IEC 60695-1-21

Edition 1.0 2016-09

INTERNATIONAL STANDARD

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BASIC SAFETY PUBLICATION

PUBLICATION FONDAMENTALE DE SÉCURITÉ

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

Essais relatifs aux risques du feu –
Partie 1-21: Lignes directrices pour l'évaluation des risques du feu des produits électrotechniques – Allumabilité – Résumé et pertinence des méthodes d'essais

IEC 60695-1-21:2016-09(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FIRE HAZARD TESTING –

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

FOREWORD

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International Standard IEC 60695-1-21 has been prepared by IEC technical committee 89: Fire hazard testing.

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

FDIS	Report on voting
89/1336/FDIS	89/1339/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 2.

It has the status of a basic safety publication in accordance with IEC Guide 104 and ISO/IEC Guide 51.

This first edition of IEC 60695-1-21 cancels and replaces the first edition of IEC TR 60695-1-21 published in 2008. It constitutes a technical revision.

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

a) Change from a TR to an international standard;

b) Modified Introduction;

c) Modified Scope;

d) Updated normative references;

e) Updated terms and definitions;

f) Updates and new text in Clause 4;

g) Addition of text concerning ASTM D 3638;

h) Updates to Annex A;

i) Updates to the bibliography.

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.

The IEC 60695-1 series, under the general title *Fire hazard testing*, 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 procedures – 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 publication 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,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

Fires are responsible for creating hazards to life and property as a result of the generation of heat (thermal hazard), and also as a result of the production of toxic effluent, corrosive effluent and smoke (non-thermal hazard). Fires start with ignition and then can grow, leading in some cases to flash-over and a fully developed fire. Ignition resistance is therefore one of the most important parameters of a material to be considered in the assessment of fire hazard. If there is no ignition, there is no fire.

For most materials (other than metals and some other elements), ignition occurs in the gas phase. Ignition occurs when combustible vapour, mixed with air, reaches a high enough temperature for exothermic oxidation reactions to rapidly propagate. The ease of ignition is a function of the chemical nature of the vapour, the fuel/air ratio and the temperature.

In the case of liquids, the combustible vapour is produced by vaporization of the liquid, and the vaporization process is dependent on the temperature and chemical composition of the liquid.

In the case of solids, the combustible vapour is produced by pyrolysis when the temperature of the solid is sufficiently high. The vaporization process is dependent on the temperature and chemical composition of the solid, and also on the thickness, density, specific heat, and thermal conductivity of the solid.

The ease of ignition of a test specimen depends on many variables. Factors that need to be considered for the assessment of ignitability are:

a) the geometry of the test specimen, including thickness and the presence of edges, corners or joints;

b) the surface orientation;

c) the rate and direction of air flow;

d) the nature and position of the ignition source;

e) the magnitude and position of any external heat flux; and

f) whether the combustible material is a solid or a liquid.

In the design of an 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.

Fires involving electrotechnical products can also 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.

For these reasons there are many tests used to evaluate the ignitability of electrotechnical products and of the materials used in their construction. This part of IEC 60695 describes ignitability test methods in common use to assess electrotechnical products, or materials used in electrotechnical products. It also includes test methods in which, by design,

ignitability is a significant quantifiable characteristic. It forms part of the IEC 60695-1 series, which gives guidance to product committees wishing to incorporate fire hazard test methods in product standards.

FIRE HAZARD TESTING –

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

1 Scope

This part of IEC 60695 provides a summary of test methods that are used to determine the ignitability of electrotechnical products or materials from which they are formed. It also includes test methods in which, by design, ignitability is a significant quantifiable characteristic.

It represents the current state of the art of the test methods and, where available, includes special observations on their relevance and use. The list of test methods is not to be considered exhaustive, and test methods which were not developed by the IEC are not to be considered as endorsed by the IEC unless this is specifically stated.

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.

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 60695-1-20, *Fire hazard testing – Part 1-20: Guidance for assessing the fire hazard of electrotechnical products – Ignitability – General guidance*

IEC 60695-1-30, *Fire hazard testing – Part 1-30: Guidance for assessing the fire hazard of electrotechnical products – Use of preselection testing procedures*

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 ISO 13943:2008 and IEC 60695-4:2012 (some of which are reproduced below) and the following 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
combustion
exothermic reaction of a substance with an oxidizing agent

Note 1 to entry: Combustion generally emits fire effluent accompanied by **flame**s (3.10) and/or glowing.

[SOURCE: ISO 13943:2008, 4.46]

3.2
end product
product that is ready for use without modification

Note 1 to entry: An end product can be a component of another end product.

[SOURCE: IEC 60695-4:2012, 3.2.7]

3.3
fire
⟨general⟩ process of **combustion** (3.1) characterized by the emission of heat and fire effluent and usually accompanied by smoke, **flame** (3.10), 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** (3.4) and **fire** (3.5), 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]

3.4
fire
⟨controlled⟩ self-supporting **combustion** (3.1) 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]

3.5
fire
⟨uncontrolled⟩ self-supporting **combustion** (3.1) 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]

3.6
fire hazard
physical object or condition with a potential for an undesirable consequence from **fire** (3.3)

[SOURCE: ISO 13943:2008, 4.112]

3.7
fire point
minimum temperature at which a material ignites and continues to burn for a specified time after a standardized small **flame** (3.10) has been applied to its surface under specified conditions

cf. **flash point** (3.15)

Note 1 to entry: In some countries the term "fire point" has an additional meaning: a location where fire fighting equipment is sited, which may also comprise a fire-alarm call point and fire instruction notices.

