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Tests on electric cables under fire conditions –

Part 3-10: Test for vertical flame spread of vertically-mounted bunched wires or cables – Apparatus

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

TESTS ON ELECTRIC CABLES UNDER FIRE CONDITIONS –

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FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The 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 60332-3-10 has been prepared by IEC technical committee 20: Electric cables.

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

IEC 60332-3-10 forms one of a series of publications dealing with tests on electric cables under fire conditions; the series supersedes IEC 60332-3 published in 1992. The parts of the series are described in the introduction.

All pre-existing categories of test are retained and updated. A new category (category D) has been added to cater for testing at very low non-metallic volumes.

The text of this standard is based on the following documents:

FDIS	Report on voting
20/402/FDIS	20/426/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

Annexes A and B are for information only.

The committee has decided that the contents of this publication will remain unchanged until 2008. At this date, the publication will be

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- withdrawn;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

INTRODUCTION

Parts 1 and 2 of IEC 60332 specify methods of test for flame spread characteristics for a single vertical insulated wire or cable. It cannot be assumed that, because a wire or cable meets the requirements of parts 1 and 2, a vertical bunch of similar cables or wires will behave in a similar manner. This is because flame spread along a vertical bunch of cables depends on a number of features, such as

a) the volume of combustible material exposed to the fire and to any flame which may be produced by the combustion of the cables;

b) the geometrical configuration of the cables and their relationship to an enclosure;

c) the temperature at which it is possible to ignite the gases emitted from the cables;

d) the quantity of combustible gas released from the cables for a given temperature rise;

e) the volume of air passing through the cable installation;

f) the construction of the cable, for example armoured or unarmoured, multi- or single-core.

All of the foregoing assume that the cables are able to be ignited when involved in an external fire.

Part 3 of IEC 60332 gives details of a test where a number of cables are bunched together to form various test sample installations. For easier use and differentiation of various test categories, the parts are designated as follows:

Part 3-10: Apparatus

Part 3-21: Category A F/R

Part 3-22: Category A

Part 3-23: Category B

Part 3-24: Category C

Part 3-25: Category D

Parts from 3-21 onwards define the various categories and the relevant procedures. The categories are distinguished by test duration, the volume of non-metallic material of the test sample and the method of mounting the sample for the test. In all categories, cables having at least one conductor of cross-sectional area greater than 35 mm^2 are tested in a spaced configuration, whereas cables of conductor cross-sectional area of 35 mm^2 or smaller are tested in a touching configuration.

The categories are not necessarily related to different safety levels in actual cable installations. The actual installed configuration of the cables may be a major determinant in the level of flame spread occurring in an actual fire.

The method of mounting described in category A F/R (part 3-21) is intended for special cable designs used in particular installations.

Categories A, B, C and D (parts 3-22 to 3-25 respectively) are for general use where different non-metallic volumes are applicable.

Additional categories, especially to cover the use of small diameter communication cables in closely bunched configurations, will be further considered when more data are available.

TESTS ON ELECTRIC CABLES UNDER FIRE CONDITIONS –

Part 3-10: Test for vertical flame spread of vertically-mounted bunched wires or cables – Apparatus

1 Scope

The series of International Standards covered by Parts 3-10, 3-21, 3-22, 3-23, 3-24 and 3-25 of IEC 60332 specifies methods of test for the assessment of vertical flame spread of vertically-mounted bunched wires or cables, electrical or optical, under defined conditions

NOTE For the purpose of this standard the term "electric wire or cable" covers all insulated metallic conductor cables used for the conveyance of energy or signals.

This part of IEC 60332 details the apparatus and its arrangement and calibration.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60332. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60332 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60695-4, *Fire hazard testing – Part 4: Terminology concerning fire tests*

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

3 Definitions

For the purpose of this part of IEC 60332 the following definition applies. The definition is taken from IEC 60695-4.

3.1
ignition source
source of energy that initiates combustion

4 Test environment

The test shall not be carried out if the external wind speed, measured by an anemometer fitted on the top of the test rig, is greater than 8 m/s and shall not be carried out if the temperature of the inside walls is below 5 °C or above 40 °C measured at a point approximately 1 500 mm above floor level, 50 mm from a side wall, and 1 000 mm from the door. The enclosure door shall be closed throughout the test.

5 Test apparatus

The test apparatus consists of the following:

5.1 Test chamber

The test rig (see figure 1) shall comprise a vertical test chamber having a width of (1 000 ± 100) mm, a depth of (2 000 ± 100) mm and a height of (4 000 ± 100) mm; the floor of the chamber shall be raised above ground level. The test chamber shall be nominally airtight along its sides, air being admitted at the base of the test chamber through an aperture of (800 ± 20) mm × (400 ± 10) mm situated (150 ± 10) mm from the front wall of the test chamber (see figure 1).

An outlet (300 ± 30) mm x (1 000 ± 100) mm shall be made at the rear edge of the top of the test chamber. The back and sides of the test chamber shall be thermally insulated to give a coefficient of heat transfer of approximately 0,7 $W \cdot m^{-2} \cdot K^{-1}$. For example, a steel plate 1,5 mm to 2,0 mm thick covered with 65 mm of mineral wool with a suitable external cladding is satisfactory (see figure 2). The distance between the ladder and the rear wall of the chamber is (150 ± 10) mm, and between the bottom rung of the ladder and the floor (400 ± 5) mm. The clearance between the lowest point of the test piece and the floor is approximately 100 mm (see figure 3).

