IEC TS 60695-2-20

Edition 3.0 2021-04

TECHNICAL SPECIFICATION

colour inside

Fire hazard testing –
Part 2-20: Glowing/hot wire based test methods – Hot-wire coil test method – Apparatus, verification, test method and guidance

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

IEC TS 60695-2-20:2021-04(en)

THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2021 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC online collection - oc.iec.ch
Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 18 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

IEC TS 60695-2-20

Edition 3.0 2021-04

TECHNICAL SPECIFICATION

colour inside

Fire hazard testing –
Part 2-20: Glowing/hot wire based test methods – Hot-wire coil test method – Apparatus, verification, test method and guidance

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 13.220.40, 29.020

ISBN 978-2-8322-9707-0

Warning! Make sure that you obtained this publication from an authorized distributor.

® Registered trademark of the International Electrotechnical Commission

CONTENTS

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

FIRE HAZARD TESTING –

Part 2-20: Glowing/hot wire based test methods – Hot-wire coil test method – Apparatus, verification, test method and guidance

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.

2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.

3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.

4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.

5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.

6) All users should ensure that they have the latest edition of this publication.

7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.

8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

IEC TS 60695-2-20 has been prepared by IEC technical committee 89: Fire hazard testing. It is a Technical Specification.

This third edition of IEC TS 60695-2-20 replaces the second edition of IEC TS 60695-2-20 published in 2004. This edition constitutes a technical revision.

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

– Contents page added
– Updated Scope (Clause 1)
– Updated Terms and Definitions, added new relevant terms (Clause 3)
– Updated Principle (Clause 4)

– Updated Apparatus (Clause 5; recommendation to change the power source from a.c. to d.c. with a constant current output. Reason for this recommendation: D.c. technology is easier to obtain and to handle, which has been found to improve the Repeatability and Reproducibility of the test.
– Updated Test specimen dimensions (6.2)
– Revised Test procedure (Clause 8)
– Revised Observations and measurements (Clause 9)
– Revised Evaluation of test results (Clause 10)
– Revised Test report (Clause 11)
– Revised Annex A: Deletion of conformational test; Guidance on verification of the heater wire winding before testing
– Addition of normative Annex B: HWCT PLC Classes
– Addition of informative Annex C: Calibration curve to determine test current (I_c) in a spreadsheet program
– Addition of informative Annex D: Precision data

The text of this Technical Specification is based on the following documents:

DTS	Report on voting
89/1465/DTS	89/1488/RVDTS

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 Technical Specification 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 and ISO/IEC Guide 51.

Part 2 of IEC 60695 consists of the following parts:

Part 2-10: *Glowing/hot-wire based test methods – Glow-wire apparatus and common test procedure*

Part 2-11: *Glowing/hot-wire based test methods – Glow-wire flammability test method for end products*

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

Part 2-13: *Glowing/hot-wire based test methods – Glow-wire ignition temperature (GWIT) test method for materials*

Part 2-20: *Glowing/hot-wire based test methods – Hot-wire coil test method – Apparatus, verification, test method and guidance*

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

Words **in bold** in the text are defined in Clause 3.

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under 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 document 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.

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

INTRODUCTION

In the design of any electrotechnical product, the risk of **abnormal heat** and the potential hazards associated with **abnormal heat** 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 during normal operating conditions, reasonably foreseeable abnormal use, malfunction and/or failure. IEC/TC 89 has developed IEC 60695-1-10 [1][1], together with its companion IEC 60695-1-11 [2], to provide guidance on how this is to be accomplished.

The primary aims of IEC 60695-1-10 [1] and IEC 60695-1-11 [2] are to provide guidance on how:

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

Secondary aims of IEC 60695-1-10 [1] and IEC 60695-1-11 [2] 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.

This test method applies to solid electrical insulating materials which can provide test specimens. It applies to materials for which the test specimen does not deform during preparation, especially during the winding of the test specimen with the heater wire as described in 5.5.

Examples of deformation that render this test method inapplicable include:

a) bowing, in either a transverse or a longitudinal direction, or twisting of the test specimen during the winding of the test specimen with the heater wire, to a degree visible to the eye, or
b) visible indentation of the test specimen by the heater wire.

An informative classification system described in Annex B can be used for the **preselection** of materials.

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

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

FIRE HAZARD TESTING –

Part 2-20: Glowing/hot wire based test methods – Hot-wire coil test method – Apparatus, verification, test method and guidance

1 Scope

This part of IEC 60695, which is a technical specification, describes a test method that applies to solid electrical insulating materials of which test specimens can be provided. The test measures the time required to ignite a test specimen when it is affected by heat from an electrically heated wire wound around the test specimen. If the test specimen drips, the time at which this occurs is also recorded.

The test method can be used to provide classifications which can be used for quality assurance, the **preselection** of materials of products as described in IEC 60695-1-30, or to verify the required minimum classification of materials used in **end products**.

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.

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

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

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

IEC GUIDE 104:2019, *The preparation of safety publications and the use of basic safety publications and group safety publications*

ISO/IEC Guide 51:2014, *Safety aspects – Guidelines for their inclusion in standards*

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

ISO 293, *Plastics – Compression moulding 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 13943:2008, *Fire safety - Vocabulary*

ISO 16012:2004, *Plastics – Determination of linear dimensions of test specimens*

JIS C 2520:1999, *Wires and rolled wires for electrical heating*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13943:2017, some of which are reproduced below for the user's convenience, as well as 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
abnormal heat
<electrotechnical> heat that is additional to that resulting from use under normal conditions, up to and including that which causes a fire

[SOURCE: ISO 13943:2017, definition 3.1]

3.2
classification time, t_A
arithmetic mean of relevant **times to ignite, IT** and **times to drip, DT**, used for the purpose of classification

3.3
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 13943:2017, definition 3.55]

3.4
draught-free environment
space in which the results of experiments are not significantly affected by the local air speed

Note 1 to entry: A qualitative example is a space in which a wax candle flame remains essentially undisturbed. Quantitative examples are small-scale fire tests in which a maximum air speed of 0,1 $m \cdot s^{-1}$ or 0,2 $m \cdot s^{-1}$ is sometimes specified

[SOURCE: ISO 13943:2017, definition 3.83]

3.5
end product
product which is ready for use

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

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

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

3.6
fire effluent
all gases and aerosols, including suspended particles, created by **combustion** or pyrolysis and emitted to the environment

[SOURCE: ISO 13943:2017, definition 3.123]

3.7
fire hazard
potential for harm associated with fire

Note 1 to entry: Alternatively, **fire hazard** can be a physical object or condition with a potential for an undesirable consequence from fire.

