IEC 61034-2

Edition 3.2 2019-11

CONSOLIDATED VERSION

VERSION CONSOLIDÉE

colour inside

Measurement of smoke density of cables burning under defined conditions – Part 2: Test procedure and requirements

Mesure de la densité de fumées dégagées par des câbles brûlant dans des conditions définies – Partie 2: Procédure d'essai et exigences

IEC 61034-2:2005-04+AMD1:2013-06+AMD2:2019-11 CSV(en-fr)

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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MEASUREMENT OF SMOKE DENSITY OF CABLES BURNING UNDER DEFINED CONDITIONS –

Part 2: Test procedure and requirements

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In this Redline version, a vertical line in the margin shows where the technical content is modified by amendments 1 and 2. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

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International Standard IEC 61034-2 has been prepared by IEC technical committee 20: Electric cables.

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

a) inclusion of cables down to 1 mm diameter;

b) inclusion of non-circular cables;

c) addition of guidance on testing cables above 80 mm diameter;

d) delineation of elements of the test report;

e) addition of guidance on the calculation for other parameters for fire safety engineering purposes;

f) removal of minor differences with equivalent CENELEC work to allow parallel voting with that body.

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

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

IEC 61034 consists of the following parts, under the general title *Measurement of smoke density of cables burning under defined conditions*,

Part 1 : Test apparatus

Part 2 : Test procedure and requirements

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the stability 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,
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INTRODUCTION

The measurement of smoke density is an important aspect in the evaluation of the burning performance of cables as it is related to the evacuation of persons and accessibility for firefighting.

IEC 61034 is published in two parts, which together specify a method of test for measurement of smoke density of cables burning under defined conditions. Users of this test are reminded that the configurations of cable in the test (i.e. as test pieces or bundles of test pieces) may not represent actual installation conditions.

Part 1 gives details of the test apparatus and verification procedure to be used for the measurement of smoke density of the products of combustion of cables burnt under defined conditions. It includes details of a test enclosure of 27m^3 volume, a photometric system for light measurement, the fire source, smoke mixing method and a qualification procedure.

This Part 2 gives the test procedure, together with an informative annex giving recommended requirements for compliance where no specified requirement is given in the particular cable standard or specification. The measurement of smoke density is expressed in terms of minimum levels of light transmittance, and Annex A explains possibilities for using these values for fire safety engineering calculations.

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MEASUREMENT OF SMOKE DENSITY OF CABLES BURNING UNDER DEFINED CONDITIONS –

Part 2: Test procedure and requirements

1 Scope

This part of IEC 61034 provides details of the test procedure to be employed for the measurement of the density of smoke emitted from cables burning under defined conditions. It describes the means of preparing and assembling cables for test, the method of burning the cables, and gives recommended requirements for evaluating test results.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC 60811-203, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 203: General tests – Measurement of overall dimensions*

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

IEC Guide 104~~:1997~~, *The preparation of safety publications and the use of basic safety publications and group safety publications*

ISO/IEC 13943:2000, *Fire safety – Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions in IEC 60695-4 apply, or if a term is not defined in IEC 60695-4 then the definition in ISO/IEC 13943 applies.

4 Test apparatus

The test procedure defined in this Part 2 of IEC 61034 shall be carried out using the test apparatus, i.e. test enclosure, photometric system and standard fire source, given in IEC 61034-1.

5 Test assembly

5.1 Test sample

The test sample shall consist of one or more test pieces of cable, each 1,00 m ± 0,05 m long, which shall be carefully straightened and then conditioned for at least 16 h at 23 °C ± 5 °C.

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5.2 Cable test piece selection and test sample assembly

5.2.1 Selection of number of test pieces

5.2.1.0 General

The cable diameter shall be measured using the method given in IEC 60811-203. The measurement shall be made at each of three places, separated by at least 1 m.

The average of the three values obtained shall be rounded to obtain the overall diameter. If the calculation gives 5 or more for the second decimal figure, raise the first to the next number; thus, for example, 5,75 is rounded to 5,8 and 5,74 to 5,7.

The overall diameter obtained shall be used for the selection of the number of test pieces.

5.2.1.1 Cables with an overall diameter ~~of~~ greater than 5,0 mm ~~or greater~~

For cables with an overall diameter ~~of~~ greater than 5,0 mm ~~or greater~~, the number of test pieces required to make up the test sample shall be in accordance with Table 1.