5.2 Air supply

A means of supplying a controlled air flow through the chamber shall be fitted.

NOTE 1 It is recommended that the air should be blown into the test chamber, via the air inlet, using a suitable fan.

Prior to burner ignition, the air flow shall be adjusted to a rate of (5 000 ± 500) l/min at a constant controlled temperature of (20 ± 10) °C and at atmospheric pressure and measured at the inlet side before the test commences. This air flow rate shall be maintained throughout the test until cable burning or glowing has ceased or for a maximum time of 1 h from completion of the test flame application period, after which period the flame or glowing shall be extinguished.

NOTE 2 In order to remove noxious gases, it is recommended to maintain the air flow for some minutes after the end of the test, before entering the test chamber.

5.3 Ladder types

There are two types of tubular steel ladder: a standard ladder of (500 ± 5) mm width and a wide ladder of (800 ± 10) mm width. Details of the types of ladder are given in figures 4a and 4b.

5.4 Effluent cleaning attachment

Legal requirements may make it necessary for equipment for collecting and washing the effluent to be fitted to the test chamber. This equipment shall not cause a change in the air flow rate through the test chamber.

6 Ignition source

6.1 Type

As required by the test procedure the ignition source shall be one or two ribbon-type propane gas burners complete with venturi mixer, and their own set of flowmeters. The propane gas shall be technical grade propane of nominal 95 % purity. The flame-producing surface of the burner(s) shall consist of a flat metal plate through which 242 holes of 1,32 mm in diameter are drilled on 3,2 mm centres in three staggered rows of 81, 80 and 81 holes each to form an array having the nominal dimensions 257 mm × 4,5 mm. As the burner plate may be drilled without the use of a drilling jig, the spacing of the holes may vary slightly. Additionally, a row of small holes may be milled on each side of the burner plate to serve as pilot holes with the function of keeping the flame burning.

The burners are shown in figures 5a and 5b, and the placement of the holes in figure 6.

NOTE 1 To ensure reproducibility between results from different testing stations, a burner, which is readily available, is recommended for use. For details, see annex A.

Each burner shall be individually fitted with an accurate means of controlling the propane gas and air input flow rates, either by means of a rotameter-type flowmeter or mass flowmeter.

NOTE 2 Mass flowmeters are recommended for ease of use.

Figure 7 shows an example of a rotameter-type system.

SAFETY NOTE – The following precautions are recommended to ensure safe operation of the ignition source:

– the gas supply system should be equipped with flashback arresters;
– a flame failure protection device should be used;
– safe sequencing of the propane and air supply should be employed during ignition and extinguishing.

The calibration of the propane gas and air rotameter-type flowmeters shall be checked after installation to ensure that the pipework and venturi mixer have not affected the calibration.

Corrections for the variations in temperature and pressure from that specified on the propane gas and air rotameter-type flowmeters shall be applied when necessary, see annex B.

Propane gas and air rotameter-type flowmeters shall be calibrated according to the following reference conditions.

Reference temperature and pressure are 20 °C and 1 bar (100 kPa).

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

The flow rates at reference conditions (1 bar and 20 °C) for the test shall be as follows:

Air (77,7 ± 4,8) l/min

Propane (13,5 ± 0,5) l/min

to provide a nominal (73,7 ± 1,68) × 10^6 J/h ((70 000 ± 1 600) Btu/h)[1)] to each burner.

NOTE 3 The net heat of combustion is used to calculate the propane flow rate.

6.2 Positioning

For the test, the burner shall be arranged horizontally at a distance of (75 ± 5) mm from the front surface of the cable sample, (600 ± 5) mm above the floor of the test chamber and approximately symmetrical with the axis of the ladder. The point of application of the burner flame shall lie in the centre between two cross-bars on the ladder and at least 500 mm above the lower end of the sample (see figure 3 and figure 5a).

Adjustment of air and gas flows prior to the test may be carried out away from the test position.

Where two burners are used in combination with the wide ladder, they shall be arranged so as to be approximately symmetrical with the axis of the ladder, as shown in figure 5b. The burner system shall be positioned such that the centre line of the burner system is approximately coincident with the centre of the ladder.

