

La paroi d'essai doit être constituée d'un panneau réalisé en matériau non combustible et non métallique résistant à la chaleur, fixé rigidement sur deux supports horizontaux en acier, l'un au sommet du panneau et l'autre à sa base, comme représenté à la Figure 1. Des supports verticaux peuvent également être utilisés. Le panneau doit avoir une longueur de (900 ± 100) mm, une hauteur de (300 ± 50) mm et une épaisseur de (10 ± 2) mm, la masse totale de la paroi d'essai (c'est-à-dire panneau et supports en acier) doit être de $(10,0 \pm 0,5)$ kg. Si nécessaire, un lest doit être placé sur les supports en acier.