

TECHNICAL SPECIFICATION



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

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INTERNATIONAL
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CONTENTS

FOREWORD.....	4
INTRODUCTION.....	2
1 Scope.....	8
2 Normative references	8
3 Terms and definitions	9
4 Principle.....	11
5 Apparatus.....	12
5.1 Test chamber.....	12
5.2 Heater wire	12
5.3 Power supply and test circuit	13
5.4 Test specimen fixture.....	13
5.5 Test specimen winding and pressing.....	13
5.6 Conditioning chamber	15
5.7 Timing device	15
5.8 Micrometer.....	15
5.9 Measuring scale.....	15
6 Test specimens	15
6.1 Test specimen preparation.....	15
6.2 Test specimen dimensions.....	15
7 Conditioning	17
7.1 Requirements	17
7.2 Test specimen conditioning.....	17
7.3 Heater wire conditioning	17
7.4 Test conditions	17
8 Test procedure	17
8.1 Verification of the heater wire	17
8.1.1 General	17
8.1.2 Apparatus Test circuit for the verification.....	17
8.1.3 Determination of the test current, I_C	18
8.1.4 Calculation of test current, I_C	19
8.2 Determination of time to ignite, IT	20
9 Observations and measurement	23
10 Evaluation of test results – Assigning an HWI PLC classification	24
11 Test report.....	24
Annex A (informative) Guidance on how to effectively wind the heater wire on to the test specimen	25
Annex B (normative) Hot Wire coil Ignition test (HWCT HWI) – Performance level category (PLC) classes.....	26
B.1 General.....	26
B.2 Reporting a classification.....	26
Annex C (informative) Calibration curve to determine test current (I_C) in a spreadsheet program.....	27
Annex D (informative) Precision data	27
D.1 General.....	27
D.2 Results of preliminary inter-laboratory round robin.....	27

D.3 — Evaluation of test results	
Bibliography.....	33
Figure 1 – Test fixture arrangement (example).....	11
Figure 2 – Test specimen winding pattern.....	12
Figure 3 – Test specimen fixture (example).....	13
Figure 4 – Heater wire winding device (Example).....	14
Figure 5 – Test circuit arrangement for the heater wire calibration verification.....	18
Figure 6 – Heater wire marking and connection.....	19
Figure 7 – Calibration curve.....	20
Figure 8 – Decision tree.....	23
Figure A.1 – Illustration of type a) behaviour.....	25
Figure A.2 – Illustration of type b) behaviour.....	25
Figure C.1 – Calibration curve in a spreadsheet program used to determine I_C	27
Table 1 – Nominal thickness tolerances.....	16
Table 2 – Heater wire verification lengths.....	18
Table B.1 – Hot Wire coil Ignition test (HWCT HWI) – Performance level category (PLC) classes.....	26
Table D.1 – Results for material 1A.....	
Table D.2 – Results for material 1B.....	
Table D.3 – Results for material 2A.....	
Table D.4 – Results for material 2B.....	
Table D.5 – Results for material 3.....	
Table D.6 – Results for material 4.....	
Table D.7 – Occurrence of PLC classes in the round robin.....	

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FIRE HAZARD TESTING –

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

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 TS 60695-2-20:2021. 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 TS 60695-2-20 has been prepared by IEC technical committee 89: Fire hazard testing. It is a Technical Specification.

This fourth edition cancels and replaces the third edition published in 2021. This edition constitutes a technical revision.

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

- a) Removed all text which was related to drip or dripping, since in this 4th edition only ignition is taken into consideration for determination of the classification level;
- b) Title changed: "Hot wire coil test method" is now "Hot wire ignition (HWI) test method".

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

Draft	Report on voting
89/1583/DTS	89/1593/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/publications.

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 ignition test method – Apparatus, verification, test method and guidance*
- Part 2-21: *Glowing/hot-wire based test methods – Fire containment test on finished units*

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.

NOTE The following print types are used:

- Terms **in bold** in the text are defined in Clause 3.

Future documents in this series will carry the new general title as cited above. Titles of existing documents in this series will be updated at the time of the next edition.

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, or
- revised.

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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 60695-1-10 [1]¹, together with its companion IEC 60695-1-11 [2], provides 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 electrotechnical 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.