[SOURCE: ISO 13943:2017, definition 3.131]

3.8
ignitability
ease of ignition
measure of the ease with which a test specimen can be ignited, under specified conditions

Note 1 to entry: Modified, notes to entry have been deleted

[SOURCE: ISO 13943:2017, definition 3.212]

3.9
ignition
sustained **ignition** (deprecated)
<general> initiation of **combustion**

[SOURCE: ISO 13943:2017, definition 3.217]

3.10
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 13943:2017, definition 3.275]

3.11
preselection
process of assessing and choosing candidate materials, components or sub-assemblies for making an **end product**

[SOURCE: IEC 60695-1-30, definition 3.5]

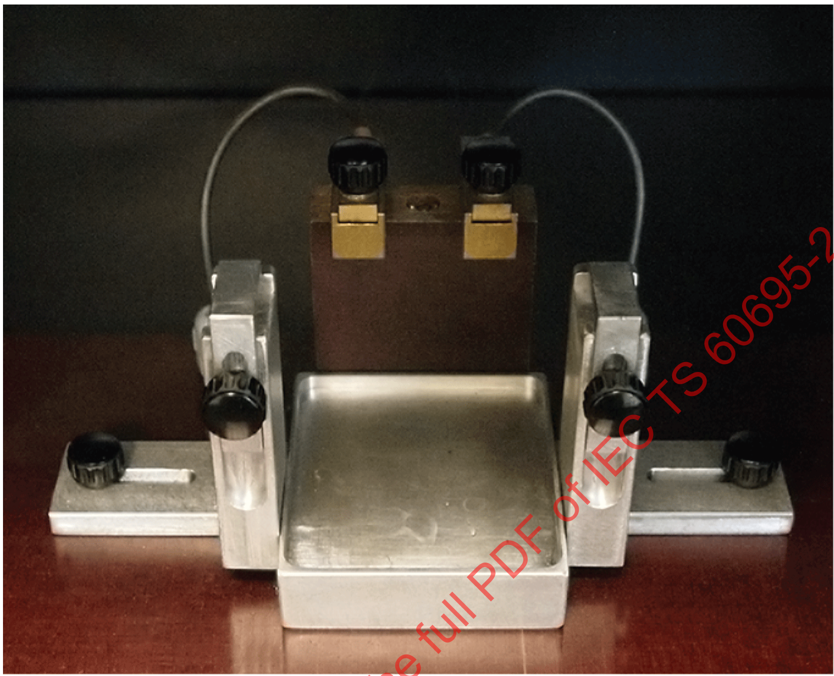
3.12
time to drip, *DT*
time elapsed after the start of a test when **molten drips** are first observed to fall from the test specimen

3.13
time to ignite, *IT*
time elapsed after the start of a test when **ignition** of the test specimen is observed to occur

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

4 Principle

A rectangular bar-shaped test specimen is supported horizontally on a test fixture (an example of a test fixture is shown in Figure 1 and Figure 3). The centre portion is wound with a coil of heater wire as shown in Figure 2. A constant current is applied to the coil, which rapidly heats up and the behaviour of the test specimen is observed. The **time to ignite,** IT and/or the **time to drip,** DT shall be recorded.

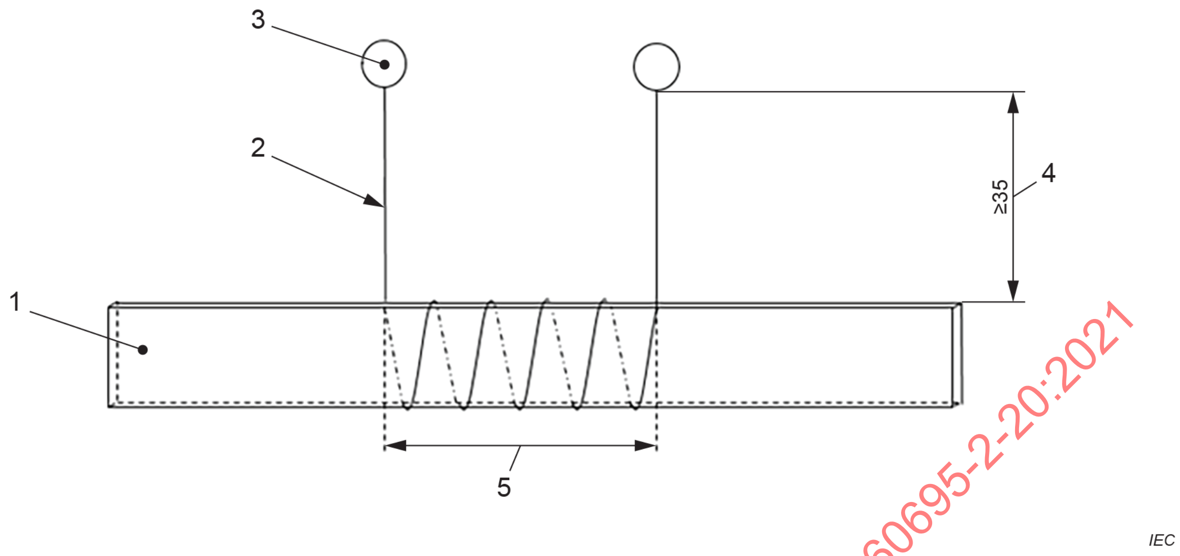


IEC

Figure 1 – Test fixture arrangement (example)

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

Dimension in millimetres



Key

1 Test specimen
2 Heater wire
3 Electrical connection point
4 Distance to electrical connection points
5 Distance between all 5 windings (31,5 – 32,0 mm)

Figure 2 – Test specimen winding pattern

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

5 Apparatus

5.1 Test chamber

The laboratory fume hood/chamber shall have an inside volume of at least 0,5 m^3. The chamber shall provide a **draught-free environment** whilst allowing normal thermal circulation of air past the test specimen. The chamber shall permit observation of the test in progress. The inside surfaces of the walls shall be a dark colour. The test chamber shall have an ambient light level not exceeding 20 lux. For safety and convenience, it is desirable that this enclosure (which can be completely closed) is fitted with an extraction device, such as an exhaust fan, to remove the **fire effluent** which may be toxic. The extraction device, if fitted, shall be turned off during the test and turned on immediately after the test. A positive closing damper may be needed.