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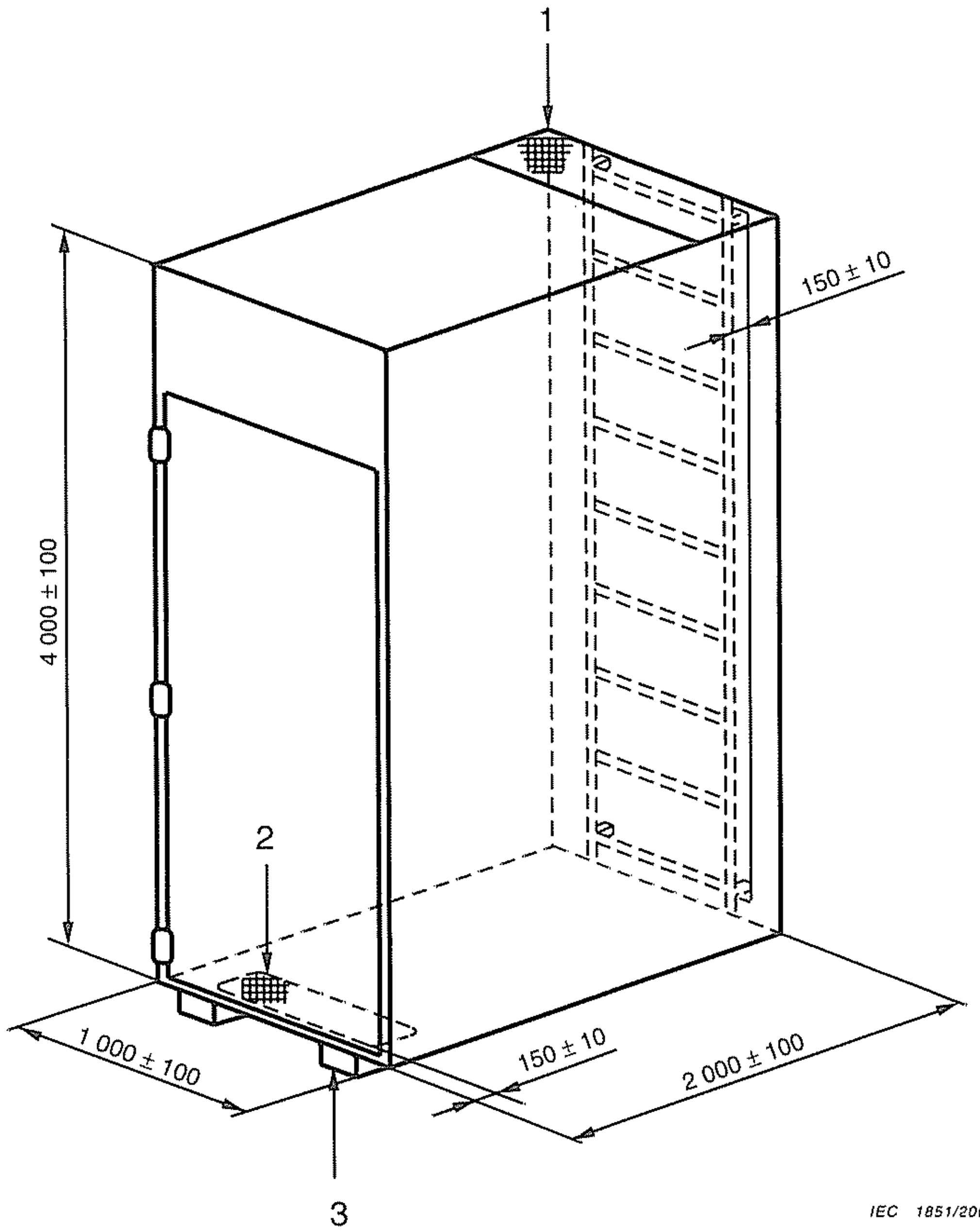
1) This is also equivalent to (20,5 ± 0,5) kW.



