IEC 60695-1-40

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

BASIC SAFETY PUBLICATION
PUBLICATION FONDAMENTALE DE SÉCURITÉ

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

Essais relatifs aux risques du feu –
Partie 1-40: Guide pour l'évaluation des risques du feu des produits électrotechniques – Liquides isolants

IEC 60695-1-40:2013

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FIRE HAZARD TESTING –

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

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 60695-1-40 has been prepared by IEC technical committee 89: Fire hazard testing.

This first edition of IEC 60695-1-40 cancels and replaces the first edition of IEC/TS 60695-1-40 published in 2002. It constitutes a technical revision and now has the status of an International Standard.

The main changes with respect to the first edition of IEC/TS 60695-1-40 are the integration of editorial and technical changes throughout the text.

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

FDIS	Report on voting
89/1191/FDIS	89/1200/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.

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

This international standard is to be used in conjunction with IEC 60695-1-10.

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 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

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 product design as well as the choice of materials is to reduce to acceptable levels the potential risks of fire even in the event of foreseeable abnormal use, malfunction or failure.

For more than 100 years, insulating liquids based on mineral oil have been used for the insulating and cooling of electrical transformers and some other types of electrotechnical equipment.

During the last 70 years, synthetic insulating liquids have been developed and used in specific electrotechnical applications for which their properties are particularly suitable. However, for technical and economic reasons, highly refined mineral oil continues to be the most widely used insulating liquid for use in transformers, the major end use application. Their safe installation is covered by local, national and international regulations.

The fire safety record of electrotechnical equipment containing insulating liquids is good, for both mineral oil and synthetic liquids. In recent years improvements in design and protective measures against fire have reduced the fire hazard for electrotechnical equipment containing mineral oil. However, as for all forms of electrotechnical equipment, the objective should be to reduce the likelihood of fire even in the event of foreseeable abnormal use.

The practical aim is to prevent ignition, but if ignition occurs, to control the fire, preferably within the enclosure of the electrotechnical equipment.

FIRE HAZARD TESTING –

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

1 Scope

This international standard provides guidance on the minimization of fire hazard arising from the use of electrical insulating liquids, with respect to:

a) electrotechnical equipment and systems,

b) people, building structures and their contents.

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 [1] [1] and ISO/IEC Guide 51 [2]. It is not intended for use by manufacturers or certification bodies.

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, 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 60050, *International electrotechnical vocabulary*

IEC 60296, *Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear*

IEC 60465, *Specification for unused insulating mineral oils for cables with oil ducts*

IEC 60695-1-10, *Fire hazard testing – Part 1-10: Guidance for assessing the fire hazard of electrotechnical products – General guidelines*

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

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

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

IEC 60695-7-2, *Fire hazard testing – Part 7-2: Toxicity of fire effluent – Summary and relevance of test methods*

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[1] Numbers in square brackets refer to the Bibliography.

IEC 60695-8-2, *Fire hazard testing – Part 8-2: Heat release – Summary and relevance of test methods*

IEC 60944, *Guide for the maintenance of silicone transformer liquids*

IEC 61039, *Classification of insulating liquids*

IEC 61203, *Synthetic organic esters for electrical purposes – Guide for maintenance of transformer esters in equipment*

IEC/TS 60695-5-2, *Fire hazard testing – Part 5-2: Corrosion damage effects of fire effluent – Summary and relevance of test methods*

IEC/TS 60695-8-3, *Fire hazard testing – Part 8-3: Heat release – Heat release of insulating liquids used in electrotechnical products*

ISO 1716, *Reaction to fire tests for products – Determination of the gross heat of combustion (calorific value)*

ISO 2592, *Determination of flash and fire points – Cleveland open cup method*

ISO 13943:2008, *Fire safety – Vocabulary*

3 Terms and definitions

For the purposes of this document, terms and definitions given in ISO 13943:2008 and IEC 60695-4:2012, some of which are reproduced below for the user's convenience, as well as the following additional definitions, apply.