5.2 Heater wire

The heater wire shall be a Nickel/Chromium wire (NCHW1 according to JIS C 2520), having a nominal composition of > 77 % Ni and 20 ± 1 % Cr, having a nominal diameter of 0,5 ± 0,016 mm and a length of 260 mm (+ 10 mm, – 0 mm).

NOTE 1 NiCr (> 77 % Ni / 20 ± 1 % Cr) heater wire has a nominal cold resistivity of (1,08 ± 0,05) × 10^{-6} Ω·m.

NOTE 2 NCHW1 according to JIS C 2520 is also known as NiCr8020 according to DIN 17470 Werkstoffnummer 2.4869.

NOTE 3 The length of wire may need to be adapted as follows: 280 mm (+10 mm, -0 mm) for specimens with thicknesses between >3 mm and ≤8 mm; and 350 mm (+10 mm, -0 mm) for specimens with thicknesses between >8 mm and ≤13 mm.

5.3 Power supply and test circuit

A constant current DC power supply which can provide a constant current of at least 8 A and a power of at least 150 W shall be used to energize the heater wire. The supply circuit shall have the following capabilities.

a) There shall be a means of measuring the test circuit current to within an accuracy of ± 0,2 %;

b) All electrical connections for the heater wire shall be capable of transmitting the test current without significant loss and shall not mechanically affect the test specimen during the test.

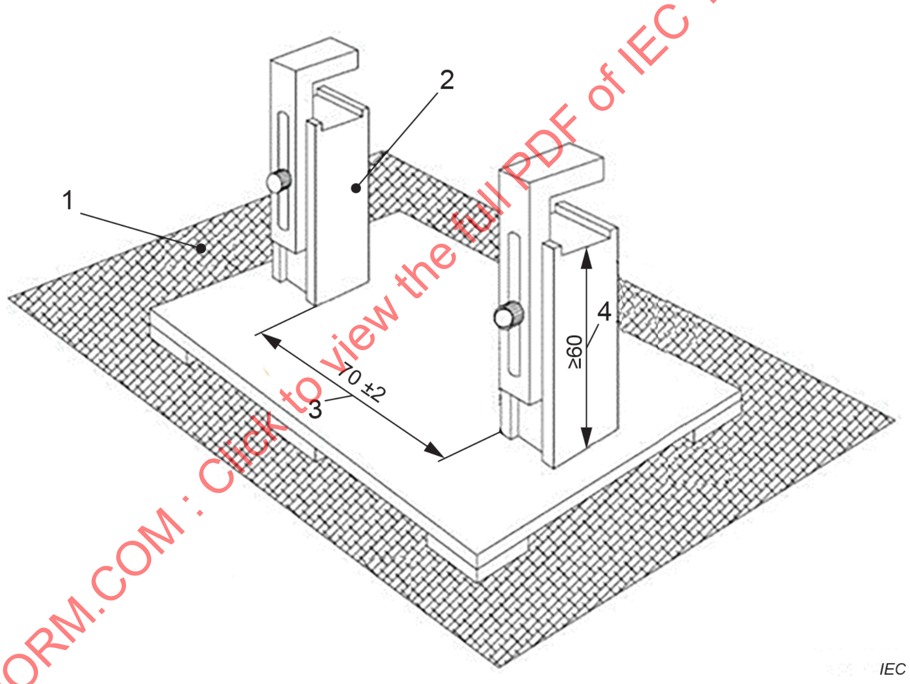
The test circuit shall be provided with an on-off switch for cutting off the test circuit current (for safety reasons).

NOTE An AC power supply is also suitable to drive the set constant current.

5.4 Test specimen fixture

An example of a test specimen fixture is shown in Figure 3. Two supporting posts positioned 70 mm ± 2 mm apart shall be provided with hold-down clamps to support the test specimen in a horizontal and flat position.

Dimensions in millimetres



Key

1 Chamber surface

2 Test specimen fixture

3 Distance between the two supporting posts

4 Distance between the top and bottom of the supporting post

Figure 3 – Test specimen fixture (example)

5.5 Test specimen winding and pressing

The heater wire shall be wound around the test specimen centred along the longitudinal axis of the specimen by hand or by using a winding device.

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

Five windings shall be applied using a force of 5,4 ± 0,02 N, equally distributed, with a pitch of 6,35 ± 0,05 mm. In practice the 5 windings on the test specimen shall be evenly spread over the test specimen which shall result in a distance of between 31,5 mm and 32,0 mm as shown in Figure 2. An example of a winding device is shown in Figure 4.

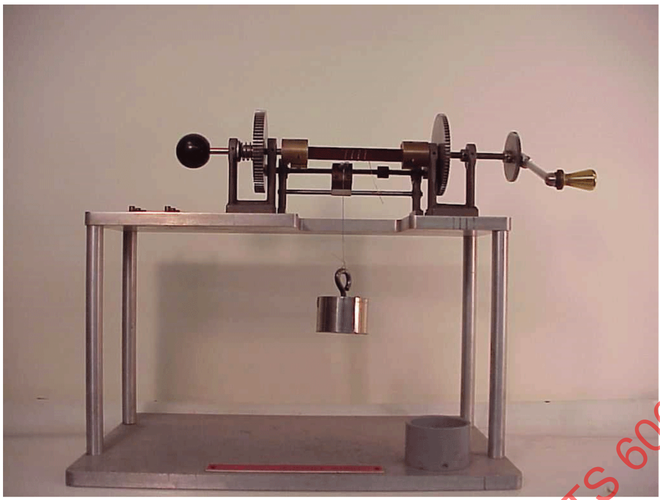


Figure 4 – Heater wire winding device (Example)

If winding by hand is done, mark the test bar in the following way.