The test method provided in this document 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.

¹ Numbers in square brackets refer to the bibliography.

FIRE HAZARD TESTING –

Part 2-20: Glowing/hot wire based test methods – Hot-wire ~~coil~~ ignition (HWI) 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.~~

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 13943:20082017, *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 t_C

arithmetic mean of ~~relevant times to ignite, t_A and times to drip, t_C~~ , 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 $0,1 \text{ m}\cdot\text{s}^{-1}$ or $0,2 \text{ m}\cdot\text{s}^{-1}$ 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]

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]~~

3.8

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]~~

3.9

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~~

3.10

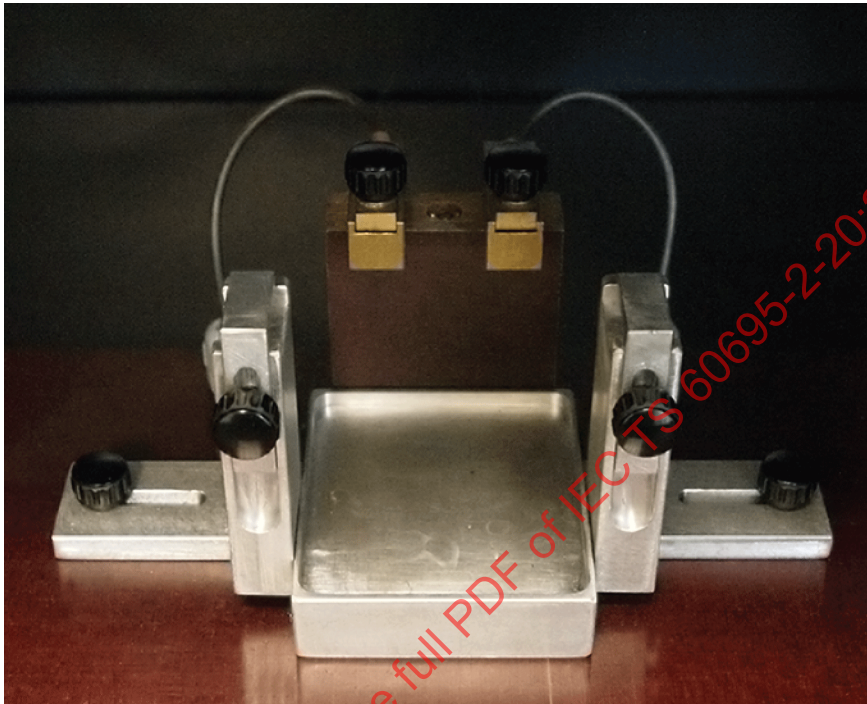
time to ignite

IT

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

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.

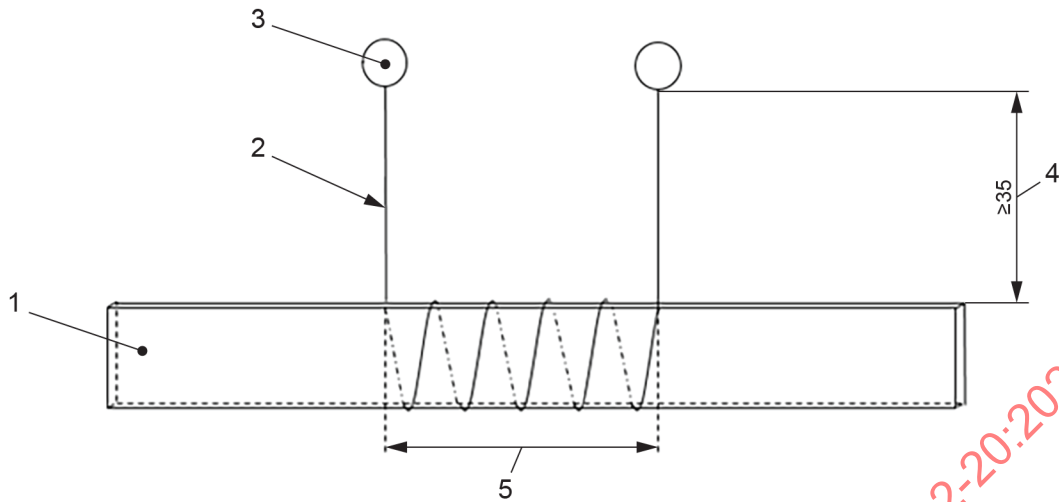


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Figure 1 – Test fixture arrangement (example)

