IEC 60695-1-10

Edition 2.0 2016-11

INTERNATIONAL STANDARD

NORME INTERNATIONALE

BASIC SAFETY PUBLICATION

PUBLICATION FONDAMENTALE DE SÉCURITÉ

Fire hazard testing –
Part 1-10: Guidance for assessing the fire hazard of electrotechnical products – General guidelines

Essais relatifs aux risques du feu –
Partie 1-10: Lignes directrices pour l'évaluation des risques du feu des produits électrotechniques – Lignes directrices générales

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INTERNATIONAL
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ICS 13.220.40; 29.020

ISBN 978-2-8322-3755-7

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FIRE HAZARD TESTING –

Part 1-10: Guidance for assessing the fire hazard of electrotechnical products – General guidelines

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 60695-1-10 has been prepared by IEC technical committee 89: Fire hazard testing.

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

This edition includes the following significant technical changes with respect to the previous edition:

a) reference to IEC 60695-1-12;
b) modified Introduction and Scope;
c) updated normative references;
d) updated terms and definitions;
e) modified Table 1;

f) addition of Table 2;

g) new text in Subclauses 5.2, 5.3 and 5.4;

h) mandatory text in Clause 8;

i) Annex B changed to Annex A, and modified;

j) new Annex B concerning common ignition sources.

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

FDIS	Report on voting
89/1341/FDIS	89/1347/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 basic safety publication in accordance with IEC Guide 104 and ISO/IEC Guide 51.

This standard is to be used in conjunction with IEC 60695-1-11 and IEC 60695-1-12.

A list of all the parts in the IEC 60695 series, under the general title *Fire hazard testing*, can be found on the IEC website.

IEC 60695-1 consists of the following parts:

Part 1-10: *Guidance for assessing the fire hazard of electrotechnical products – General guidelines*

Part 1-11: *Guidance for assessing the fire hazard of electrotechnical products – Fire hazard assessment*

Part 1-12: Guidance for assessing *the fire hazard of electrotechnical products – Fire-safety engineering*

Part 1-20: *Guidance for assessing the fire hazard of electrotechnical products – Ignitability – General guidance*

Part 1-21: *Guidance for assessing the fire hazard of electrotechnical products – Ignitability – Summary and relevance of test methods*

Part 1-30: *Guidance for assessing the fire hazard of electrotechnical products – Preselection testing process – General guidelines*

Part 1-40: *Guidance for assessing the fire hazard of electrotechnical products – Insulating liquids*

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

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

INTRODUCTION

In the design of any electrotechnical product, the risk of fire and the potential hazards associated with fire need to be considered. In this respect the objective of component, circuit and equipment design, as well as the choice of materials, is to reduce the risk of fire to a tolerable level even in the event of reasonably foreseeable (mis)use, malfunction or failure. This standard, together with its companions, IEC 60695-1-11 and IEC 60695-1-12, provides guidance on how this is to be accomplished.

The use of compartments with fire-resistant boundaries, and the use of detection and suppression systems are important methods for the mitigation of fire risk, but are not dealt with in this standard. Fires involving electrotechnical products can be initiated from external non-electrical sources. Considerations of this nature are dealt with in an overall fire hazard assessment.

The aim of the IEC 60695 series of standards is to save lives and property by reducing the number of fires or reducing the consequences of the fire. This can be accomplished by:

- trying to prevent ignition caused by an electrically energised component part and, in the event of ignition, to confine any resulting fire within the bounds of the enclosure of the electrotechnical product;
- trying to minimise flame spread beyond the product's enclosure and to minimise the harmful effects of fire effluents including heat, smoke, and toxic or corrosive combustion products.

Assessing the fire hazard of electrotechnical products is accomplished by performing fire hazard tests. These tests are divided into two fundamental groups: qualitative fire tests and quantitative fire tests.

