

INTERNATIONAL STANDARD



HORIZONTAL PUBLICATION

**Fire hazard testing –
Part 2-12: Glowing/hot-wire based test methods – Glow-wire flammability index
(GWFI) test method for materials**



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Edition 3.0 2021-10
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(GWFI) test method for materials**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 13.220.40; 29.020

ISBN 978-2-8322-1038-2

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIRE HAZARD TESTING –

**Part 2-12: Glowing/hot-wire based test methods –
Glow-wire flammability index (GWFI) test method for materials**

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 60695-2-12:2010+AMD1:2014 CSV. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC 60695-2-12 has been prepared by IEC technical committee 89: Fire hazard testing. It is an International Standard.

This third edition cancels and replaces the second edition published in 2010 and Amendment 1:2014. This edition constitutes a technical revision.

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

- a) New terms and definitions with regards to times and durations have been added to Clause 3, with an effect on the application of the test method.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
89/1537/FDIS	89/1545/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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

This standard is to be used in conjunction with IEC 60695-2-10.

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

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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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 during normal operating conditions, reasonable foreseeable abnormal use, malfunction and/or failure. IEC 60695-1-10 [1]¹, together with its companion IEC 60695-1-11 [2], has been developed to provide guidance on how this is to be accomplished.

The primary aims of IEC 60695-1-10 and IEC 60695-1-11 are to provide guidance on how to:

- a) prevent ignition caused by an electrically energized component part, and
- b) confine any resulting fire within the bounds of the enclosure of the electrotechnical product in the event of ignition.

Secondary aims of IEC 60695-1-10 and IEC 60695-1-11 include the minimization of any flame spread beyond the product's enclosure and the minimization of the harmful effects of fire effluents such as heat, smoke, toxicity and/or corrosivity.

Fires involving electrotechnical products can also be initiated from external non-electrical sources. Considerations of this nature ~~should be~~ are normally dealt with in the overall fire hazard assessment.

In electrotechnical equipment, overheated metal parts can act as ignition sources. In glow-wire tests, a ~~red-hot~~ glowing wire is used to simulate such an ignition source.

IEC 60695-2-10 describes a glow-wire test apparatus and common test procedure, IEC 60695-2-11 [3] describes a glow-wire flammability test for end products, and IEC 60695-2-13 describes a glow-wire ignition temperature (GWIT) test method for materials.

This document describes a glow-wire flammability index test for materials. It ~~should~~ is intended to be used to measure, describe, and rank the properties of materials in response to heat caused by contact with an electrically heated wire under controlled laboratory conditions. This may be useful for the evaluation of materials for use in products that may be exposed to excess thermal stress such as a fault current flowing through a wire, overloading of components, and/or bad connections. It ~~should~~ is not intended to be used to solely describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test ~~may~~ can be used as elements of a fire hazard assessment which takes into account all of the factors which are pertinent to a particular end use.

This document may involve hazardous materials, operations, and equipment. It does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this document to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

¹ Numbers in square brackets refer to the bibliography.

FIRE HAZARD TESTING –

Part 2-12: Glowing/hot-wire based test methods – Glow-wire flammability index (GWFI) test method for materials

1 Scope

This part of IEC 60695 specifies the details of the glow-wire test to be applied to test specimens of solid electrical insulating materials or other solid materials for flammability testing to determine the glow-wire flammability index (GWFI).

GWFI is the highest temperature, determined during this standardized procedure, at which the tested material does not ignite or, if it does, extinguishes within 30 s after removal of the glow-wire and is not totally consumed; and molten drips, if they occur, do not ignite the wrapping tissue.

This test method is a materials test carried out on a series of standard test specimens. The data obtained, along with data from the glow-wire ignition temperature (GWIT) test method for materials, IEC 60695-2-13, can then be used in a preselection process in accordance with IEC 60695-1-30 [4] to judge the ability of materials to meet the requirements of IEC 60695-2-11.

NOTE As an outcome of conducting a fire hazard assessment, an appropriate series of preselection flammability and ignition tests ~~may~~ can allow a reduction of end product testing.