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Dimension in millimetres



IEC

Key

- 1 Test specimen
- 2 Heater wire
- 3 Electrical connection point
- 4 Distance to electrical connection points (≥ 35 mm)
- 5 Distance between all 5 windings (31,5 to 32,0 30,5 to 32,5 mm)

Figure 2 – Test specimen winding pattern

5 Apparatus

5.1 Test chamber

The test chamber consists of a laboratory fume hood/chamber ~~shall have~~ having an inside volume of at least 0,5 m³. The test chamber shall provide a **draught-free environment** ~~whilst allowing normal thermal circulation of air past the test specimen~~. The test 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~~ test chamber (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 The Nickel/Chromium wire is also known as NCHW1 according to JIS C 2520 ~~is also known as~~ and NiCr8020 according to DIN 17470 Werkstoffnummer 2.4869, or as specified in ASTM D3874.

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.

- There shall be a means for measuring the current through the test circuit ~~current to within~~ with an accuracy of $\pm 0,2\%$;
- 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.
- A voltmeter shall be provided to measure the voltage using small probes as shown in Figure 5.

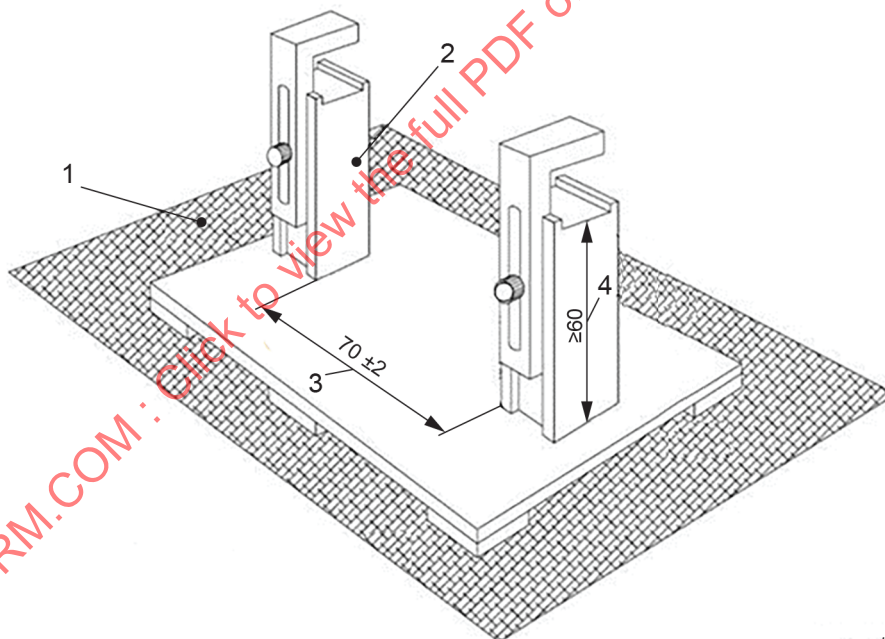
The test circuit shall be provided with an on-off switch for cutting off the test circuit current (for safety reasons).

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 $70\text{ mm} \pm 2\text{ mm}$ apart shall be provided with hold-down clamps to support the test specimen in a horizontal and flat position.

Dimensions in millimetres



IEC

Key

- Chamber surface
- Test specimen fixture
- Distance between the two supporting posts
- 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.

Five windings shall be applied using a force of $(5,40 \pm 0,02)$ N, equally distributed, with a pitch of ~~$6,35 \pm 0,05$~~ $(6,3 \pm 0,2)$ mm. In practice the five windings on the test specimen shall be evenly spread over the test specimen which shall result in a distance of between ~~31,5~~ 30,5 mm and ~~32,0~~ 32,5 mm as shown in Figure 2. An example of a winding device is shown in Figure 4.