Fire testing of electrotechnical products should, whenever possible, be carried out using quantitative fire tests having the following characteristics.

a) The test should take into account the circumstances of product use, i.e. contemplated end-use conditions as well as foreseeable abnormal use. This is because fire conditions that may be hazardous under one set of circumstances will not necessarily pose the same threat under a different set.

b) It should be possible to correlate the test results with the harmful effects of fire effluents referred to above, i.e. the thermal and airborne threats to people and/or property in the relevant end-use situation. This avoids the creation of artificial, and sometimes distorted, performance scales with no clear relationship to fire safety.

c) Recognizing that there are usually multiple contributions to the effects of real fires, the test results should be expressed in well-defined terms and using rational scientific units, so that the product's contribution to the overall fire effects can be quantitatively assessed and compared with that of other products' contributions.

Although quantitative tests are preferred, the characteristics of qualitative fire tests are that they provide pass/fail and classification results. Under certain circumstances it will be appropriate to maintain such qualitative test methods or to develop new ones. This part of IEC 60695-1 establishes the circumstances under which such maintenance or development is appropriate.

FIRE HAZARD TESTING –

Part 1-10: Guidance for assessing the fire hazard of electrotechnical products – General guidelines

1 Scope

This part of IEC 60695-1 provides general guidance with respect to fire hazard testing on how to reduce to a tolerable level the risk of fire and the potential effects of fires involving electrotechnical products. It also serves as a signpost standard to the other guidance publications in the IEC 60695 series.

It does not give guidance on the use of fire-resistant compartment boundaries or on the use of detection and suppression systems for the mitigation of fire risk.

It describes the relationship between fire risk and the potential effects of fire, and provides guidance to IEC product committees on the applicability of qualitative and quantitative fire tests to the fire hazard assessment of electrotechnical products. Details of the calculation of fire risk are not included in the scope of this document.

It emphasises the importance of the scenario approach to fire hazard and risk assessment and discusses criteria intended to ensure the development of technically sound hazard-based fire test methods.

It discusses the different types of fire tests, in particular the nature of qualitative and quantitative fire tests. It also describes the circumstances under which it is appropriate for IEC product committees to maintain or develop qualitative fire tests.

This standard is intended as guidance to IEC committees, and is to be used with respect to their individual applications.

This basic safety publication is intended for use by technical committees in the preparation of standards in accordance with the principles laid down in IEC Guide 104 and ISO/IEC Guide 51.

One of the responsibilities of a technical committee is, wherever applicable, to make use of basic safety publications in the preparation of its publications. The requirements, test methods or test conditions of this basic safety publication will not apply unless specifically referred to or included in the relevant publications.

2 Normative references

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

IEC 60079-0, *Explosive atmospheres − Part 0: Equipment − General requirements*

IEC 60695-1-11, *Fire hazard testing – Part 1-11: Guidance for assessing the fire hazard of electrotechnical products – Fire hazard assessment*

IEC 60695-1-12, *Fire hazard testing – Part 1-12: Guidance for assessing the fire hazard of electrotechnical products – Fire-safety engineering*

IEC 60695-1-30, *Fire hazard testing – Part 1-30: Guidance for assessing the fire hazard of electrotechnical products – Preselection testing process – General guidelines*[1]

IEC 60695-4:2012, *Fire hazard testing – Part 4: Terminology concerning fire tests for electrotechnical products*

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

ISO/IEC Guide 51, *Safety aspects – Guidelines for their inclusion in standards*

ISO 13943:2008, *Fire safety – Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60695-4:2012 and ISO 13943:2008 (some of which are reproduced below), as well as the following, apply.

3.1
fire
〈general〉 process of combustion characterized by the emission of heat and fire effluent and usually accompanied by smoke, flame, glowing or a combination thereof

Note 1 to entry: In the English language, the term "fire" is used to designate three concepts, two of which, *fire* (3.2) and *fire* (3.3), relate to specific types of self-supporting combustion with different meanings and two of them are designated using two different terms in both French and German.