Note 2 to entry: The typical units are degrees Celsius (°C).

[SOURCE: ISO 13943:2008, 4.119]

3.8
fire retardant, noun
substance added or a treatment applied to a material in order to delay **ignition** (3.19) or to reduce the rate of combustion (3.1)

cf. **flame retardant** (3.11)

Note 1 to entry: The use of (a) fire retardant(s) does not necessarily suppress **fire** (3.3) or terminate **combustion (3.1)**.

[SOURCE: ISO 13943:2008, 4.123]

3.9
fire scenario
qualitative description of the course of a **fire** (3.5) 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** (3.19) and fire-growth processes, the **fully developed fire** (3.16) stage, the fire decay stage, and the environment and systems that impact on the course of the fire.

[SOURCE: ISO 13943:2008, 4.129]

3.10
flame, noun
zone in which there is rapid, self-sustaining, sub-sonic propagation of **combustion** (3.1) in a gaseous medium, usually with emission of light

[SOURCE: ISO 13943:2008, 4.133, modified (addition of "zone in which there is")]

3.11
flame retardant, noun
substance added, or a treatment applied, to a material in order to suppress or delay the appearance of a **flame** (3.10) and/or reduce the flame spread rate

cf. **fire retardant** (3.8)

Note 1 to entry: The use of (a) flame retardant(s) does not necessarily suppress **fire** (3.3) or terminate **combustion** (3.1).

[SOURCE: ISO 13943:2008, 4.139]

3.12
flaming combustion
combustion (3.1) in the gaseous phase, usually with emission of light

[SOURCE: ISO 13943:2008, 4.148]

3.13
flash-ignition temperature
FIT
minimum temperature at which, under specified test conditions, sufficient flammable gases are emitted to ignite momentarily on application of a pilot **flame** (3.10)

[SOURCE: ISO 871:2006, 3.1]

3.14
flash-over
⟨stage of fire⟩ transition to a state of total surface involvement in a **fire** (3.3) of combustible materials within an enclosure

[SOURCE: ISO 13943:2008, 4.157]

3.15
flash point (°C)
minimum temperature to which it is necessary to heat a material or a product for the vapours emitted to ignite momentarily in the presence of **flame** (3.10), under specified test conditions

Note 1 to entry: The typical units are degrees Celsius (°C).

[SOURCE: ISO 13943:2008, 4.154]

3.16
fully developed fire
state of total involvement of combustible materials in a **fire** (3.5)

[SOURCE: ISO 13943:2008, 4.164]

3.17
glowing combustion
combustion (3.1) of a material in the solid phase without **flame** (3.10) but with emission of light from the combustion zone

[SOURCE: ISO 13943:2008, 4.169]

3.18
ignitability
ease of ignition
measure of the ease with which a test specimen can be ignited, under specified conditions

[SOURCE: ISO 13943:2008, 4.182]

3.19
ignition
sustained ignition (deprecated)
⟨general⟩ initiation of **combustion** (3.1)

[SOURCE: ISO 13943:2008, 4.187]

3.20
ignition
sustained ignition (deprecated)
⟨flaming combustion⟩ initiation of sustained **flame** (3.10)

[SOURCE: ISO 13943:2008, 4.188]

3.21
ignition source
source of energy that initiates **combustion** (3.1)

[SOURCE: ISO 13943:2008, 4.189]

3.22
lower flammability limit
LFL
minimum concentration of fuel vapour in air below which propagation of a **flame** (3.10) does not occur in the presence of an **ignition source** (3.21)

Note 1 to entry: The concentration is usually expressed as a volume fraction at a defined temperature and pressure, and expressed as a percentage.

[SOURCE: ISO 13943:2008, 4.216]

3.23
minimum ignition temperature
ignition point
minimum temperature at which sustained **combustion** (3.1) can be initiated under specified test conditions

Note 1 to entry: The minimum ignition temperature implies the application of a thermal stress for an infinite length of time.

Note 2 to entry: The typical units are degrees Celsius (°C).

[SOURCE: ISO 13943:2008, 4.231]

3.24
spontaneous-ignition temperature
SIT
minimum temperature at which **ignition** (3.19) is obtained by heating, under specified test conditions, in the absence of any additional **flame** (3.10) **ignition source** (3.21)

[SOURCE: ISO 871, 3.2]

3.25
thermal inertia
product of thermal conductivity, density and specific heat capacity

EXAMPLES The thermal inertia of steel is $2{,}3 \times 10^8$ $J^2 \cdot s^{-1} \cdot m^{-4} \cdot K^{-2}$. The thermal inertia of polystyrene foam is $1{,}4 \times 10^3$ $J^2 \cdot s^{-1} \cdot m^{-4} \cdot K^{-2}$.