Assuming a test bar of 125 mm in length is used and knowing that the distance between the 5 windings should be between 31,5 mm and 32 mm, the first winding shall start at: (125-31,5)/2 mm from one end of the test bar.

NOTE 1 Thin specimens can be wound by supporting the specimen on one side with a steel bar which has the same size as the test specimen and a thickness at which the steel does not bend. The steel bar needs to be removed prior to the test, taking care to ensure that the spacing of the windings on the specimen are not affected. When the specimen is pliable and susceptible to indentation, the steel bar can also be used on both sides of the test specimen.

Deformation of the test specimens during preparation is to be kept to an absolute minimum.

Examples of deformation are:

– bowing, in either transverse or longitudinal directions, or twisting during the winding process to a degree visible to the eye, or
– visible indentation of the wound wire into the edges of the test specimen.

The wound part of the wire should be in good contact with the test specimen.

This is achieved by pressing the wound test specimen between two stiff surfaces; pressing them together with enough force sufficient to flatten the wire on to the test specimen surface.

NOTE 2 It has been found useful to use boards made of pinewood that are flat and smooth and having a minimum thickness of 10 mm, and to apply a pressing force of approximately 150 N.

NOTE 3 See informative Annex A for guidance on properly wound test specimen.

5.6 Conditioning chamber

The conditioning chamber shall be maintained at 23 °C ± 2 °C at a relative humidity of 50 % ± 10 %.

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

5.7 Timing device

The timing device shall have a resolution of 0,5 s or less.

5.8 Micrometer

The micrometer shall have a resolution of

a) 0,01 mm or less for test specimens with a thickness of 0,25 mm or greater; and
b) 0,001 mm or less for test specimens with a thickness less than 0,250 mm.

5.9 Measuring scale

The measuring scale shall be graduated in millimetres.

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

6 Test specimens

6.1 Test specimen preparation

10 test specimens shall be prepared.

When tests are carried out on materials for **preselection** purposes, they shall be conducted on uncoloured test specimens or on normally supplied coloured test specimens.

Test specimens shall be cut from a representative test specimen of the material (sheets or **end products**) or shall be cast or injection moulded in accordance with ISO 294, compression moulded in accordance with ISO 293 or ISO 295 or transfer moulded to the necessary shape.

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

6.2 Test specimen dimensions

This test method applies to moulded or sheet materials available in nominal thicknesses of up to and including 13 mm.

Test specimens shall be 125 mm ± 5 mm long by 13,0 mm ± 0,5 mm wide.

The preferred thicknesses for **preselection** purposes include 0,4 mm, 0,75 mm, 1,5 mm and 3,0 mm. Other thicknesses may be used by agreement between the interested parties and if so, shall be noted in the test report.

NOTE 1 Some materials can be tested at lower thicknesses, depending on the rigidity of the test specimens. As long as the test specimens do not deform during winding, the test method is applicable.

NOTE 2 The maximum thickness is not to exceed 3,0 mm, when using the nominal 260 mm length of wire. For specimens with thicknesses between > 3 mm and ≤ 8 mm the length of the wire may need to be adapted to 280 mm, and for specimens with thicknesses between > 8 mm and 13 mm the length of the wire may need to be adapted to 350 mm.

Thickness measurements are to be taken at the approximate center of the test specimen.

When test specimens are taken from **end products**, three measurements along that part of the test specimen which is wound with heater wire, are to be taken. The arithmetic mean of the three measured values is to be taken as the value of the thickness of the test specimen.

For rigid test specimens, thickness measurements shall be performed in accordance with ISO 16012 as follows. Using a ratchet micrometer, close the micrometer at such a rate that the change in reading on the scale or digital display can be easily followed. Continue the closing motion until the ratchet clicks three times, the friction thimble slips, or the two contact surfaces can be felt to be in full contact with the test specimen. Record the indicated reading. For flexible, non-rigid, or elastic test specimens, a dial gauge micrometer may be used. The closing motion shall be stopped when the pressure foot just contacts the test specimen.

NOTE 3 Other measuring devices equivalent to a micrometer may be used to measure thickness if found to be satisfactory.

In order for test specimens to accurately represent a nominal thickness, the thickness shall meet the tolerances given in Table 1.

Table 1 – Nominal thickness tolerances

Thickness x Mm	**Tolerance** mm
< 0,02	± 10%
0,02 ≤ x < 0,05	± 0,005
0,05 ≤ x < 0,1	± 0,01
0,1 ≤ x < 0,2	± 0,02
0,2 ≤ x < 0,3	± 0,03
0,3 ≤ x < 0,5	± 0,04
0,5 ≤ x < 0,6	± 0,05
0,6 ≤ x < 3,0	± 0,15
3,0 ≤ x < 6,0	± 0,25
6,0 ≤ x < 13,0	± 0,40
NOTE For example, to represent a thickness of 1,5 mm, all tested specimens should measure between 1,35 mm and 1,65 mm.	

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

7 Conditioning

7.1 Requirements

Unless otherwise required by the relevant material specifications, the following requirements shall apply.

7.2 Test specimen conditioning

10 test specimens shall be placed in a conditioning chamber for a minimum of 48 h at 23 °C ± 2 °C at a relative humidity of 50 % ± 10 % (see ISO 291:2008, Clause 6, Table 2, Class 2).

7.3 Heater wire conditioning

10 pieces of un-annealed heater wires to be used for testing shall be placed in a conditioning chamber for a minimum of 48 h at 23 °C ± 2 °C at a relative humidity of 50 % ± 10 % (see ISO 291:2008, Clause 6, Table 2, Class 2).