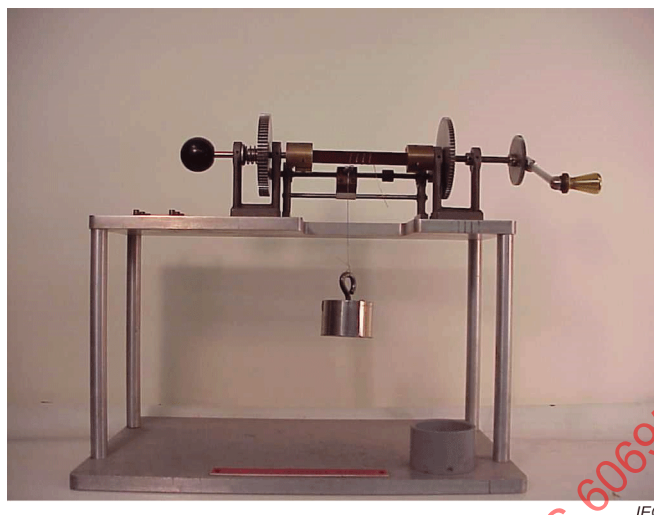


Figure 4 – Heater wire winding device (Example)

If winding is done manually, ~~mark the test bar in the following way~~ the first winding point at the test bar shall be calculated according to Formula (1) and marked on the test specimen.

$$(125,0 \text{ mm} - 30,5 \text{ mm})/2 \quad (1)$$

For a test bar of 125,0 mm in length, knowing that the total distance between the 5 windings should be between ~~31,5~~ 30,5 mm and ~~32~~ 32,5 mm, the first winding point shall start at: ~~$(125 - 31,5)/2$~~ 47,25 mm from one of the test bar ends.

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 $23\text{ °C} \pm 2\text{ °C}$ at a relative humidity of $50\% \pm 10\%$.

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.

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 $125\text{ mm} \pm 5\text{ mm}$ long by $13,0\text{ mm} \pm 0,5\text{ mm}$ 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.

Test specimens having thickness up to 3,0 mm shall be tested using the nominal 260 mm length of wire.

For test specimens having thickness more than 3,0 mm and up to 8,0 mm the length of the wire to be used shall be 280 mm.

For test specimens having thickness more than 8,0 mm and up to 13,0 mm the length of the wire to be used shall be 350 mm.

NOTE 4 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.~~

Other measuring device can be used to measure the thickness of the test specimen, provided that the device resolution complies with those specified in 5.8.

The thickness of the 10 specimens shall be measured to determine the test specimens set nominal thickness and identify if any non-conform specimen is present. Each measured test specimen thickness shall meet the tolerance provided in Table 1 for the specific thickness range. Non-conform specimens shall be discarded and replaced by new conform specimens.

Table 1 – Nominal thickness tolerances

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

7 Conditioning

7.1 Requirements

Unless otherwise required by the relevant material specifications or relevant product standards, 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 $23\text{ °C} \pm 2\text{ °C}$ at a relative humidity of $50\% \pm 10\%$ (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 $23\text{ °C} \pm 2\text{ °C}$ at a relative humidity of $50\% \pm 10\%$ (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 Verification of the heater wire

8.1.1 General

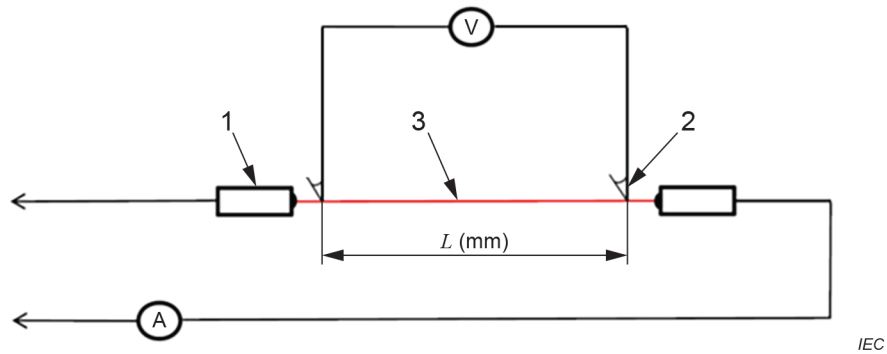
Due to normal variations in metal alloys, it is essential that each spool of heater wire shall be verified with respect to its energized resistance according to the following procedure. A mathematical relationship exists between the supplied current and power dissipation, ~~based on performance under 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~~ advisable to perform the verification of the wire after a long period of non-use, or once a year. This procedure ~~should~~ has been found to be good laboratory practice when performed in a **draught-free environment**.

