

Fire hazard testing —

Part 6-1: Smoke opacity — General guidance

The European Standard EN 60695-6-1:2001 has the status of a British Standard

ICS 13.220.99; 29.020

National foreword

This British Standard is the official English language version of EN 60695-6-1:2001. It is identical with IEC 60695-6-1:2001.

The UK participation in its preparation was entrusted to Technical Committee GEL/89, Fire hazard testing, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
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Partie 6-1: Opacité des fumées -
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European Committee for Electrotechnical Standardization
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Foreword

The text of document 89/447/FDIS, future edition 1 of IEC 60695-6-1, prepared by IEC TC 89, Fire hazard testing, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60695-6-1 on 2001-10-01.

The following dates were fixed:

- latest date by which the EN has to be implemented
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- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2004-10-01

Annexes designated "normative" are part of the body of the standard.

Annexes designated "informative" are given for information only.

In this standard, annex ZA is normative and annexes A, B and C are informative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60695-6-1:2001 was approved by CENELEC as a European Standard without any modification.

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INTRODUCTION

The risk of fire needs to be considered in any electrical circuit, and the objective of component, circuit and equipment design, as well as the choice of material, is to reduce the likelihood of fire, even in the event of foreseeable abnormal use, malfunction or failure.

Electrotechnical products, primarily victims of a fire, may nevertheless contribute to the fire hazard due to the release of smoke, which may cause loss of vision and/or disorientation which could impede escape from the building or fire fighting.

Smoke particles reduce the visibility due to light absorption and scattering. Consequently, people may experience difficulties in finding exit signs, doors and windows. Visibility is often determined as the distance at which an object is no longer visible. It depends on many factors, but close relationships have been established between visibility and the measurements of the extinction coefficient of smoke – see annex A.

The production of smoke and its optical properties may be measured simultaneously with other fire properties, such as heat release and flame spread. This part of IEC 60695 serves as a guidance document and focuses on obscuration of light by smoke.

FIRE HAZARD TESTING –

Part 6-1: Smoke obscuration – General guidance

1 Scope

This part of IEC 60695 gives guidance on:

- a) optical measurement of smoke obscuration;
- b) general aspects of optical smoke test methods;
- c) consideration of test methods;
- d) expression of smoke test data;
- e) relevance of optical smoke data to hazard assessment.

One of the responsibilities of a technical committee is, wherever applicable, to make use of basic safety publications in the preparation of its publications.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60695. 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 60695 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 60695-1-1:1999, *Fire hazard testing – Part 1-1: Guidance for assessing the fire hazard of electrotechnical products – General guidelines*

IEC 60695-6-2:2001, *Fire hazard testing – Part 6-2: Smoke obscuration – Summary and relevance of test methods*

IEC 60695-6-30:1996, *Fire hazard testing – Part 6: Guidance and test methods on the assessment of obscuration hazard of vision caused by smoke opacity from electrotechnical products involved in fires – Section 30: Small scale static method – Determination of smoke opacity – Description of the apparatus*

IEC 60695-6-31:1999, *Fire hazard testing – Part 6-31: Smoke obscuration – Small scale static test – Materials*

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

ISO/TR 9122-1:1989, *Toxicity testing of fire effluents – Part 1: General*

ISO 5659-2:1994, *Plastics – Smoke generation – Part 2: Determination of optical density by a single-chamber test*

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

3 Definitions and nomenclature

For the purpose of this part of IEC 60695, the definitions taken from ISO/IEC 13943, together with the following definitions, apply.

3.1

extinction coefficient of smoke

natural logarithm of the opacity of smoke divided by the path length of the light used to measure the smoke opacity

3.2

extinction area of smoke

product of the extinction coefficient and the volume occupied by the smoke

NOTE It is a measure of the amount of smoke.

3.3

specific optical density of smoke

optical density multiplied by a geometric factor

[ISO/IEC 13943, definition 154, modified]

NOTE The use of the term 'specific' does not, in this case, denote the 'per unit mass' but rather denotes a quantity associated with a particular test apparatus and exposed surface area of the test specimen. The geometric factor is V/AL , where V is the volume of the test chamber, A is the exposed surface area of the test specimen and L is the light path length.