Table 1 – Number of test pieces

Overall diameter of the cable (D) mm	Number of test pieces
$D > 40{,}0$	1
$20{,}0 < D \leq 40{,}0$	2
$10{,}0 < D \leq 20{,}0$	3
$5{,}0 < D \leq 10{,}0$	N_1
where $N_1 = \frac{45}{D}$ test pieces The value of N_1 shall be rounded downwards to the integer to give the number of test pieces.	

5.2.1.2 Cables with an overall diameter of less than or equal to 5,0 mm, but not less than 1,0 mm

For cables with an overall diameter of less than or equal to 5,0 mm, but not less than 1,0 mm, seven test pieces shall be formed into a bundle. The number of bundles (N_2) required to make up the test sample shall be calculated according to the following formula:

$$N_2 = \frac{45}{3D}$$

The value of N_2 shall be rounded downwards to the integer to give the number of bundles.

For each bundle, the seven test pieces shall be twisted together with a lay between 20 D and 30 D and bound with two turns of approximately 0,5 mm diameter wire in the centre and at every 100 mm each side from the centre (see Figure 1).

5.2.1.3 Non-circular cables

The test sample for non-circular cables shall be a flat horizontal unit in which the minor axis of each test piece is presented to the fire source. ~~The following criteria for determination of the number of test pieces required to make up the test sample shall apply:~~

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~~a) the nominal minor axis shall be used as the diameter (D) for cables in which the major to minor axis ratio is equal to or less than 3;~~

~~b) half the circumference of the cable shall be used to calculate an equivalent diameter for cables in which the major to minor axis ratio lies between 3 and 5;~~

~~c) for cables in which the major to minor axis ratio exceeds 5, or the dimension of the minor axis is less than 2,0 mm, the formation of the assembly remains under consideration~~

The unit shall be bound with two turns of approximately 0,5 mm wire in the centre and at every 100 mm each side from the centre (see Figure 3). The number of test pieces required to make up the test sample shall be in accordance with Table 1, except that in the case of cables in which the overall diameter is less than or equal to 5,0 mm, the test pieces shall not be bundled and the number of test pieces in the flat horizontal unit calculated according to the formula $N_1 = 45/D$.

The following criteria for determination of the overall diameter (D) to be used in the determination of the number of test pieces shall apply for cables in which the minor axis is 2,0 mm or greater:

a) for cables in which the major to minor axis ratio is equal to or less than 3, the nominal minor axis shall be used as the overall diameter (D);

b) for cables in which the major to minor axis ratio lies between 3 and 16, the overall diameter (D) shall be taken as half the circumference of the cable divided by 3,14 (π).

For cables in which the minor axis is less than 2,0 mm or the major to minor axis ratio exceeds 16, the test criteria shall be given in the product standard or, if not, agreed between manufacturer and purchaser.

5.2.2 Mounting of test sample

The test sample shall remain in situ during the test as follows:

– individual test pieces or bundles of test pieces shall be bound together at the ends, and at 300 mm from each end, at which place they shall be clamped to the support by means of wire binders.

~~NOTE Depending upon construction, test samples prepared from small cables or flexible cables may be subject to movement during the test. In these cases, it is also recommended that the test pieces or bundles are bound with two turns of approximately 0,5 mm diameter wire in the centre and at every 100 mm each side from the centre. Alternatively, the test pieces or bundles may be tensioned at one or both ends by means of an appropriate device, for example a spring or a weight.~~

To avoid movement during the test, the test pieces or bundles shall be bound with two turns of approximately 0,5 mm diameter wire in the centre and at every 100 mm each side from the centre. In addition, the test pieces or bundles may be tensioned at one or both ends by means of an appropriate device for example a spring or a weight.

5.3 Positioning of test sample

The tray containing the alcohol shall be supported above the ground surface to permit air circulation around and beneath the tray. The individual test pieces or the bundles of test pieces shall be laid touching in a horizontal position and centred above the tray so that the distance between the underneath of the test sample and the bottom of the tray is 150 mm ± 5 mm (see Figure 2).

6 Test procedure

NOTE Before each test, it may be necessary to clean the windows of the photometric system to regain 100 % light transmission after stabilization of the voltage (see also Clause A.2 of IEC 61034-1).

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6.1 Immediately before commencing a test, the temperature within the cube shall be in the range of 25 °C ± 5 °C when measured at the internal door surface at a height of 1,5 m to 2,0 m and a minimum of 0,2 m from the walls.