Key

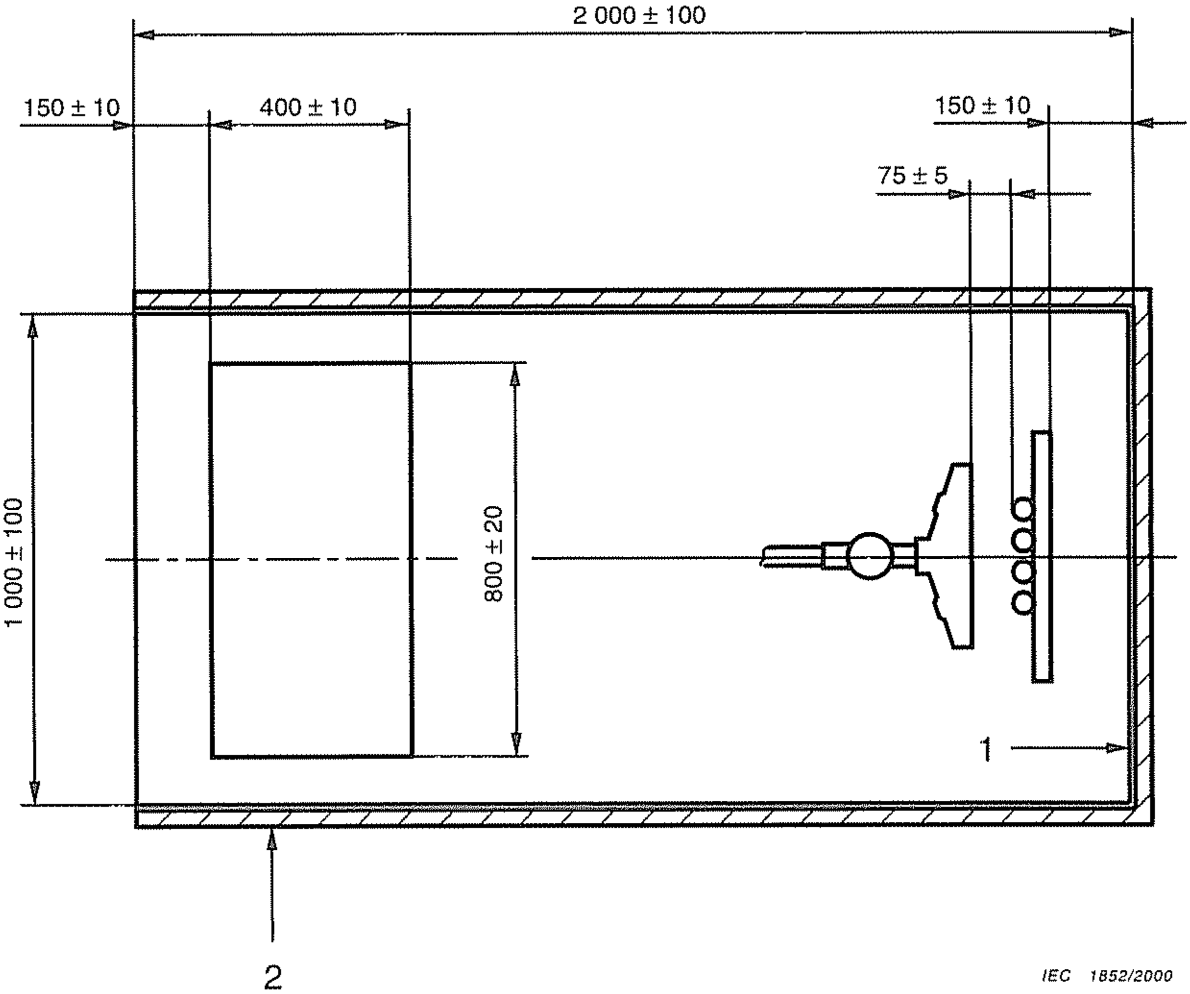
1 Smoke outlet (300 ± 30) × (1 000 ± 100)