This basic safety publication ~~is~~ focusing on safety test method(s) is primarily intended for use by technical committees in the preparation of ~~standards~~ safety publications 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 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 60695-1-30:2008, Fire hazard testing – Part 1-30: Guidance for assessing the fire hazard of electrotechnical products – Preselection testing process – General guidelines~~

IEC 60695-2-10:2000, Fire hazard testing – Part 2-10: Glowing/hot-wire based test methods – Glow-wire apparatus and common test procedure

IEC 60695-2-13, Fire hazard testing – Part 2-13: Glowing/hot-wire based test methods – Glow-wire ignition temperature (GWIT) test method for materials

IEC 60695-4:2021, 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 inclusion in standards~~

ISO 291:2008, *Plastics – Standard atmospheres for conditioning and testing*

ISO 293, *Plastics – Compression moulding of test specimens of thermoplastic materials*

ISO 294 (all parts), *Plastics – Injection moulding of test specimens of thermoplastic materials*

ISO 295, *Plastics – Compression moulding of test specimens of thermosetting materials*

ISO 13943:2017, *Fire safety – Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 13943:2017 and IEC 60695-4:2012, some of which are reproduced below for the user's convenience, and in IEC 60695-2-10 regarding times and durations, 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 flames and/or glowing.

[SOURCE: ~~ISO/IEC 13943:2008, definition 4.46~~ ISO 13943:2017, 3.55]

3.2

flame, noun

rapid, self-sustaining, sub-sonic propagation of combustion in a gaseous medium, usually with emission of light

[SOURCE: ~~ISO/IEC 13943:2008, definition 4.133~~ ISO 13943:2017, 3.159]

3.3

flame event

sustained flaming and/or glowing combustion

3.4

flammability

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

[SOURCE: ISO 13943:2017, 3.178]

3.5

glowing, noun

luminosity caused by heat

[SOURCE: ~~ISO/IEC 13943:2008, definition 4.168~~ ISO 13943:2017, 3.196]

3.6

glowing combustion

combustion of a material in the solid phase without flame but with emission of light from the combustion zone

[SOURCE: ~~ISO/IEC 13943:2008, definition 4.169~~ ISO 13943:2017, 3.197]

3.7

ignition

DEPRECATED: sustained ignition
<general> initiation of combustion

[SOURCE: ~~ISO/IEC 13943:2008, definition 4.187~~ ISO 13943:2017, 3.217]

3.8

ignition

DEPRECATED: sustained ignition
<flaming combustion> initiation of sustained flame

[SOURCE: ~~ISO/IEC 13943:2008, definition 4.188~~ ISO 13943:2017, 3.218]

3.9

molten drip

falling droplet of material which has been softened or liquefied by heat

Note 1 to entry: The droplets can be flaming or not flaming.

[SOURCE: ~~ISO/IEC 13943:2008, definition 4.232~~ ISO 13943:2017, 3.275]

3.10

preselection

process of assessing and choosing candidate materials, components or subassemblies for making an end product

[SOURCE: ~~IEC 60695-1-30:2008, definition 3.2~~ IEC 60695-4:2012, 3.2.21]

4 Test specimens

4.1 Test specimen preparation

Test specimens shall be fabricated using the appropriate ISO method, e.g. casting and injection moulding in accordance with the ISO 294 series, compression moulding in accordance with ISO 293 or ISO 295, or transfer moulding to the necessary shape **as specified in 4.2**. Where this is not possible, the test specimen shall be cut and/or sliced from a representative sample of the material (for example, produced using the same fabrication process as would be used to mould a part of a product).

After any fabrication or cutting operation, ~~care shall be taken to remove~~ all dust and any particles **shall be removed** from the surface; cut edges shall be fine sanded to a smooth finish.

4.2 Test specimen dimensions

The dimensions of the planar sections of the test specimens shall be at least 60 mm in length and 60 mm in width (measured inside the clamping areas) and shall be provided in all thicknesses under consideration. ~~The preferred values include 0,1 mm ± 0,02 mm, 0,2 mm ± 0,02 mm, 0,4 mm ± 0,05 mm, 0,75 mm ± 0,1 mm, 1,5 mm ± 0,15 mm, 3,0 mm ± 0,2 mm, or 6,0 mm ± 0,4 mm.~~ The preferred values of thickness include 0,1 mm ± 0,02 mm, 0,2 mm ± 0,03 mm, 0,4 mm ± 0,04 mm, 0,75 mm ± 0,15 mm, 1,5 mm ± 0,15 mm, 3,0 mm ± 0,25 mm, or 6,0 mm ± 0,4 mm.