3.4

specific extinction area of smoke

extinction area of smoke divided by the mass loss of the test specimen

3.5

mass optical density of smoke

optical density multiplied by a factor, $V/\Delta m L$, where V is the volume of the test chamber, Δm is the mass loss of the test specimen and L is the light path length

3.6

fire model

procedure or process intended to represent, predict or reproduce one or more phases of a fire, or the transition between phases

[ISO/IEC 13943, definition 51]

3.7

flash-over

transition to a state of total surface involvement in a fire of combustible materials within an enclosure

[ISO/IEC 13943, definition 77]

Nomenclature

Symbol	Quantity	Typical units
A	exposed area of test specimen	m^2
D	linear decadic absorption coefficient (commonly called optical density per metre)	m^{-1}
D'	optical density	dimensionless
D_{mass}	mass optical density	$\text{m}^2 \text{ kg}^{-1}$
D_{s}	specific optical density	dimensionless
D_{max} (also D_{m})	maximum specific optical density	dimensionless
I	intensity of incident light	W
I / T	ratio of incident light to transmitted light	dimensionless
k	linear Napierian absorption coefficient (commonly called extinction coefficient)	m^{-1}
L	light path length through smoke	m
Δm	mass loss of test specimen	kg
$\dot{m}$	mass loss rate	kg s^{-1}
S	smoke extinction area (also total smoke)	m^2
$\dot{S}$	smoke production rate (rate of change of extinction area)	$\text{m}^2 \text{ s}^{-1}$
t	time	s
Δt	sampling time interval	s
T	intensity of transmitted light	W
V	volume of chamber	m^3
$\dot{V}$	volume flow rate of smoke	$\text{m}^3 \text{ s}^{-1}$
σ_{f}	specific extinction area	$\text{m}^2 \text{ kg}^{-1}$
γ	a constant of proportionality between visibility and extinction coefficient	dimensionless
ω	visibility	m

NOTE 1 The quantities based on $\log_{10}$, i.e. D , D' , D_{max} , D_{mass} and D_{s} , have similar symbols but they are different quantities and have different units.

NOTE 2 The use of the term "specific" in the case of specific optical density, D_{s} , does not denote "per unit mass".

4 General aspects of smoke test methods

4.1 Fire scenarios and fire models

During recent years, major advances have been made in the analysis of fire effluents. It is recognised that the composition of the mixture of combustion products is particularly dependent upon the nature of the combusting materials, the prevailing temperatures and ventilation conditions, especially access of oxygen to the seat of the fire. Table 1 shows how the different stages of a fire relate to the changing atmosphere. Conditions for use in laboratory scale tests can be derived from the table in order to correspond, as far as possible, to full scale fires.

Fire involves a complex and interrelated array of physical and chemical phenomena. As a result, it is difficult to simulate all aspects of a real fire in a laboratory-scale apparatus. This problem of fire model validity is perhaps the single most perplexing technical problem associated with all fire testing.

General guidance for assessing the fire hazard of electrotechnical products is given in IEC 60695-1-1.

After ignition, fire development may occur in different ways depending on the environmental conditions, as well as on the physical arrangement of the combustible materials. However, a general pattern can be established for fire development within a compartment, where the general temperature-time curve shows three stages, plus a decay stage (see figure 1).

Stage 1 is the incipient stage of the fire prior to sustained flaming, with little rise in the fire room temperature. Ignition and smoke generation are the main hazards during this stage. Stage 2 (developing fire) starts with ignition and ends with an exponential rise in the fire room temperature. Spread of flame and heat release are the main hazards in addition to smoke during this stage. Stage 3 (fully developed fire) starts when the surface of all of the combustible contents of the room has decomposed to such an extent that sudden ignition occurs all over the room, with a rapid and large increase in temperature (flash-over).

At the end of stage 3, the combustibles and/or oxygen have been largely consumed and hence the temperature decreases at a rate which depends on the ventilation and the heat and mass transfer characteristics of the system. This is known as decay.

In each of these stages, a different mixture of decomposition products may be formed and this, in turn, influences the smoke density produced during that stage. Moreover, information is required on the fire scenario being considered, in particular the conditions of incident heat flux, oxygen availability and smoke-venting facilities.