2 Air inlet (800 ± 20) × (400 ± 10)

3 Rig raised above ground level

Dimensions in millimetres

Figure 1 – Test chamber



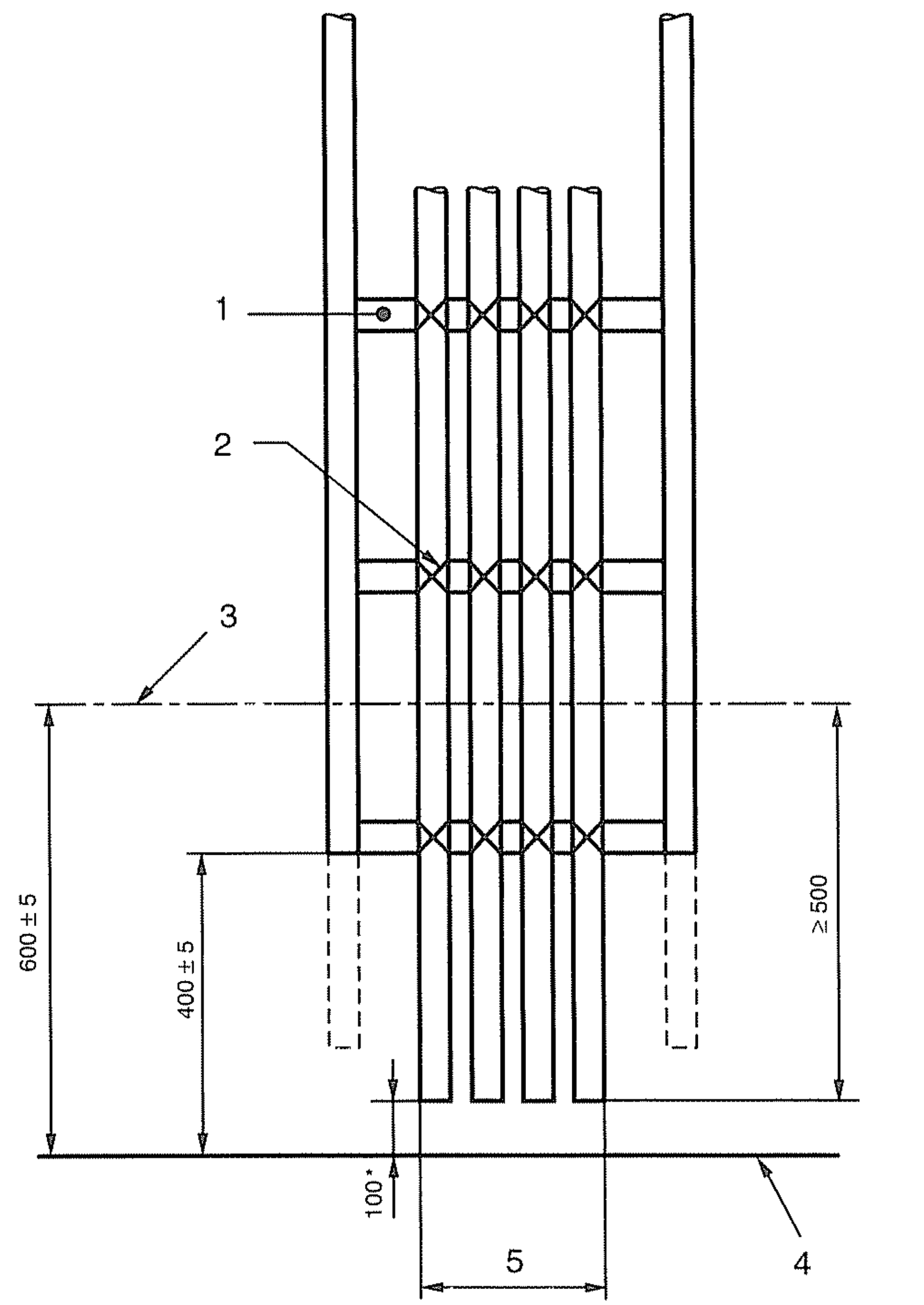
Key

1 Steel plate, 1,5 mm to 2 mm thick

2 Thermal insulation of mineral wool approximately 65 mm thick with suitable external cladding to give a coefficient of heat transfer of approximately 0,7 W × m^{-2} × K^{-1}