3.1
arc
electrical breakdown of a gas which produces a sustained plasma discharge, resulting from an electric current flowing through a normally nonconductive medium such as air

3.2
bund
outer wall or tank designed to retain the contents of an inner container in the event of leakage or spillage

Note 1 to entry: A bund should be designed to capture well in excess of the volume of liquids held within the bund area.

3.3
bushing
insulating liner in an opening through which a conductor passes

3.4
combustion
exothermic reaction of a substance with an oxidizing agent

Note 1 to entry: Combustion generally emits fire effluent accompanied by flames and/or glowing.

[SOURCE: ISO 13943:2008, 4.46]

3.5
corrosion damage
physical and/or chemical damage or impaired function caused by chemical action

[SOURCE: ISO 13943:2008, 4.56]

3.6
enclosure
⟨electrotechnical⟩ external casing protecting the electrical and mechanical parts of apparatus

Note 1 to entry: The term excludes cables.

[SOURCE: IEC 60695-4:2012, 3.2.6]

3.7
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 and fire, 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]

3.8
fire effluent
totality of gases and aerosols, including suspended particles, created by combustion or pyrolysis in a fire

[SOURCE: ISO 13943:2008, 4.105]

3.9
fire growth
stage of fire development during which the heat release rate and the temperature of the fire are increasing

[SOURCE: ISO 13943:2008, 4.111]

3.10
fire hazard
physical object or condition with a potential for an undesirable consequence from fire

[SOURCE: ISO 13943:2008, definition 4.112]

3.11
fire load
quantity of heat which can be released by the complete combustion of all the combustible materials in a volume, including the facings of all bounding surfaces

Note 1 to entry: Fire load may be based on effective heat of combustion, gross heat of combustion, or net heat of combustion as required by the specifier.

Note 2 to entry: The word "load" can be used to denote force or power or energy. In this context, it is being used to denote energy.

Note 3 to entry: The typical units are kilojoules (kJ) or megajoules (MJ).

[SOURCE: ISO 13943:2008, 4.114]

3.12
fire point
minimum temperature at which a material ignites and continues to burn for a specified time after a standardized small flame has been applied to its surface under specified conditions

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]

3.13
fire risk
probability of a fire 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]

3.14
fire scenario
qualitative description of the course of a fire 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]

3.15
flame, noun
zone in which there is rapid, self-sustaining, sub-sonic propagation of combustion in a gaseous medium, usually with emission of light

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

3.16
flammability
ability of a material or product to burn with a flame under specified conditions

[SOURCE: ISO 13943:2008, 4.151]

3.17
flash point
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 under specified conditions

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

[SOURCE: ISO 13943:2008, 4.154]

3.18
gross heat of combustion
heat of combustion of a substance when the combustion is complete and any produced water is entirely condensed under specified conditions

Note 1 to entry: The typical units are kilojoules per gram ($kJ \cdot g^{-1}$).

[SOURCE: ISO 13943:2008, 4.170]

3.19
heat of combustion
thermal energy produced by combustion of unit mass of a given substance

Note 1 to entry: The typical units are kilojoules per gram ($kJ \cdot g^{-1}$).

[SOURCE: ISO 13943:2008, 4.174]

3.20
heat of gasification
thermal energy required to change a unit mass of material from the condensed phase to the vapour phase at a given temperature

Note 1 to entry: The typical units are kilojoules per gram ($kJ \cdot g^{-1}$).

[SOURCE: ISO 13943:2008, 4.175]

3.21
heat release
thermal energy produced by combustion

Note 1 to entry: The typical units are joules (J).

[SOURCE: ISO 13943:2008, 4.176]

3.22
heat release rate
burning rate (deprecated)
rate of burning (deprecated)
rate of thermal energy production generated by combustion

Note 1 to entry: The typical units are watts (W).

[SOURCE: ISO 13943:2008, 4.177]

3.23
high voltage
HV
voltage greater than 1 kV (a.c.) or greater than 1,5 kV (d.c.)