NOTE A set of 30 test specimens per thickness will, in general, be adequate to concurrently establish the GWFI and the glow wire ignition temperature, GWIT (see IEC 60695-2-13).

4.3 Testing ranges in formulations

4.3.1 General

The results of tests carried out on test specimen sets of different colour, thickness, density, molecular mass, anisotropic type/direction, additives, fillers, and/or reinforcements can vary. When agreed between the parties involved, the test programmes outlined in 4.3.2 and 4.3.3 may be employed in order to evaluate these variations.

4.3.2 Density, melt flows and filler/reinforcement

Test specimens covering all combinations of minimum and maximum levels of density, melt flows and filler/reinforcement content ~~may~~ shall be provided and considered representative of the range if the test results yield the same GWFI. If the test results do not yield the same GWFI for all test specimens representing the range, evaluation shall be limited to the materials with the specific levels of density, melt flows and filler/reinforcement tested. In addition, test specimens with intermediate density, melt flows, and filler/reinforcement content shall be tested to determine the representative range for each GWFI determination. However, as an alternative, the least favourable performance of the specific levels of density, melt flows and filler/reinforcement tested ~~may~~ shall be considered representative of intermediate levels without additional testing.

4.3.3 Colour

When evaluating a range of colours, test specimens that

- a) contain no colouring,
- b) contain the highest level of organic pigments/colorants/dyes and/or carbon black,
- c) contain the highest level of inorganic pigments, and
- d) contain pigments/colorants/dyes which are known to adversely affect flammability characteristics

are considered representative of the colour range if the test results yield the same GWFI.

If the colours do not yield the same GWFI, when evaluating a range of colours, the GWFI with the least favourable performance should yield the GWFI for an all colour range.

5 Apparatus

~~The description of the test apparatus is specified in Clause 5 of IEC 60695-2-10.~~

~~The wrapping tissue and wooden board to be placed underneath the test specimen are specified in 5.3 of IEC 60695-2-10.~~

The test apparatus of IEC 60695-2-10 shall be used.

6 Temperature measuring system verification

The ~~method of~~ verification of the temperature measuring system ~~is~~ as specified in IEC 60695-2-10 shall have been performed.

7 Conditioning and test conditions

7.1 Conditioning of test specimens

The test specimens shall be conditioned for a minimum of 48 h at $23\text{ °C} \pm 2\text{ °C}$ and at a relative humidity between 40 % and 60 % (in accordance with ISO 291:2008, Clause 6, Table 2, Class 2). Once removed from the conditioning atmosphere, the test specimens shall be tested within 4 h ~~(see ISO 291, Clause 6, Table 2, Class 2).~~

7.2 Conditioning of the wrapping tissue and the wooden board

~~The wrapping tissue and the wooden board to be placed underneath the test specimen are specified in 5.3 of IEC 60695-2-10. They shall be conditioned for a minimum of 48 h at $23\text{ °C} \pm 2\text{ °C}$ and at a relative humidity between 40 % and 60 %. Once removed from the conditioning atmosphere, the wrapping tissue and wooden board shall be used within 1 h (see ISO 291, Clause 6, Table 2, Class 2).~~

The wrapping tissue and the wooden board to be placed underneath the test specimen as well as their conditioning are specified in IEC 60695-2-10. Once removed from the conditioning atmosphere, the wrapping tissue and wooden board shall be used within 4 h.

7.3 Testing conditions

The test specimens shall be tested in a laboratory atmosphere having a temperature between 15 °C and 35 °C and a relative humidity less than or equal to 75 %.

8 Test procedure

8.1 General

The test specimens shall be identified ~~and examined visually.~~

The general test procedure shall be as specified in IEC 60695-2-10.

8.2 Initial test temperatures

The glow-wire is heated to one of the initial test temperatures specified in Table 1, which is considered to be just high enough to cause ignition. If unknown, the initial test temperature shall not exceed 650 °C .