Dimensions in millimetres

Figure 2 – Thermal insulation of back and sides of the test chamber



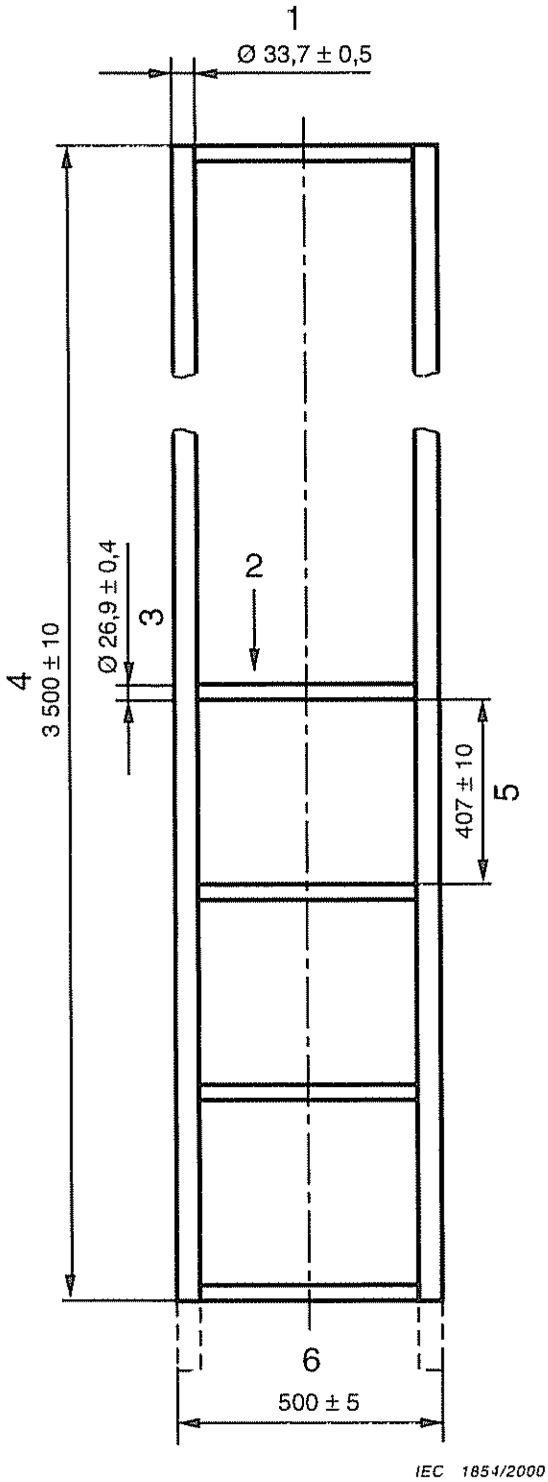
* Approximate

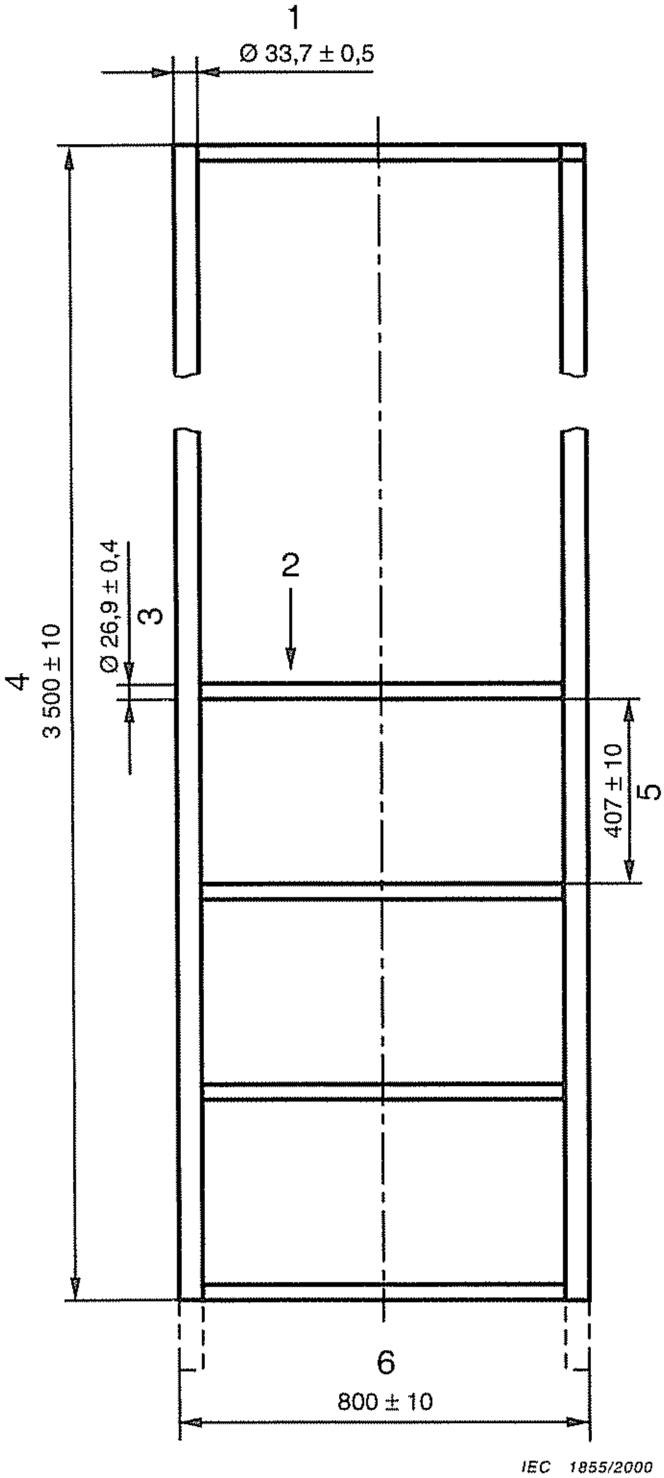
Key

1 Round steel rungs
2 Metal wire ties
3 Centre line of burner
4 Floor
5 Maximum width (according to test category)

Dimensions in millimetres

Figure 3 – Positioning of burner and typical arrangement of test sample on ladder