[SOURCE: ISO 13943:2008, 4.96]

3.2
fire
〈controlled〉 self-supporting combustion that has been deliberately arranged to provide useful effects and is limited in its extent in time and space

[SOURCE: ISO 13943:2008, 4.97]

3.3
fire
〈uncontrolled〉 self-supporting combustion that has not been deliberately arranged to provide useful effects and is not limited in its extent in time and space

[SOURCE: ISO 13943:2008, 4.98]

3.4
fire hazard
physical object or condition with a potential for an undesirable consequence from *fire* (3.3)

[SOURCE: ISO 13943:2008, 4.112]

[1] Under preparation. Stage at time of publication: IEC/FDIS 60695-1-30:2016.

3.5
fire risk
probability of a *fire* (3.3) combined with a quantified measure of its consequence

Note 1 to entry: It is often calculated as the product of probability and consequence.

[SOURCE: ISO 13943:2008, 4.124]

3.6
fire-safety engineering
application of engineering methods based on scientific principles to the development or assessment of designs in the built environment through the analysis of specific *fire scenarios* (3.7) or through the quantification of risk for a group of fire scenarios

[SOURCE: ISO 13943:2008, 4.126]

3.7
fire scenario
qualitative description of the course of a *fire* (3.3) with respect to time, identifying key events that characterise the studied fire and differentiate it from other possible fires

Note 1 to entry: It typically defines the ignition and fire growth processes, the fully developed fire stage, the fire decay stage, and the environment and systems that impact on the course of the fire.

[SOURCE: ISO 13943:2008, 4.129]

3.8
intermediate-scale fire test
fire test performed on a test specimen of medium dimensions

Note 1 to entry: A fire test performed on a test specimen for which the maximum dimension is between 1 m and 3 m is usually called an intermediate-scale fire test.

[SOURCE: ISO 13943:2008, 4.200]

3.9
large-scale fire test
fire test that cannot be carried out in a typical laboratory chamber, performed on a test specimen of large dimensions

Note 1 to entry: A fire test performed on a test specimen of which the maximum dimension is greater than 3 m is usually called a large-scale fire test.

[SOURCE: ISO 13943:2008, 4.205]

3.10
qualitative fire test
fire test which is either:

a) a pass/fail test; or

b) a test which categorizes the behaviour of the test specimen by determining its position in a rank order of performance

[SOURCE: IEC 60695-4:2012, 3.2.22]

3.11
quantitative fire test
fire test which takes into account the circumstances of product use in which the test conditions are based on, or are relatable to, the circumstances of use of the test specimen,

and which measures a parameter or parameters, expressed in well-defined terms and using rational scientific units, which can be used in the quantitative assessment of fire risk

[SOURCE: IEC 60695-4:2012, 3.2.23]

3.12
reaction to fire
response of a test specimen when it is exposed to *fire* (3.2) under specified conditions in a fire test

Note 1 to entry: Fire resistance is regarded as a special case and is not normally considered as a reaction to fire property.

[SOURCE: ISO 13943:2008, 4.272]

3.13
real-scale fire test
fire test that simulates a given application, taking into account the real scale, the real way the item is installed and used, and the environment

Note 1 to entry: Such a fire test normally assumes that the products are used in accordance with the conditions laid down by the specifier and/or in accordance with normal practice.

[SOURCE: ISO 13943:2008, 4.273]

3.14
short-circuit
unintended connection of two nodes of an electrical circuit

Note 1 to entry: Current flow can occur, which could cause circuit damage, overheating, fire or explosion.

3.15
small-scale fire test
fire test performed on a test specimen of small dimensions

Note 1 to entry: A fire test performed on a test specimen of which the maximum dimension is less than 1 m is usually called a small-scale fire test.

[SOURCE: ISO 13943:2008, 4.292]

4 Fire hazards associated with electrotechnical products

The transmission, distribution, storage and utilization of electrical energy can have the potential to contribute to fire hazard.

With electrotechnical products, the most frequent causes of ignition are overheating and arcing. The likelihood of ignition will depend on the product and system design, the use of safety devices and systems, and the type of materials used.