6.2 Before a test, carry out one blank test as defined in Clause 8 of IEC 61034-1 to preheat the test enclosure if necessary.

6.3 For the test, the fire source shall be as defined in Clause 6 of IEC 61034-1.

6.4 With the test sample supported above the tray, start the air circulation and ignite the alcohol. Make sure that all persons leave the cube immediately, and that the door is closed.

6.5 The test is considered as ended when there is no decrease in light transmittance for 5 min after the fire source has extinguished or when the test duration reaches 40 min.

6.6 Record the minimum light transmittance. The light transmittance l_t shall be calculated as follows:

$$l_t = I_t/I_0$$

where

I_t is the intensity of transmitted light;

I_0 is the intensity of incident light.

l_t shall be expressed as a percentage.

NOTE If it is required to use information on smoke density for wider hazard evaluation or fire safety engineering purposes, it may be necessary to calculate other parameters. Guidance on such calculations is given in Annex A.

6.7 Extract the combustion products at the end of each test.

7 Evaluation of test results

The requirement shall be given in the relevant cable specification.

~~For cables up to and including 80 mm overall diameter, the recorded minimum light transmittance (6.6) shall be taken as the cable light transmittance.~~

~~For cables above 80 mm overall diameter, the recorded minimum light transmittance (6.6) shall be normalized by multiplying by a factor of D/80 (where D is the actual diameter in millimetres of the cable under test) and the resulting value shall be taken as the cable light transmittance for determining compliance.~~

~~NOTE If no value is given in the relevant cable specification it is recommended that the recommendation in Annex B be adopted as a minimum.~~

For cables with an overall diameter above 20,0 mm, the recorded minimum light transmittance I_t/I_0 (see 6.6) shall be normalized as follows:

$$(I_t/I_0)_{norm} = [I_t/I_0]^{(40\ \mathrm{mm}/ND)}$$

where

I_0 is the incident light intensity,

I_t is the transmitted light intensity,

I_t/I_0 is the transmittance,

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$(I_t/I_0)_{norm}$ is the normalized transmittance,

N is the number of test pieces in accordance with Table 1,

D is the overall diameter of the cable in mm.

The resulting value $(I_t/I_0)_{norm}$ (expressed as a percentage) shall be taken for determining compliance.

If no value is given in the relevant cable specification, it is recommended that the recommendation in Annex B be adopted as a minimum.

EXAMPLE

The measured transmittance I_t/I_0 of a cable with overall diameter D of 38 mm is equal to 0,7. The number of test pieces N is 2. The normalized transmittance $(I_t/I_0)_{norm}$ is then equal to $0{,}7^{(40/(2\times38))}$ = 0,83 and expressed in a percentage equal to 83 %.

8 Retest procedure

~~In case of dispute, a further two tests shall be undertaken using similar cables.~~

~~Both of these test results shall comply with Clause 7.~~

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

9 Test report

The test report shall include the following information:

a) full description of cable tested;
b) manufacturer of cable tested;
c) the overall diameter of the cable tested;
d) the number and disposition of test pieces in the test sample;
e) details of any binding or tensioning of the test pieces in the test sample;
f) the minimum light transmittance recorded during the test duration.

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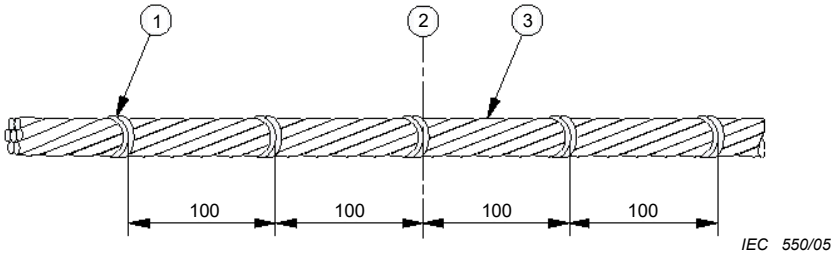
Dimensions in millimetres