Key

1 Diameter of upright
2 Number rungs = 9
3 Diameter of rungs
4 Total height of ladder
5 Distance between rungs
6 Width

Dimensions in millimetres

Figure 4a – Standard ladder

Figure 4b – Wide ladder

Figure 4 – Tubular steel ladders for cable test

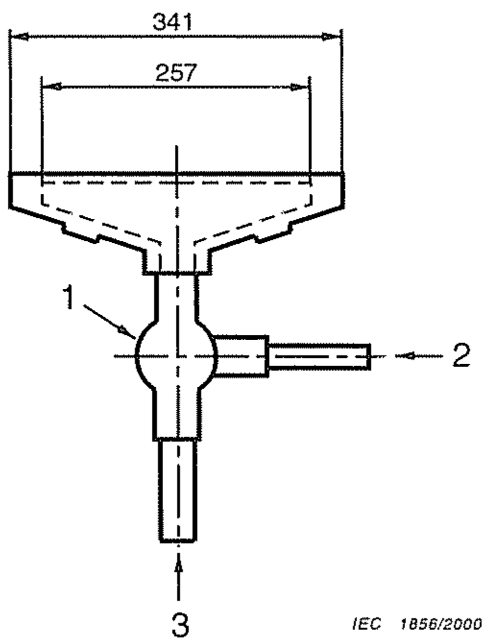


Figure 5a – Single burner for use with standard ladder

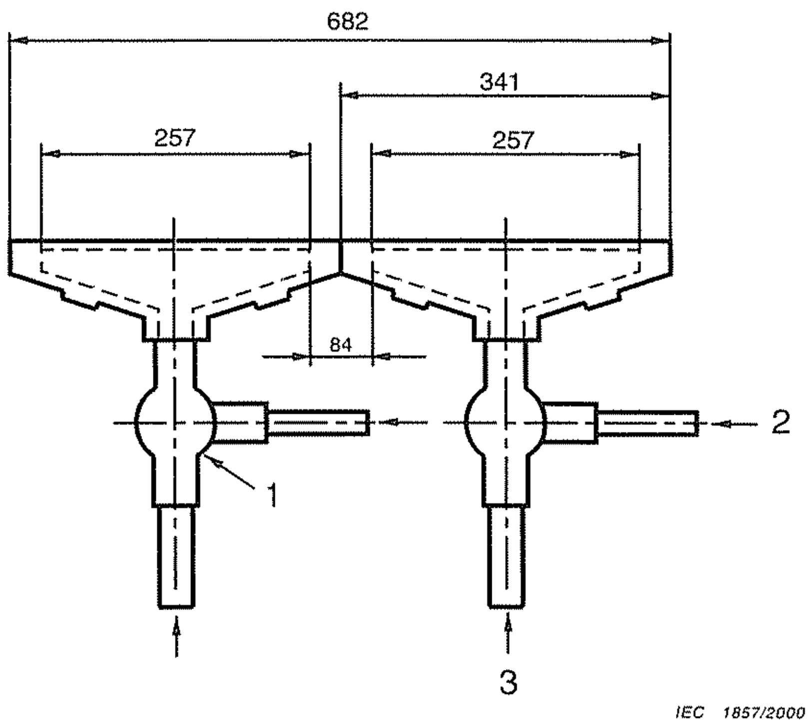


Figure 5b — Two burners in combination for use with the wide ladder

Key

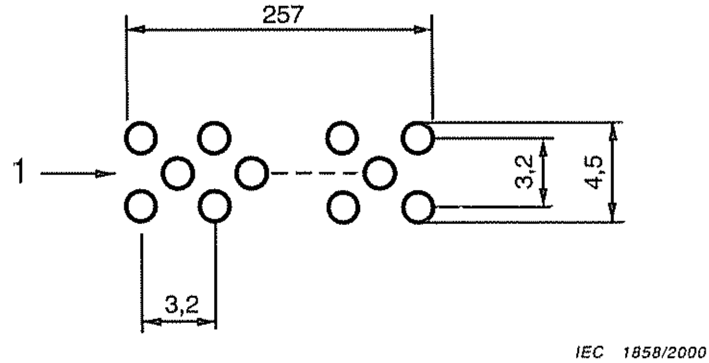
1 Venturi air-gas mixer

2 Propane gas entry

3 Compressed air entry

Dimensions in millimetres

Figure 5 – Burner configurations

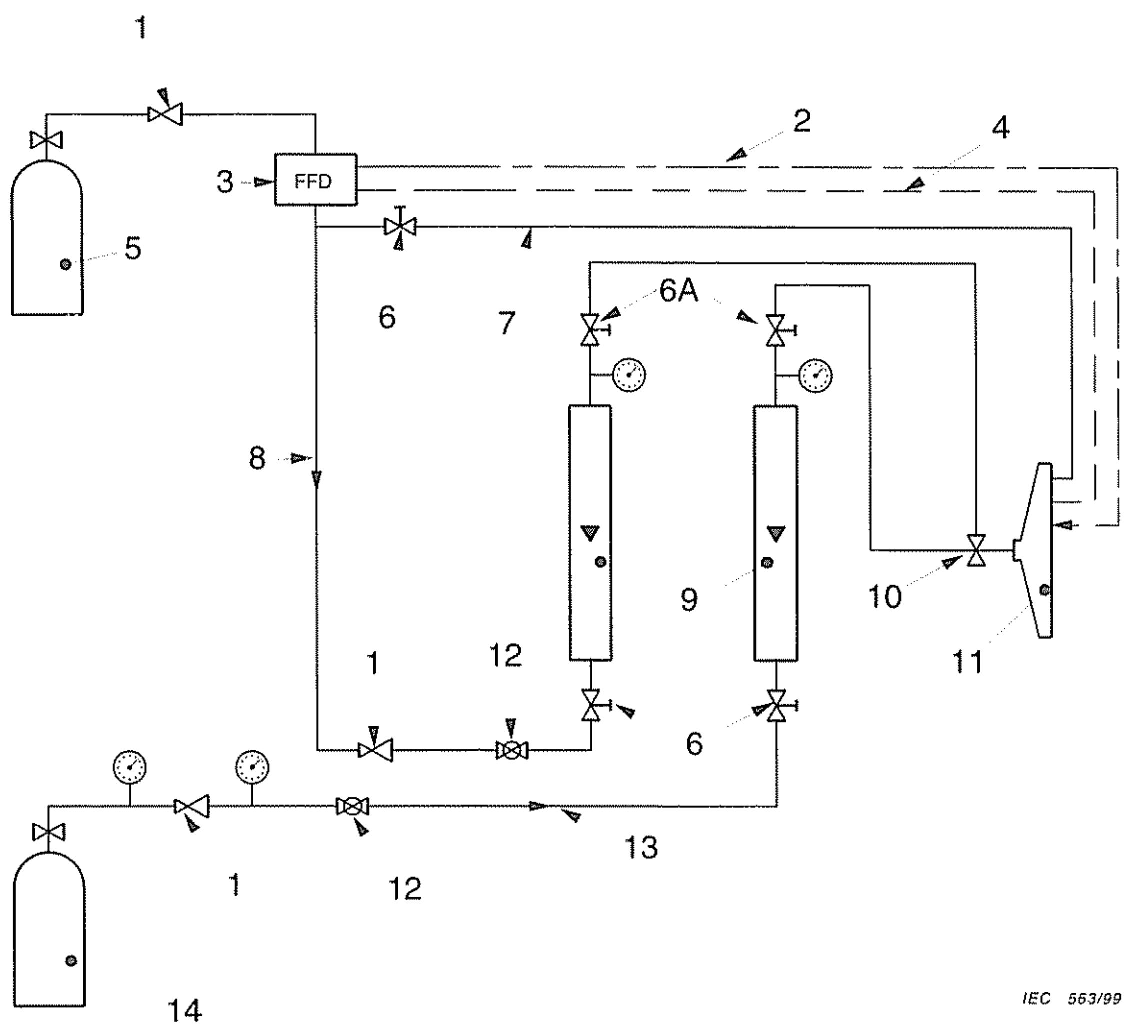


Key

1 242 round holes, 1,32 mm in diameter on 3,2 mm centres, staggered in three rows of 81, 80 and 81 holes, centred on the face of the burner