7.4 Test conditions

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

8 Test procedure

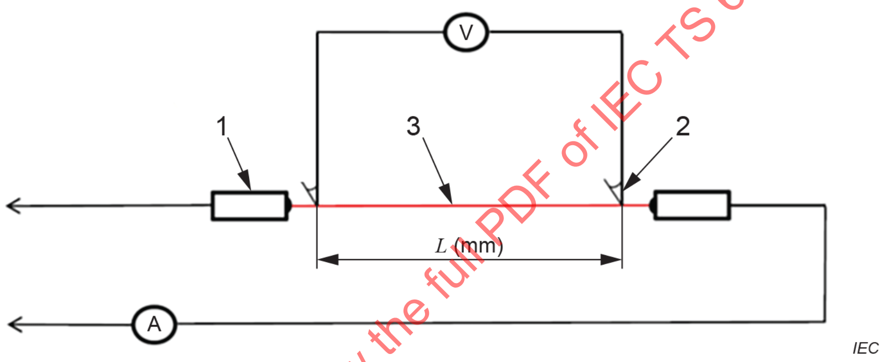
8.1 General

Due to normal variations in metal alloys, it is essential that each spool of heater wire be verified with respect to its energized resistance according to the following procedure. A mathematical relationship exists between current and power dissipation, based on performance under the verification procedure. Essentially, the voltage across a known length of wire is measured over a range of current values to establish the power-current relationship used to calculate the test current, I_c.

NOTE It has been found that the variation of electrical resistance within a given spool is not significant. However, it is recommended to perform the verification of the wire after a long period of non-use, or once a year. This procedure should be performed in a **draught-free environment**.

8.2 Apparatus

A current supply shall be provided as described in 5.3 with a means to measure current. A voltmeter shall be provided to measure the voltage using small probes as shown in Figure 5.



Key

1 Current connection point

2 Voltage measuring probes

3 Test wire

Figure 5 – Test circuit arrangement for heater wire calibration

8.3 Determination of the test current, I_c

Use a 260 mm long piece of heater wire. Mark it at 5 mm and 10 mm from each end. Connect the heater wire to the current supply in such a way that 5 mm of wire is inserted, resulting in 250 mm wire in the circuit. Attach the small voltage-measuring probes to the heater wire at the 10 mm marks at each end, to measure the voltage to within ± 2 %, as shown in Figure 5. Measure and record the length L of the wire between the voltage probes to an accuracy of ± 1 mm. The length of the wire between the voltage probes should be 240 mm.

NOTE 1 In Figure 5 the heater wire is straightened but it can also be inserted in a horse shoe shaped loop.

NOTE 2 When specimens with thicknesses > 3 mm and ≤ 8 mm are to be tested, calibration needs to be performed by using 280 mm of wire. When specimens with thickness > 8 mm and ≤ 13 mm are to be tested, calibration needs to be performed by using 350 mm of wire.

Apply current levels in increments of 1 A, starting from 1 A up to 8 A ± 1 %. Maintain the current for a minimum of 10 s to achieve thermal equilibrium and record the current and voltage at each level.

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

8.4 Calculation of test current, I_c

For each measurement, calculate the linear power density as follows:

$$W = E * I / L$$

where:

W = linear power density, W/mm

E = measured voltage, V

I = measured current, A

L = measured length between voltage probes, mm

Construct a calibration curve of current as a function of linear power density. The desired test current I_c for the individual heater wire obtained from the calibration curve shown in Figure 6, is that which corresponds to 0,26 W/mm ± 0,01 W/mm. Annex C describes how to determine the test current I_c in using a spreadsheet program.

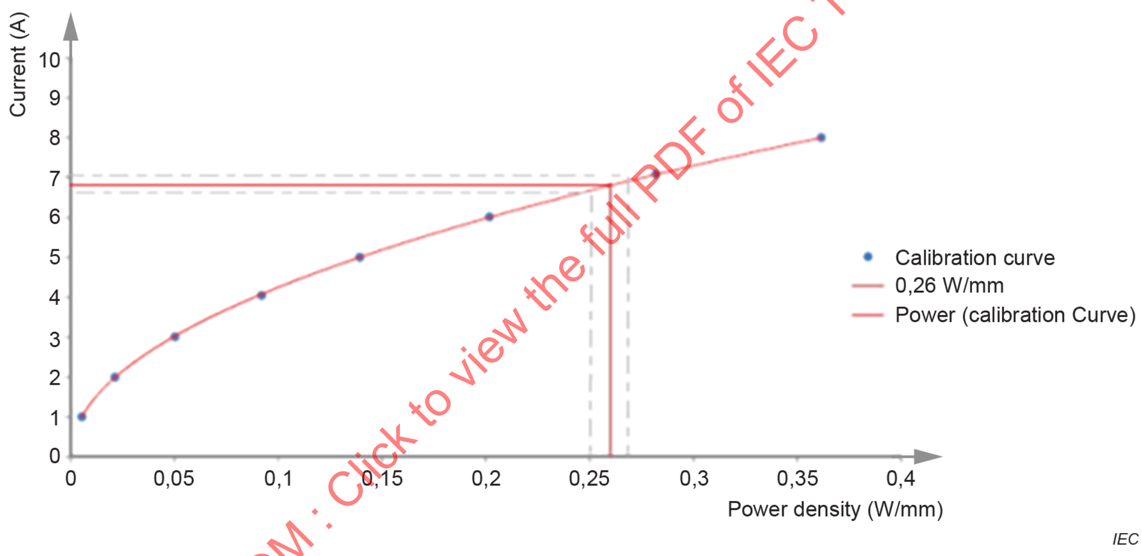


Figure 6 – Calibration curve

8.5 Determination of time to ignite, *IT* and/or time to drip, *DT*

All test specimens shall be tested within 3 h of removal from the conditioning chamber.

Wind the center portion of the test specimen with a heater wire according to 5.5.