8.1.2 ~~Apparatus~~ Test circuit for the verification

~~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.~~

In addition to the test circuit described in 5.3, a voltmeter is used to measure the voltage over the heating wire by means of 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 the heater wire calibration verification

8.1.3 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 $\pm 2\%$, 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.

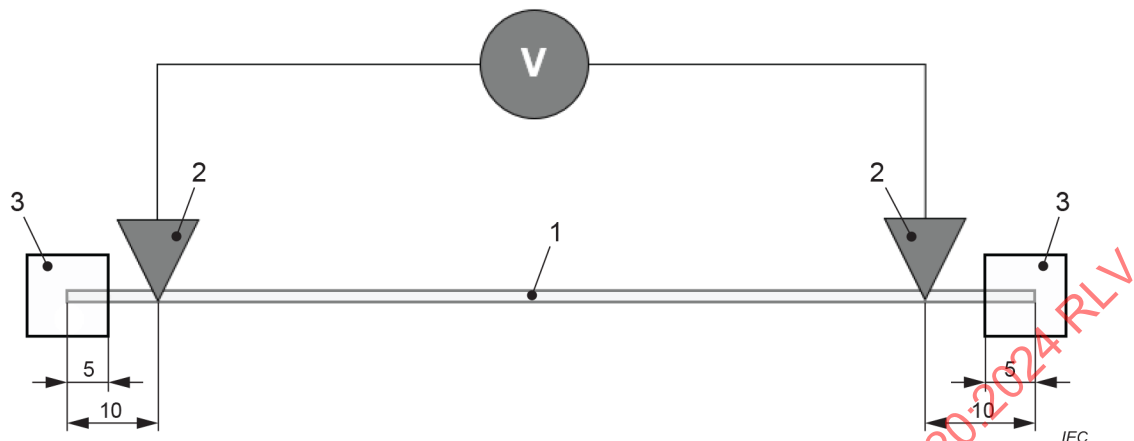
Determination of the test current shall be performed using heater wire length according to the specimen thickness to be tested. For specimens having thickness up to 3,0 mm, heater wire 260 mm in length shall be used. For specimens having thickness more than 3,0 mm and up to 8,0 mm, heater wire 280 mm in length shall be used. For specimens having thickness more than 8,0 mm and up to 13,0 mm, heater wire 350 mm in length shall be used.

The heater wire shall be marked at 5 mm and 10 mm from each end. Connect the heater wire to the current supply by using only the 5 mm of heater wire length for each end. Connect the voltmeter measuring probes to the heater wire at the 10 mm marked point on each end. Measure and record the length L of the heater wire between the voltmeter probes to an accuracy of ± 1 mm. The measured length L shall meet the value specified in Table 2.

Table 2 – Heater wire verification lengths

Heater wire length	Measured length L
260 mm	240 mm + 0 mm / - 1 mm
280 mm	260 mm + 0 mm / - 1 mm
350 mm	330 mm + 0 mm / - 1 mm

The heating wire marking, and connection are shown in Figure 6.

**Key**

- 1 Heater wire
- 2 Voltage measuring probes
- 3 Power supply connections

Figure 6 – Heater wire marking and connection

NOTE In Figure 5 and Figure 6 the heater wire is straightened but it can also be inserted in a horseshoe shaped loop.

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

8.1.4 Calculation of test current, I_c

For each measurement, ~~calculate~~ the linear power density shall be calculated according to Formula (2).

$$W = E * I / L \quad (2)$$

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 \pm 0,01 W/mm. Annex C describes how to determine the test current I_c in using a spreadsheet program.~~

Plot the measured current values as function of the calculated linear power density values to create a calibration curve as shown in Figure 7. The test current I_c for the specific heater wire as verified in 8.1, is the current (A) value that corresponds to a linear power density of 0,26 W/mm \pm 0,01 W/mm. Annex C describes how to determine the test current I_c using a spreadsheet program.