3.24
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]

3.25
ignition
sustained ignition (deprecated)
⟨general⟩ initiation of combustion

[SOURCE: ISO 13943:2008, 4.187]

3.26
mineral oil

liquid conforming to IEC 60296 or IEC 60465

3.27
net heat of combustion
heat of combustion when any water produced is considered to be in the gaseous state

Note 1 to entry: The net heat of combustion is always smaller than the gross heat of combustion because the heat released by the condensation of water vapour is not included.

Note 2 to entry: The typical units are kilojoules per gram ($kJ \cdot g^{-1}$).

[SOURCE: ISO 13943:2008, 4.237]

3.28
opacity of smoke
ratio of incident light intensity to transmitted light intensity through smoke, under specified conditions

Note 1 to entry: Opacity of smoke is the reciprocal of transmittance.

Note 2 to entry: The opacity of smoke is dimensionless.

[SOURCE: ISO 13943:2008, 4.243]

3.29
origin fire scenario
fire scenario involving electrotechnical equipment where the electrotechnical equipment is the source of ignition

3.30
PCB
polychlorinated biphenyl

Note 1 to entry: PCB mixtures were developed as insulating liquids in the 1930s. They are known by various trade names, e.g. Aroclor™, Askarel™, Clophen™, Inerteen™ and Pyranol™ [2].

3.31
pool fire
fire characterized by diffusion flames formed above a horizontal body of liquid fuel where buoyancy is the controlling mechanism for transport of fire effluent from the fire and transport of air to the fire

3.32
routine test
test on a number of items taken at random from a batch

3.33
sampling test
conformity test made on each individual item during or after manufacture

[SOURCE: IEC 60050-151:2001, 151-16-17, modified – original term was “routine test”]

3.34
tapchanger
device fitted to power transformers for regulation of the output voltage to required levels

3.35
toxic hazard
potential for harm resulting from exposure to toxic combustion products

[SOURCE: ISO 13943:2008, 4.337]

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2 Aroclor™, Askarel™, Clophen™, Inerteen™ and Pyranol™ are examples of suitable products available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of these products.

3.36
type test
conformity test made on one or more items representative of the production

[SOURCE: IEC 60050-581:2008, 581-21-08]

3.37
victim fire scenario
fire scenario involving electrotechnical equipment where the electrotechnical equipment is the victim of a fire of external origin

4 Classification of insulating liquids

Insulating liquids have been classified in IEC 61039 according to fire point and net heat of combustion, as shown in Table 1.

Table 1 – Classification of insulating liquids

Fire point		Net heat of combustion	
Class O	≤300 °C	Class 1	≥42 MJ/kg
Class K	>300 °C	Class 2	<42 MJ/kg ≥32 MJ/kg
Class L	No measurable fire point	Class 3	<32 MJ/kg
EXAMPLE Mineral transformer oil (IEC 60296) has a classification of O1.			

NOTE 1 Fire point is measured using the Cleveland open cup method, ISO 2592, and is used as the primary method of classification.

NOTE 2 The determination of the flash point is sometimes used as a secondary method of classification. IEC TC10 usually adopts ISO 2719:2002 [3] in order to measure the flash point using the Pensky-Martens methodology (closed cup). If the value of the flash point determined by this method is < 250 °C, then the product is classified with the letter “O”; if the flash point is ≥ 250 °C, then the product is classified with the letter “K”, and, if there is no detectable flash point, the product is classified with the letter “L”.

5 Types of electrotechnical equipment containing insulating liquids

Insulating liquids are used in some designs of:

– transformers and reactors,
– capacitors,
– cables,
– bushings,
– switchgear, and
– miscellaneous power electronics (and in some other electrotechnical applications in which the liquid serves partly as an insulant, but primarily as a coolant)

In many cases, alternative designs use solid or gaseous insulation materials as an alternative to liquids. This international standard does not discuss the relative advantages and disadvantages of these alternatives.

NOTE As insulating liquids are always part of an insulating system, the fire hazard assessment of the complete system could also be of interest.