Preset the power supply at the level that will yield the test current I_c by using a fresh NiCr wire of 260 mm, 280 mm or 350 mm, depending on the thickness of the test specimen.

NOTE 1 To avoid any influence on the test current, a fresh piece of heater wire is used to preset the power supply to the test current.

This will yield a linear power density of 0,26 W/mm ± 0,01 W/mm. Remove this piece of wire once the power supply has been set to the test current I_c.

Clamp the wound test specimen onto the test fixture. The test specimen shall be supported at least 60 mm above and in the approximate centre of the bottom of the chamber as shown in

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

Figure 3. Connect the free ends of the heater wire to the test circuit in such a way that the distance between the test specimen and the electrical connections is as shown in Figure 2 while maintaining the winding angle from the plane perpendicular to the test specimen. Depending on the thickness of the test specimen it might be necessary to cut the wire at both ends in order to maintain a distance of 35 mm to the electrical connection points.

The free ends of the wound test specimen may be pushed towards the electrical connection points but the angle of the windings must stay in the same angle over the surface of the test specimen.

Energize the circuit and immediately start the timing device.

NOTE 2 It is preferable to integrate the timing device in the test circuit so that it starts at the same moment the circuit has been energized.

If **ignition** of the test specimen occurs, record the **time to ignite,** ***IT*** and switch off the power. If a specimen drips, record this **time to drip,** ***DT*** as well. The test shall be continued until **ignition** of the test specimen is observed but, if **ignition** does not occur, for up to but no longer than 120 s.

A minimum sample set of five specimens shall be tested. Depending on the results of this first set of five specimens a second set of five specimens may need to be tested. See Figure 7 (decision tree).

If the individual **times to ignite,** ***IT*** and/or **times to drip,** ***DT*** in the first set of 5 test specimens are more than 2 adjacent Performance Level Categories (PLC classes, see Annex B) apart, then a second set of five specimens shall be tested. If the individual test results of the first 5 test specimens are within 2 adjacent PLC classes, then a second set is not needed to be tested.

If in a first set of 5 test specimens, only one test specimen ignites then a second set shall be tested. If within the second set another **time to ignite,** ***IT*** or **time to drip,** ***DT*** is recorded, the **times to ignite,** ***IT*** and/or **times to drip,** ***DT*** from both sets shall be used to calculate the **classification time,** t_A. However, if within the second set all 5 test specimens do not ignite nor show any dripping, then a PLC 0 shall be assigned. If within the second set of 5 specimens any **time to drip,** ***DT*** was recorded, then a PLC D-0 shall be assigned.

If in the first set of 5 test specimens, all 5 test specimens drip without **ignition**, a PLC class D-0 shall be assigned.

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

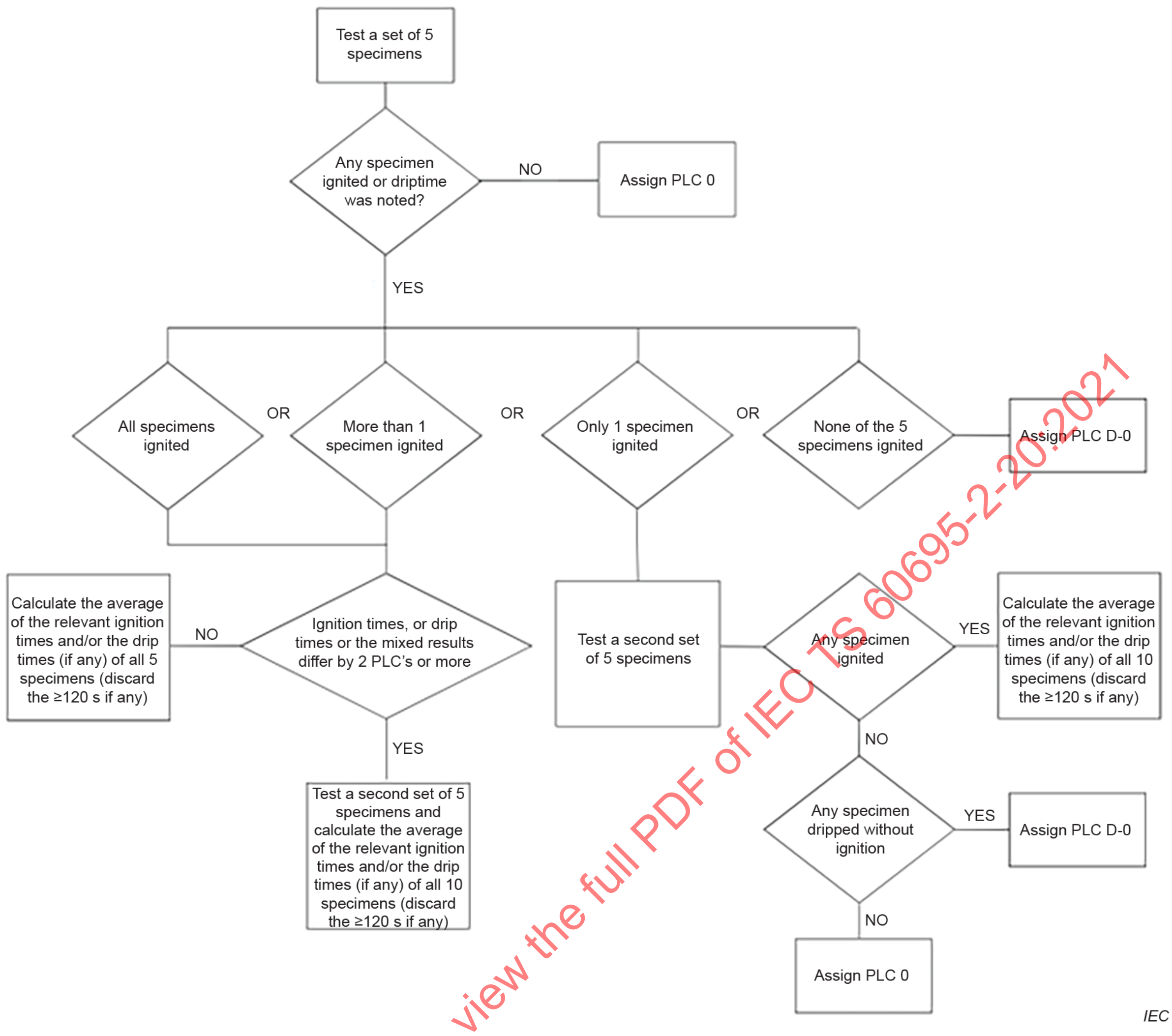


Figure 7 – Decision tree

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

NOTE Besides this Technical Specification, also another document will be published (INF document) in which a second decision tree and a second evaluation method is added. This describes a method in which dripping is not part of the classification of the material. The INF document shall serve as a guide when work on the Edition 4 will start.