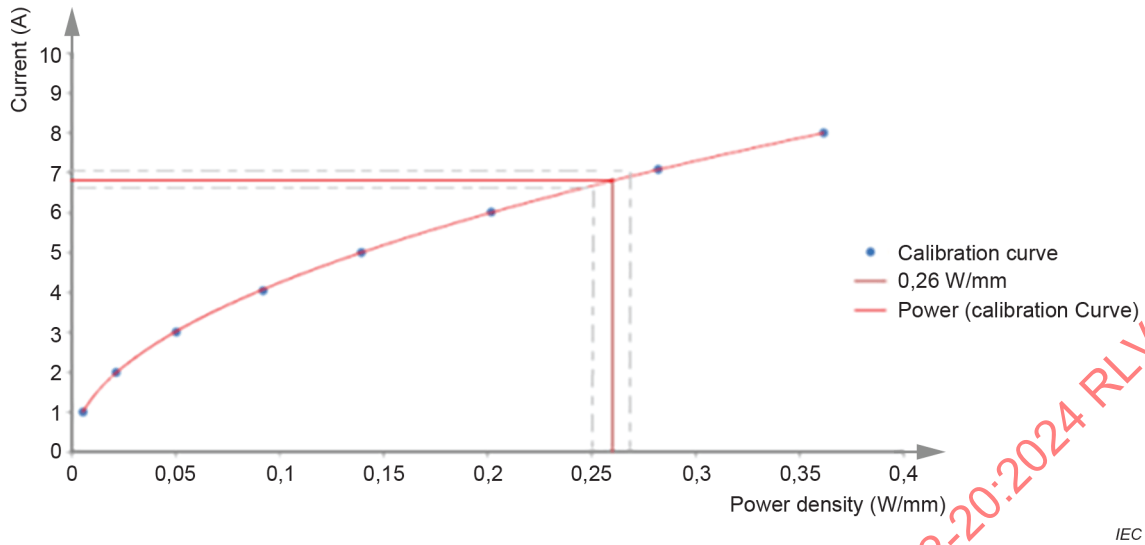


Figure 7 – Calibration curve

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

All test specimens shall be tested within 3 h after having been removed 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 $0,26 \text{ W/mm} \pm 0,01 \text{ W/mm}$. Remove this piece of wire after switching off the power supply, 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 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.~~ The test shall be continued until **ignition** of the test specimen is observed. If **ignition** does not occur within 120 s from beginning of the test, the test shall be terminated.