Note 1 to entry: When a material is exposed to a heat flux, the rate of increase of surface temperature depends strongly on the value of the thermal inertia of the material. The surface temperature of a material with a low thermal inertia rises relatively quickly when it is heated, and vice versa.

Note 2 to entry: The typical units are joules squared per second per metre to the fourth power per Kelvin squared ($J^2 \cdot s^{-1} \cdot m^{-4} \cdot K^{-2}$).

[SOURCE: ISO 13943:2008, 4.326]

3.26
tracking
arc tracking
⟨electrotechnical⟩ progressive formation of conducting paths that are produced on the surface and/or within a solid insulating material, due to the combined effects of electric stress and electrolytic contamination

[SOURCE: ISO 13943:2008, 4.342]

3.27
upper flammability limit
UFL
maximum concentration of fuel vapour in air above which propagation of a **flame** (3.10) will not occur in the presence of an **ignition source** (3.21)

Note 1 to entry: The concentration is usually expressed as a volume fraction at a defined temperature and pressure, and expressed as a percentage.

[SOURCE: ISO 13943:2008, 4.349]

4 Summary of published test methods

4.1 General

This summary cannot be used in place of published standards which are the only valid reference documents. It represents the current state of the art of the test methods and, where available, includes special observations on their relevance and use. The list of test methods is not to be considered exhaustive, and test methods which were not developed by the IEC are not to be considered as endorsed by the IEC unless this is specifically stated. General guidance on ignitability is given in IEC 60695-1-20.

Some test methods are material tests and some are end product tests. Table A.1 lists the test methods described below and distinguishes between material tests and end product tests.

In cases where fire tests are not yet specified, and need to be developed or altered for the special purpose of an IEC technical committee, this shall be done in liaison with IEC Technical Committee 89.

The test method(s) selected shall be relevant to the fire scenario of concern.

NOTE 1 Not all the following test methods are specifically ignition or ignitability tests, but some tests have been included because ignition data are, or can be, measured.

NOTE 2 Where no repeatability and reproducibility data are known to be available, information may be available from the author/publisher of the relevant test method.

4.2 Tests using heated air or electrical heating

4.2.1 Determination of ignition temperature using a hot-air furnace, ISO 871

4.2.1.1 Purpose and principle

ISO 871 specifies a laboratory method for determining the flash-ignition temperature and spontaneous-ignition temperature of plastics using a hot-air furnace.

A specimen of the material is heated in a hot-air ignition furnace using various temperatures within the heated chamber, and the flash-ignition temperature is determined with a small pilot flame directed at the opening in the top of the furnace to ignite evolved gases. The spontaneous-ignition temperature is determined in the same manner as the flash-ignition temperature, but without the ignition flame.

4.2.1.2 Test specimen

Materials supplied in any form, including composites, may be used. A 3 g sample is used if the density is greater than 100 $kg \cdot m^{-3}$. For cellular materials having a density less than 100 $kg \cdot m^{-3}$, any outer skin is removed and a block of dimensions 20 mm × 20 mm × 50 mm is cut.

4.2.1.3 Test method

An air velocity of 25 $mm \cdot s^{-1}$ is set and an initial test temperature is chosen. At the end of 10 min the temperature is lowered or raised by 50 °C, depending on whether ignition has or has not occurred and a fresh sample is tested. When the range within which the ignition temperature lies has been determined, tests are begun 10 °C below the highest temperature within this range and continued by dropping the temperature in 10 °C steps until the temperature is reached at which there is no ignition during a 10 min period. The ignition temperature is recorded as the lowest test temperature at which ignition is observed.

4.2.1.4 Repeatability and reproducibility

Data are available in Annex A of ISO 871:2006.

4.2.1.5 Relevance of test data

Tests made under the conditions of this method can be of considerable value in comparing the relative ignition characteristics of different materials. Values obtained represent the lowest ambient air temperature that will cause ignition of the material under the conditions of this test. Test values are expected to rank materials according to ignition susceptibility under actual use conditions.

4.2.2 Differential scanning calorimetry (DSC), ISO 11357 [1][1]

4.2.2.1 Introduction

Differential scanning calorimetry (DSC) is one of a number of thermal methods of analysis which are not used to directly measure ignition, but which are used to measure a number of properties which affect ignitability and which can be used in fire safety engineering studies and in fire modelling.

NOTE Other useful techniques include thermogravimetric analysis (TGA), differential thermal analysis (DTA), thermomechanical analysis (TMA), dynamic mechanical thermal analysis (DMTA), and pyrolysis gas chromatography [2], [3].

4.2.2.2 Purpose and principle

ISO 11357 consists of seven parts, and describes methods using DSC to measure the following properties of polymeric materials such as thermoplastics and thermosetting plastics, including moulded materials and composite materials:

- Glass transition temperature
- Temperature and enthalpy of melting and crystallization
- Specific heat capacity
- Polymerization temperatures and/or times and polymerization kinetics
- Oxidation induction time
- Crystallization kinetics

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1 Numbers in square brackets refer to the bibliography.