Electrotechnical products, when operating, generate heat. In some cases, arcing and sparking are normal phenomena. They should not lead to hazardous conditions provided that they have been taken into account initially at the design stage, and subsequently during installation, use and maintenance.

Although it is a commonly held belief that most electrical fires are caused by a short-circuit, there are many other possible causes of ignition. These can include improper installation, improper usage, and inadequate maintenance. Examples are: operation under overload for temporary or extended periods; operation under conditions not provided for by the manufacturer or contractor; inadequate heat dissipation; faulty ventilation. Table 1 lists common ignition phenomena encountered in electrotechnical products.

In Table 1, unless otherwise indicated, the sources of ignition are considered to be internal to the electrotechnical product. The table lists the most frequently encountered cases.

Fires involving electrotechnical products can also be initiated from external non-electrical sources. Hazardous conditions, which do not arise from the use of the electrotechnical product itself, can and often do involve that product. Considerations of this nature are dealt with in the overall hazard assessment, individual product safety standards, or, for example, by the provisions of IEC TS 62441 [21].

Examples of the power output of potential ignition sources are provided in Annex A.

When designing products, the prevention of ignition in normal and abnormal operating conditions requires a higher priority compared to minimizing the eventual spread of flames.

After ignition has occurred, for whatever reason, the effects of the subsequent fire must be assessed. Factors to be taken into account include:

a) fire growth and flame spread;
b) heat release;
c) smoke generation (visibility);
d) production of toxic fire effluent;
e) production of potentially corrosive fire effluent;
f) the potential for explosion.

References to IEC guidance on items a) to e) can be found in Annex B. The safety of electrotechnical equipment used in explosive atmospheres is discussed in IEC 60079-0.

5 Fundamentals of fire hazard testing

5.1 Objectives

The objectives of fire hazard testing of electrotechnical products are to determine which fire properties of the product contribute to the potential effects of fire and/or how the product or part of the product contributes to the initiation, growth and effect of fire, and then to use this knowledge to reduce the risks of fire in electrotechnical products.

5.2 Fire hazard and fire risk

5.2.1 Fire hazard

A fire hazard is a physical object or condition with a potential for an undesirable consequence from fire (see 3.4). Fire hazards therefore encompass potential fuels and ignition sources. Ignition of an electrotechnical product can be caused by an electrically energised component part. Ignition occurs as a result of an increase in temperature (see IEC 60695-1-20 [20]) that may have a chemical, mechanical or electrical origin.

Common ignition phenomena encountered in electrotechnical products are described in detail in Table 1, which also lists possible consequential effects.

Fires involving electrotechnical products can also be initiated from external non-electrical sources, and an overall fire hazard assessment should include this possibility.

Table 1 – Common causes of ignition encountered in electrotechnical products

Cause [a, b]	Possible origins	Possible consequential effects and comments
Short-circuit (see 3.14)	Direct contact of conducting live parts at different potentials (e.g. because of the loosening of terminals, disengaged conductors, or ingress of conducting foreign bodies). Gradual degradation of some components causing changes in their insulation impedances. Sudden failure of a component or an internal part.	Protection devices [c] may not always be activated. The rise in temperature is significant after a very short time and may be localized. Possible emission of light, smoke and/or flammable gases. Possible production of flames Ignition can occur locally in surrounding components. Possible release of glowing material.
Accidental sparks or arcs NOTE 1 Some products produce sparks or arcs in normal operation.	A cause external to the product (e.g. overvoltage of the system network, or an accidental mechanical action that exposes live parts). An internal cause (e.g. gradual degradation of a component, or ingress of moisture). Sudden failure of a component or an internal part.	Protection devices [c] may not always be activated. Possible emission of light, smoke and/or flammable gases. Possible production of flames. Substantial risk of ignition in potentially explosive atmospheres. Ignition can occur locally in surrounding components or gases.
High transient peak current	A defect in the electrical circuit. A cause external to the product (e.g. overvoltage of the system network).	Protection devices [c] may not always be activated.
An abnormal temperature rise (other than that caused by any of the above) NOTE 2 Some products dissipate heat in normal operation.	Overcurrent in a conductor. Defective contacts. Leakage currents (insulation loss and heating). Failure of a component, an internal part or an associated system, e.g. ventilation. Mechanical distortions which modify electrical contacts or the insulation system. Seizure of a motor shaft (locked rotor). Premature thermal ageing.	At start-up, protection devices [c] are not normally activated (except in special protection cases). They may be activated after a variable length of time. The temperature rises are gradual and can be very slow. Therefore a significant accumulation of heat and effluent in the vicinity of the product may result, sufficient to support fire as soon as ignition occurs. Accumulation and diffusion of flammable gases in air may give rise to an ignition or explosion, especially inside hermetically sealed products. A seized motor shaft (locked rotor) can cause smouldering or flaming due to excessive heating of the windings of the motor.