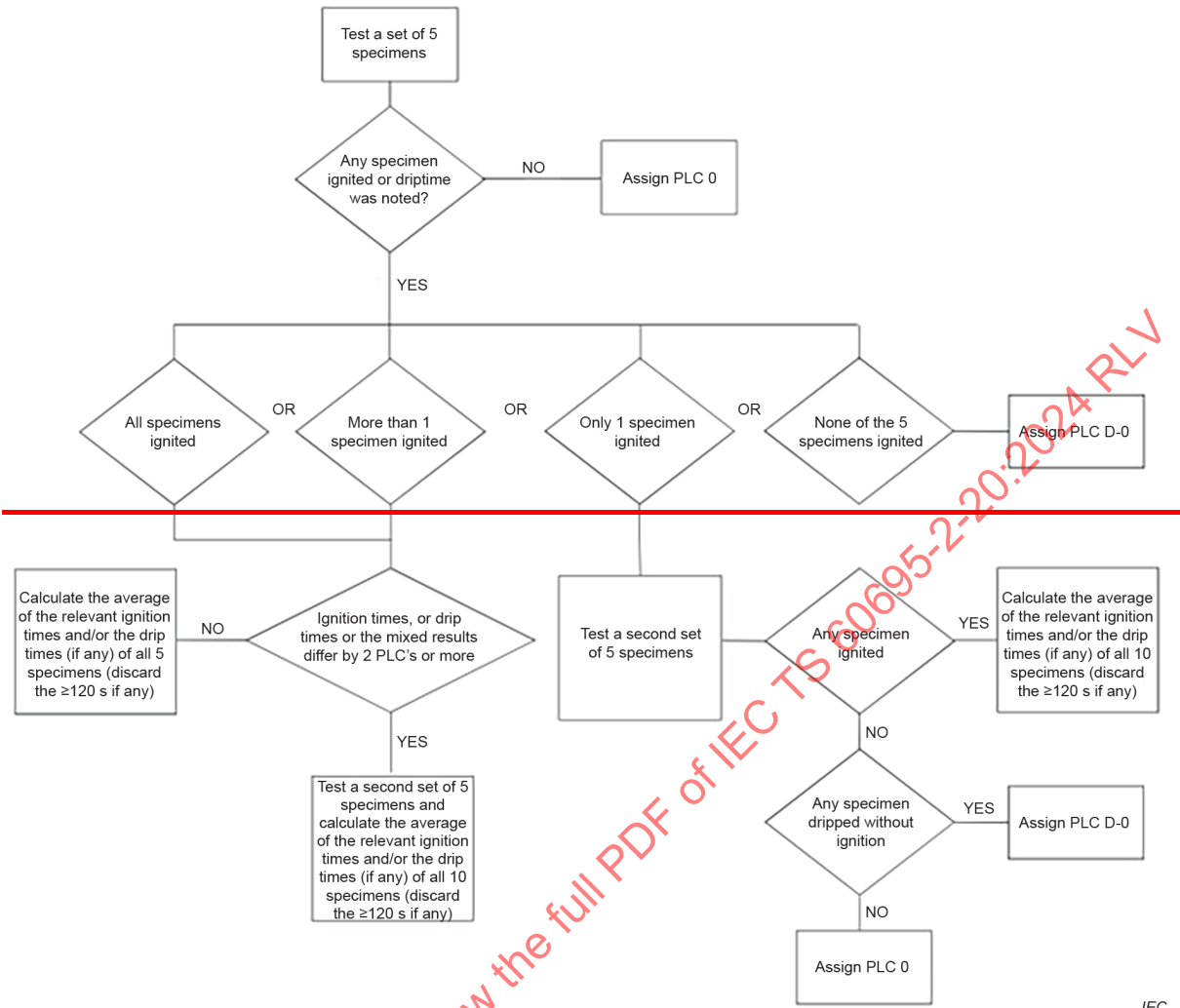
A minimum sample set of five specimens shall be tested. Depending on the results of this first set of five specimens a second set of five specimens may need to be tested. See Figure 8 (decision tree).

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.