Key

1 wire binder

2 centre

3 number of test pieces = 7

Figure 1 – Method of binding for bundles of test pieces

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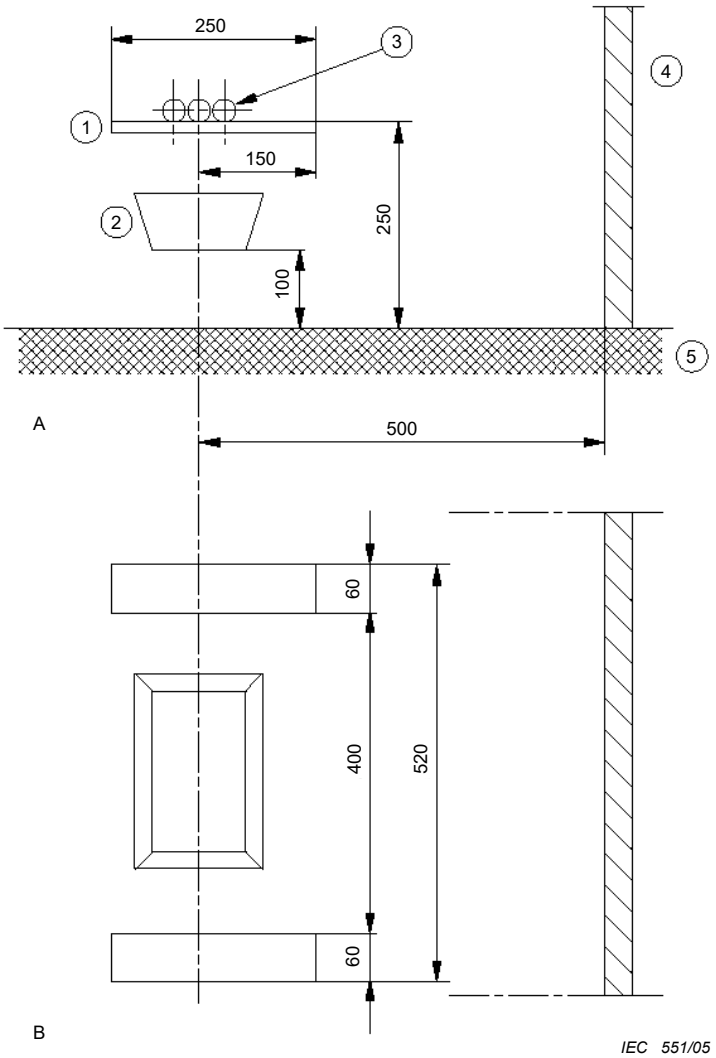
Dimensions in millimetres



Key

A Side view
B Plan view

1 support
2 metal tray
3 test sample
4 back wall
5 floor

Figure 2 – Method of support of test sample

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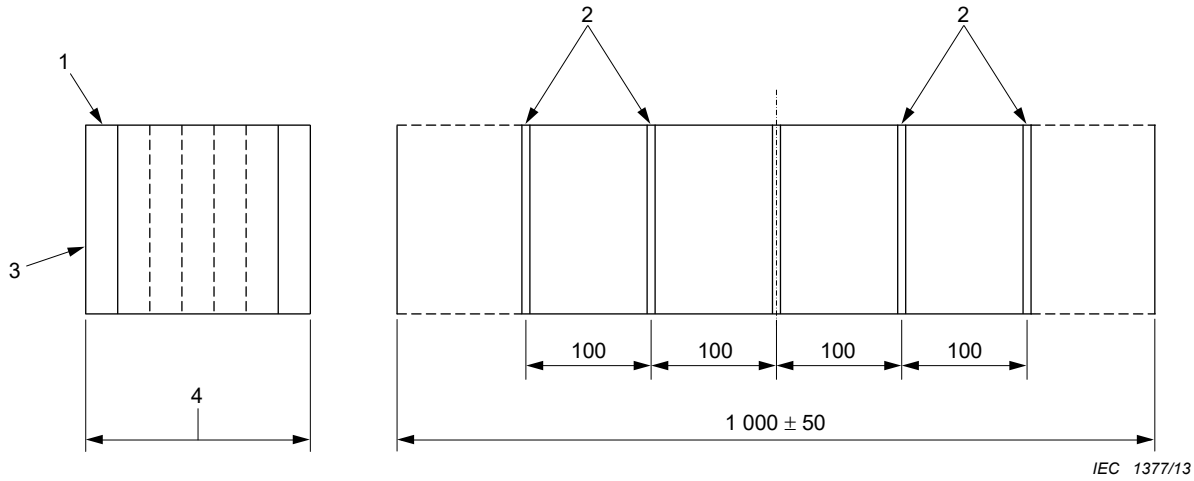