9 Observations and measurement

For each individual test specimen, the following data shall be recorded:

a) a test specimen that neither drips nor ignites within 120 seconds shall be recorded as having a **time to ignite,** ***IT*** of > 120 s.

b) the **time to ignite,** ***IT*** shall be recorded if the test specimen ignites within 120 s.

c) the **time to drip,** ***DT*** shall be recorded only in the following cases:

- Dripping is observed before specimen **ignition**;
- Dripping is observed at the same time of specimen **ignition**;
- Dripping is observed without specimen **ignition,** before test conclusion.

Time to drip, ***DT*** is not recorded if dripping is observed after the **ignition** of the specimen.

For the purposes of classification, if all tests in a set of five give an ***IT*** > 120 s result, then t_A is assigned a "> 120 s" value.

Otherwise, the following data shall be used to calculate the **classification time,** t_A.

a) the **time to ignite**, IT; or

b) the **time to drip**, DT, if the test specimen does not ignite.

10 Evaluation of test results

10.1 Assigning a HWCT PLC classification

If none of the 5 test specimens in the first set ignite within 120 seconds and also do not show any dripping (all 5 specimens have been recorded as IT > 120 s and DT > 120 s), then a PLC 0 shall be assigned.

All other classifications shall be based upon the average of the relevant **times to ignite,** IT and/or **times to drip,** DT. Discard any samples that do not ignite without showing any dripping, so discard any result which is recorded as IT > 120 s.

The **classification time,** t_A, shall be calculated as follows:

a) If only a first set of five specimens was needed to complete the test and all 5 specimens ignited or dripped without **ignition**, without differing by two PLCs or more, the average of all the relevant **times to ignite,** IT and/or **times to drip,** DT (see 8.5 and Clause 9) shall be used to generate a calculated average. Based on this average a PLC shall be assigned (see Annex B).

b) If a second set of five specimens has been tested, based upon the fact that the results of the first set differed by two PLCs or more or because in the first set only one specimen ignited, the average of the relevant **times to ignite,** IT and/or **times to drip,** DT of all ten specimens shall be used to generate the **classification time,** t_A, but with the exclusion of any IT > 120 s results.

10.2 Precision data

Precision data for this test method were collected in a preliminary inter-laboratory trial. The results of these tests are summarized in Annex D.

11 Test report

The test report shall include the following information:

a) a reference to this Technical Specification;

b) all information necessary to identify the material tested, including the manufacturer's name, and type and colour of the material;

c) a description of the method used for the preparation of the test specimens (see 6.1);

d) the thickness of the test specimens (see 6.2);

e) the conditioning of the test specimens (see 7.2);

f) the results of tests (see Clause 9);

g) any deviation from specified conditions; and

h) the HWCT PLC Class found according to normative Annex B.

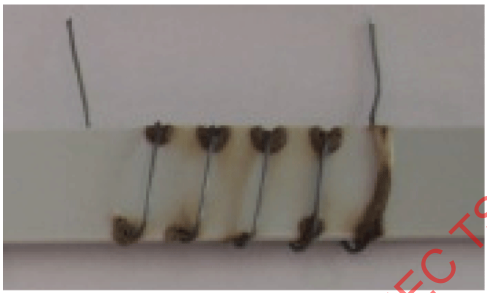
IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

Annex A
(informative)

Guidance on how to effectively wind the heater wire on to the test specimen

During the hot wire test, the following phenomena can occur:

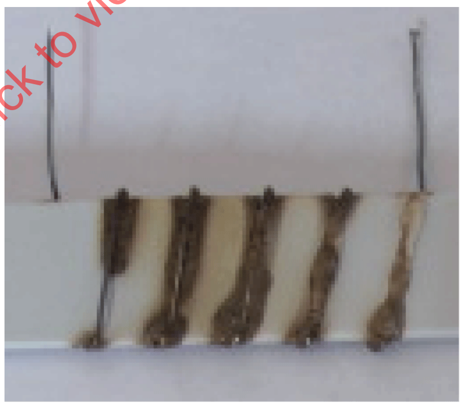
a) Thermal damage is observed only at the edges of a test specimen (see Figure A.1). This tends to occur when the heater wire is only in close contact at the edges. Laboratory experience has shown that for some materials such wire winding can cause wide variation in test results.



IEC

Figure A.1 – Illustration of type a) behaviour

b) Thermal damage is observed across the surface area of a test specimen (see Figure A.2). This tends to occur when the heater wire is in close contact across the surface of the test specimen. Such winding is achieved by pressing the wound test specimen (see 5.5). Laboratory experience has shown that for many materials such pressed winding can cause a reduced variation in test results.



IEC

Figure A.2 – Illustration of type b) behaviour

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

Annex B
(normative)

Hot wire coil test (HWCT) – Performance level category (PLC) classes

B.1 General

For a given material, a class shall be assigned based on the average of relevant **times to ignite,** ***IT*** and/or **times to drip,** ***DT*** (as determined in 8.5 and Clause 9) in accordance with the ranges specified in Table B.1.

Table B.1 – Hot wire coil test (HWCT) – Performance level category (PLC) classes

Time interval / s	HWCT PLC Classes
IT > 120 and DT >120	0
IT > 120 and DT ≤ 120	D-0
t_A = 60 – 120	1
t_A = 30 – 59	2
t_A = 15 – 29	3
t_A = 7 – 14	4
t_A = 0 – 6	5

B.2 Reporting a classification

The performance of a given material shall be reported using a class in the following manner.