[a] The sequence indicated is not related to the magnitude or frequency of occurrence.

[b] Mechanical distortions and structural changes induced by any one of the four causes can result in the occurrence of one or more of the other three.

[c] The protection devices can include thermal (fuse), mechanical (circuit breaker), electrical or electronic types.

5.2.2 Fire risk

5.2.2.1 Quantification of fire risk

In order to calculate fire risk, it is necessary to quantify the consequences of the fire that is being assessed. The consequences may refer to injury or loss of life from threats such as heat, low oxygen levels, or the concentration of incapacitating fire gases; or the consequences may refer to loss of property, such as the extent of fire damage. A wide range of potential fire scenarios may be analysed quantitatively to establish measures of overall fire risk.

If c is the consequence of the fire (i.e. a quantified measure), and p is the probability of the fire occurring within a defined time period, then the fire risk (in that time period) is usually calculated as the product of p and c:

$$\text{Fire risk} = p \times c \qquad (1)$$

If it is assumed that, within a given time-frame, that there is a probability, p_1, of a fire incident involving a given product in a given scenario (scenario 1), and a probability, p_2, of a fire incident involving the same product in a different scenario (scenario 2), and so on, covering all relevant scenarios, the total fire risk associated with that product, within that time-frame is:

$$\text{Total fire risk} = \sum_{i=1}^{m} p_i c_i \qquad (2)$$

where

p_i is the probability of scenario i;

c_i is the consequence of scenario i;

m is the total number of scenarios being considered.

NOTE Further discussions of fire risk, and its use in selecting scenarios on which to base fire hazard tests, can be found in ISO/TS 16732 [1][2].

5.2.2.2 Mitigation of fire risk

There are two ways of mitigating fire risks. One is to reduce the probability of occurrence (reduction of p in Equation 1). The other is to reduce the consequence (reduction of c in Equation 1). Fire hazard testing is concerned with the reduction of p.

There are several distinct ways in which the probability of fire can be reduced. The most important, in no particular order, are:

a) product design and selection, including the selection of appropriate materials;

b) containment using fire resistant enclosures and compartment boundaries;

c) the use of appropriate assembly and installation methods;

d) the incorporation of circuit protection devices;

e) the use of detection and suppression systems.

Fire tests (see Clause 6) are used principally for a) and b) and also to some extent for c).

NOTE 1 Guidance on containment and fire resistance testing for buildings is given in the ISO 834 series of standards [2].

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2 Numbers in square brackets refer to the Bibliography.

NOTE 2 Guidance on detection, activation and suppression is given in ISO/TR 13387-7 [3].

5.3 Fire scenarios

Fire scenarios differ in fire stages (phases), the oxygen content, the CO/CO_2 ratio, the temperature and the irradiance (see Table 2).

Analysis of the circumstances of use of a product involved in a given fire incident (real or hypothetical) facilitates the description of the conditions and the chain of events that play a significant role in the outcome of the fire.

Analysis of product fire incidence using the scenario approach links product fire behaviour to the outcome of the incident. Part of the rationale for choosing any set of fire hazard tests of an electrotechnical product should be a description of the fire scenario or scenarios on which the set of tests is based. This effectively tells the user why this set of test and exposure conditions was chosen and not another.