NOTE When determining both the GWIT and GWFI, it has been found to be useful to first perform the procedure in IEC 60695-2-13. Once the GWIT has been determined, this ~~should be used as~~ information is useful to set the initial test temperature for the GWFI test.

Table 1 – Initial test temperatures

Initial test temperatures °C	Tolerances °K°C
550	±10
600	±10
650	±10
700	±10
750	±10
800	±15
850	±15
900	±15
960	±15

8.3 Test temperatures

A set of three test specimens shall be prepared for testing at a chosen initial test temperature.

If one of the three test specimens fails to withstand the test criteria as defined in 10.1, the test shall be repeated with three new test specimens at a test temperature preferably 50-K °C (60-K °C for 960 °C) lower.

If the three test specimens withstand the test criteria as defined in 10.1, the test shall be repeated with three new test specimens at a test temperature preferably 50-K °C (60-K °C for 900 °C) higher.

Repeat the tests with three new test specimens each time and reduce the interval of test temperatures to 25-K °C (30-K °C for 960 °C) in the final approach to determine the maximum test temperature at which all three test specimens withstand the test criteria as defined in 10.1.

However, there is no need to go to the higher temperature if it has already been determined that at least one of the three test specimens will not withstand the test criteria as defined in 10.1.

NOTE 1 The minimum test temperature is 550 °C. The maximum test temperature is 960 °C.

NOTE 2 60 K and 30 K are the appropriate temperature intervals for temperatures above 900 °C.

NOTE 3 It is recommended to start with a test temperature of 650 °C.

9 Observations and measurements

9.1 General

~~The following observations and measurements shall be recorded.~~

9.1 Initial observations

After identifying and visually inspecting the test specimens, the following shall be recorded:

- a description of the tested material, including thickness, colour, type and manufacturer;
- a description of the method for the preparation of the test specimens, if available

- c) the direction of any anisotropy, if known, relative to the dimensions of the test specimen; and
- d) the pre-test conditioning of the test specimens and wrapping tissue.

9.2 Test observations

During the time of application of the glow-wire, t_{APP} ($30 \text{ s} \pm 1 \text{ s}$), and during a further period of 30 s, time of observation, t_{OBS} , the test specimen and the wrapping tissue placed below it shall be observed and the following shall be recorded:

- ~~a) the time, t_R , of the longest sustained flaming and/or glowing combustion observed after the removal of the glow-wire tip from the test specimen (to the nearest 0,5 s);~~
- ~~b) the test temperatures from Clause 8;~~
- ~~c) total consumption of the test specimen, if this occurs;~~
- ~~d) ignition of the wrapping tissue, if this occurs; and~~
- ~~e) additional observations that may be agreed to by both parties.~~

~~NOTE If the measured value is 30,2 s this should be recorded as 30,0 s. If the measured value is 30,3 s this should be recorded as 30,5 s.~~

- a) whether there is no ignition; or, if there is ignition, the time of ignition, t_I for the test specimen;
- a) the time of extinguishment, t_E ;
- b) based on the recording of measured values t_I and t_E , the calculated value for t_R shall be recorded as well;
- c) the test temperatures from Clause 8;
- d) whether the test specimen is totally consumed;
- e) whether there is any ignition of the wrapping tissue placed underneath the test specimen; and
- f) additional observations that may be agreed to by both parties.

10 Evaluation of test results

10.1 Test criteria

~~The test specimen is considered to have withstood this test if there is no ignition, or if all of the following situations apply:~~

- ~~a) the longest sustained flames or glowing of the test specimen after removal of the glow-wire, t_R , extinguish within 30 s;~~
- ~~b) the specimen is not totally consumed; and~~
- ~~c) there is no ignition of the wrapping tissue.~~

The test specimen is considered to have achieved the severity level of a specific test temperature of T °C, if

- a) there is no ignition, or
- b) all of the following situations apply when ignition has occurred:
 - 1) flames or glowing combustion of the test specimen extinguish within 30 s after removal of the glow-wire (t_{OBS}), i.e. $t_R \leq 30 \text{ s}$;
 - 2) the test specimen is not totally consumed; and
 - 3) the wrapping tissue placed underneath the test specimen does not ignite.