For example, for a set of 10 test specimens in the 3,0 mm thickness with a **classification time**, $\boldsymbol{t_A}$, of 76 s and a PLC class 1:

IEC TS 60695-2-20: HWCT: 1/3,0

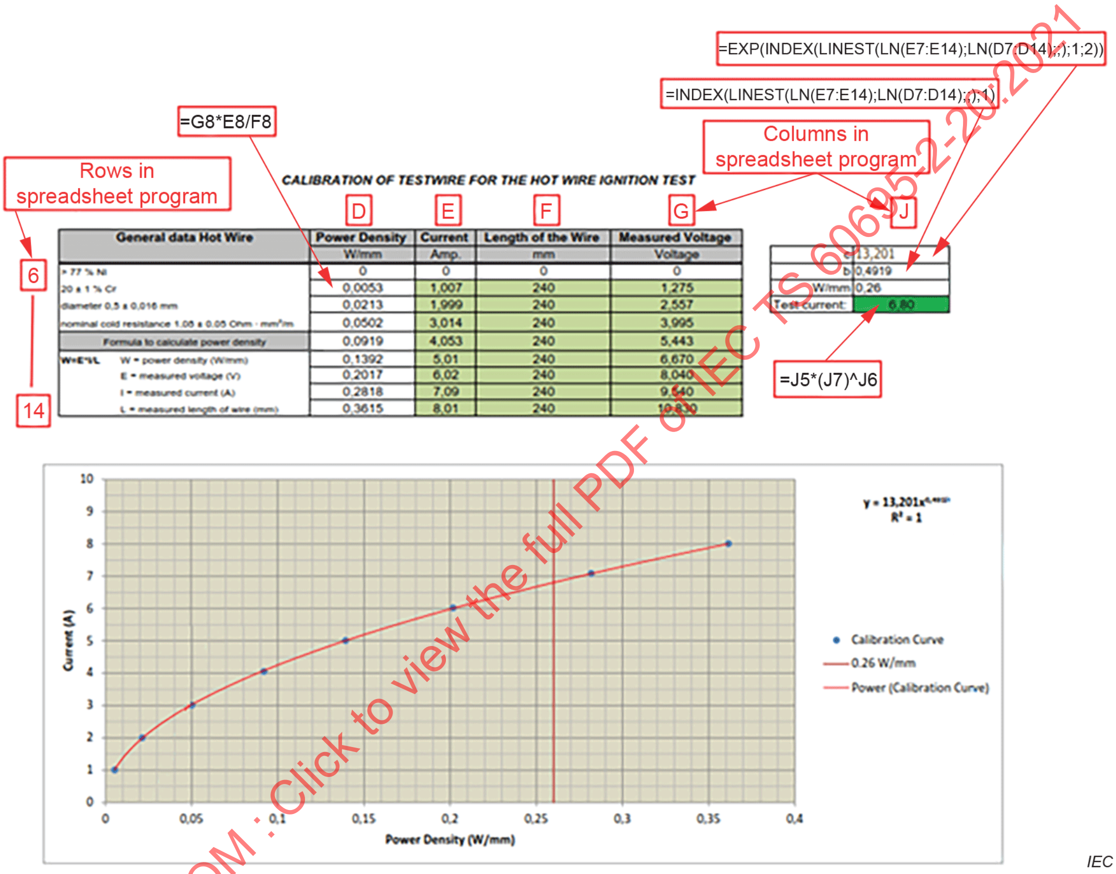
IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

Annex C
(informative)

Calibration curve to determine test current (I_c) in a spreadsheet program

The determination of I_c can be difficult using only the formula as given in 8.4. Using a spreadsheet program has been found useful.

Figure C.1 gives an example and explanation on how to calculate I_c in a spreadsheet program.



General data Hot Wire	Power Density W/mm	Current Amp.	Length of the Wire mm	Measured Voltage Voltage
> 77 % Ni	0	0	0	0
20 ± 1 % Cr	0,0053	1,007	240	1,275
diameter 0,5 ± 0,016 mm	0,0213	1,999	240	2,557
nominal cold resistance 1,08 ± 0,05 Ohm · mm²/m	0,0502	3,014	240	3,995
Formula to calculate power density	0,0919	4,053	240	5,443
W=E*I/L　W = power density (W/mm)	0,1392	5,01	240	6,670
E = measured voltage (V)	0,2017	6,02	240	8,040
I = measured current (A)	0,2818	7,09	240	9,640
L = measured length of wire (mm)	0,3615	8,01	240	10,830

c	13,201
b	0,4919
W/mm	0,26
Test current:	6,80

IEC

Figure C.1 – Calibration curve in a spreadsheet program used to determine I_c

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021

Annex D
(informative)

Precision data

D.1 General

A preliminary inter-laboratory round robin has been conducted by four different international laboratories, using four different materials, where, materials 1 and 2 have been tested in two different thicknesses. The tests were conducted by the different laboratories using their own heater wire.

Materials used:

- Material 1A: PA 6 Glass filled, Flame Retardant, 0,75 mm
- Material 1B: PA 6 Glass filled, Flame Retardant, 1,5 mm
- Material 2A: PA 6 Glass filled, Flame Retardant, 0,75 mm
- Material 2B: PA 6 Glass filled, Flame Retardant, 1,5 mm
- Material 3: PA 6 Glass filled, Flame Retardant, 1,5 mm
- Material 4: PBT Glass filled, Flame Retardant, 0,75 mm

In order to gain more statistics, 10 test specimens per sample were tested by two different technicians.

Results can be found in Clause D.2.

D.2 Results of preliminary inter-laboratory round robin

The results of the round robin are presented in Table D.1 to Table D.6.

NOTE Highlighted data were used to calculate t_A values.

IECNORM.COM : Click to view the full PDF of IEC TS 60695-2-20:2021