Dimensions in millimetres (approximate values)

Figure 6 – Arrangement of holes for burners



Key

1 Regulator	8 Gas flow
2 Piezoelectric igniter	9 Rotameter-type flowmeters
3 Flame failure device	10 Venturi mixer
4 Control thermocouples	11 Burner
5 Propane cylinder	12 Ball valve
6 Screw valve (6A = alternative position)	13 Air flow
7 Pilot feed	14 Compressed air cylinder

Figure 7 – Example of schematic diagram of burner control systems

Annex A
(informative)

Details of recommended burner

A burner (catalogue number 10L11-55) and venturi mixer (catalogue number 14-18) complying with the requirements of clause 6 can be obtained from:

American Gas Furnace
PO Box 496
140 Spring Street
Elizabeth, NJ 07207
USA

Tel: +1 201 352 2120
Telefax: +1 201 352 5174

NOTE The information given in this annex, covering named products and their suppliers, 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

Annex B
(informative)

Flowmeter calibration correction factors

B.1 General

When using the rotameter type flowmeters to monitor the supply rate of the gases, two factors need to be considered in order to use them correctly. It is important

a) to know what the flowmeter is indicating when used under the actual operating conditions;

b) to know under what conditions of temperature and gas pressure the flowmeter was calibrated, and at what conditions it was designed to operate.

Considering point a), most flowmeters are designed to indicate the volumetric flow rate at atmospheric temperature and pressure, i.e. 20 °C and 1 bar. However, considering point b), not all flowmeters are calibrated and designed to work at the same temperature and pressure, and care should be taken to ensure that the temperature and pressure of the gas flowing through a flowmeter are correct for that particular meter. Working the flowmeter at temperatures and pressures different from these conditions requires application of a correction factor such as provided hereinafter.

B.2 Example

B.2.1 General

Assume that air flow rate of 77,7 l/min at 1 bar and 20 °C is required at the burner.

Flowmeter 1 is calibrated to operate at 2,4 bar absolute and 15 °C, but to indicate l/min at 1 bar and 15 °C.

Flowmeter 2 is calibrated to operate at 1 bar absolute and 20 °C, but to indicate l/min at 1 bar and 20 °C.

Assume that the air supply pressure up to and including the flowmeters is alternatively at 1 bar (see B.2.2) or at 2,4 bar (see B.2.3) and 20 °C.

The calibration correction factor is given as follows:

$$C = \sqrt{\frac{P_1}{P_2} \times \frac{T_2}{T_1}}$$

where

T is the absolute temperature, in kelvins (K);

P is the absolute pressure, in bars (bar);

P_1, T_1 are the calibration conditions;

P_2, T_2 are the operating conditions.

B.2.2 Air supplied at 1 bar

Flowmeter 1

This will require a correction factor to be used since the meter is operating in conditions removed from its designed operating conditions.

P_1 = 2,4 bar T_1 = 15 °C = 288 K

P_2 = 1 bar T_2 = 20 °C = 293 K

Substituting these values:

$$C = \sqrt{\frac{2{,}4}{1} \times \frac{293}{288}} = 1{,}56$$

Thus, to set a flow rate of 77,7 l/min at reference conditions, a reading on this flowmeter of 121,2 l/min (77,7 × 1,56) is required.

Flowmeter 2

Since this meter is operating under its design conditions, the required flow rate of 77,7 l/min can be read directly from the meter with no correction factor necessary.

B.2.3 Air supplied at 2,4 bar

Flowmeter 1

This will require a correction factor for temperature, but not for pressure since the meter is operating at its design pressure.

P_1 = 2,4 bar T_1 = 15 °C = 288 K

P_2 = 2,4 bar T_2 = 20 °C = 293 K

Substituting these values:

$$C = \sqrt{\frac{2{,}4}{2{,}4} \times \frac{293}{288}} = 1{,}01$$

Thus, to set a flow rate of 77,7 l/min at reference conditions, a reading of 78,5 l/min (77,7 × 1,01) on this flowmeter is required.

Flowmeter 2

This will also require a correction factor since it is operating in conditions removed from its design conditions.

P_1 = 1 bar T_1 = 20 °C = 293 K

P_2 = 2,4 bar T_2 = 20 °C = 293 K

Substituting these values:

$$C = \sqrt{\frac{1}{2{,}4} \times \frac{293}{293}} = 0{,}65$$

Thus, to set a flow rate of 77,7 l/min at reference conditions, a reading of 50,5 l/min (77,7 × 0,65) on this flowmeter is required.

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Enquête sur les normes

La CEI ambitionne de vous offrir les meilleures normes possibles. Pour nous assurer que nous continuons à répondre à votre attente, nous avons besoin de quelques renseignements de votre part. Nous vous demandons simplement de consacrer un instant pour répondre au questionnaire ci-après et de nous le retourner par fax au +41 22 919 03 00 ou par courrier à l'adresse ci-dessous. Merci !

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