Key

1	minor axis of cable	2	wire binder
3	major axis of cable	4	n test pieces

Figure 3 – Method of assembly of flat horizontal unit of non-circular cables

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Annex A
(informative)

Guidance on the principles and use of smoke measurements

A.1 Background

A.1.1 Bouguer's Law

Smoke consists of an aerosol of particles which can either be measured as a function of its gravimetric properties, its light obscuring properties, or a mixture of the two. This standard measures smoke as a function of light obscuring properties which are a function of the number and size of the particles in the light path. If the particles are considered as opaque, the capacity of the smoke to obscure light is related to the sum of the cross-sectional areas of the particles in the light path. It is measured in units of area, e.g. in square metres (m^2), and is called the extinction area, see A.1.2.

Optical smoke measurements are derived from Bouguer's Law which describes the attenuation of monochromatic light by smoke.

$$I_t / I_o = e^{-kL}$$

$$k = (1/L) \ln (I_o / I_t)$$

where

I_t is the intensity of transmitted light;

I_o is the intensity of incident light;

L is the light path length through the smoke ;

k is the linear Napierian absorption coefficient (or extinction coefficient).

NOTE 1 The units of k are of reciprocal length and are expressed, e.g., in m^{-1}.

In some cases, including this standard, base 10 logarithms are used to calculate the optical density, D', where

$$D' = \log_{10} (I_o / I_t)$$

and also to calculate the optical density per unit light path length, (D), which is also known as the linear decadic absorption coefficient or the decadic extinction coefficient.

NOTE 2 D has units of reciprocal length, e.g. m^{-1}.

$$I_t / I_o = 10^{-DL}$$

$$D = (1/L) \log_{10} (I_o / I_t)$$

$$k = D \ln 10 \quad \text{or} \quad k = 2{,}303\, D$$

A.1.2 Extinction area

A useful measurement of the amount of smoke, particularly for fire safety engineering purposes, is the total effective cross sectional area of all the smoke particles. This is known as the extinction area of the smoke, S.

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The extinction area is related both to the extinction coefficient of the smoke and to the volume that the smoke is contained within, by the equation:

$$S = k\,V$$

where V is the volume of the chamber in which the smoke is contained.

The extinction area of smoke can also be calculated from D using the equation

$$S = 2{,}303\ D\ V$$

NOTE S has units of area, e.g. m^2.

A.1.3 Visibility

Correlations have been established between visibility levels in smoke and measurements of smoke extinction coefficient for targets with specified contrast and illumination.

It has been found that visibility is inversely proportional to k (or D), i.e. $\omega \times k$ is a constant.

If the relationship between visibility (ω) and k (or D) is known, then visibility can be readily calculated if the amount of smoke (extinction area) is known and the volume occupied by the smoke is also known.

$$\omega = \gamma\,(V / S)$$

where $\gamma = \omega\,k = 2{,}303\ \omega\,D$

A.2 Use of parameters measured in the standard

The output from the evaluation of the test results is a transmittance, (I_t / I_o), which is usually expressed as a percentage. This enables the determination of the dimensionless optical density, D',

$$D' = \log_{10}(I_o / I_t)$$

and the linear decadic absorption coefficient, D

$$D = (1/L) \times D'$$

where L is the light path length through the test cube (nominally 3 m).

The extinction area of the smoke is calculated from

$$S = 2{,}303\ D\ V$$

where V is the volume of the test cube (nominally $27 m^3$).

The extinction area per length of cable, S_n, is calculated from

$$S_n = S/n$$

where n is the number of test pieces.

Data from the test can then be used to predict visibility for a defined fire scenario.

Documents
Document Sharing Hub
Full document details: IEC 61034-2-2019

NOTE General guidance is given in IEC 60695-6-1, Fire hazard testing – Part 6-1: Smoke opacity – General guidance.

Documents
Document Sharing Hub

Full document details: IEC 61034-2-2019

Annex B
(informative)

Recommended performance requirement

The performance requirements for a particular type or class of insulated conductor or cable should preferably be given in the individual cable standard.

In the absence of any given requirement, it is recommended that a value of 60 % cable light transmittance is adopted as a minimum for any cable tested against this standard.

Documents
Document Sharing Hub

Full document details: IEC 61034-2-2019

Bibliography

IEC 60695-6-1, *Fire hazard testing – Part 6-1: Smoke opacity – General guidance.*

Documents
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