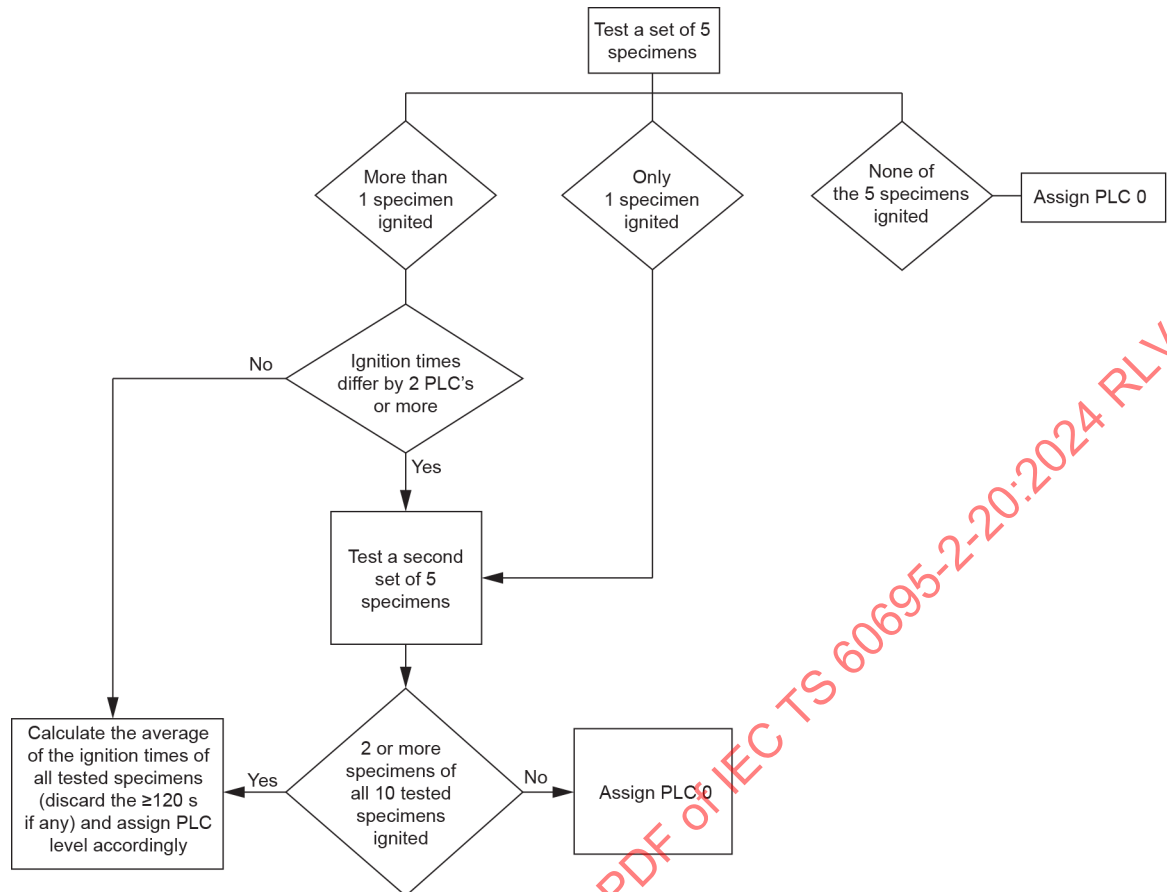
If in a first set of 5 test specimens, only one test specimen ignites then a second set shall be tested. If within the second set another **time to ignite, ~~IT~~** or **time to drip, ~~DT~~** is recorded, the **times to ignite, ~~IT~~** and/or **times to drip, ~~DT~~** from both sets shall be used to calculate the **classification time, ~~t_A t_C~~** . 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.~~

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Figure 8 – Decision tree

~~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** does not ignite 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~~ t_C 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.~~

Otherwise, the **times to ignite, IT** shall be used to calculate the **classification time, t_C** .

10 Evaluation of test results – Assigning an HWI PLC classification

~~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_C** , shall be calculated as follows:

- 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 8.2 and Clause 9) shall be used to generate a calculated average. Based on this average a PLC shall be assigned (see Annex 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_C** , 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 reference to this Technical Specification;
- all information necessary to identify the material tested, including the manufacturer's name, and type and colour of the material;
- a description of the method used for the preparation of the test specimens (see 6.1);
- the thickness of the test specimens (see 6.2);
- the conditioning of the test specimens (see 7.2);
- the results of tests (see Clause 9);
- any deviation from specified conditions; and
- the ~~HWCT~~ HWI PLC Class found according to normative Annex B.

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.

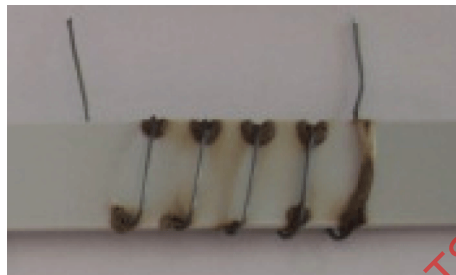


Figure A.1 – Illustration of type a) behaviour

- 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.



Figure A.2 – Illustration of type b) behaviour

Annex B
(normative)

**Hot Wire ~~coil~~ Ignition test (HWCT HWI) –
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 8.2 and Clause 9) in accordance with the ranges specified in Table B.1.

Table B.1 – Hot Wire ~~coil~~ Ignition test (HWCT HWI) – Performance level category (PLC) classes

Time interval / s	HWCT HWI PLC Classes
$IT > 120$ and $DT > 120$	0
$IT > 120$ and $DT \leq 120$	D-0
$t_A t_C = 60 - 120$	1
$t_A t_C = 30 - 59$	2
$t_A t_C = 15 - 29$	3
$t_A t_C = 7 - 14$	4
$t_A t_C = 0 - 6$	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**, $t_A t_C$, of 76 s and a PLC class 1:

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

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 8.1.4. 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.

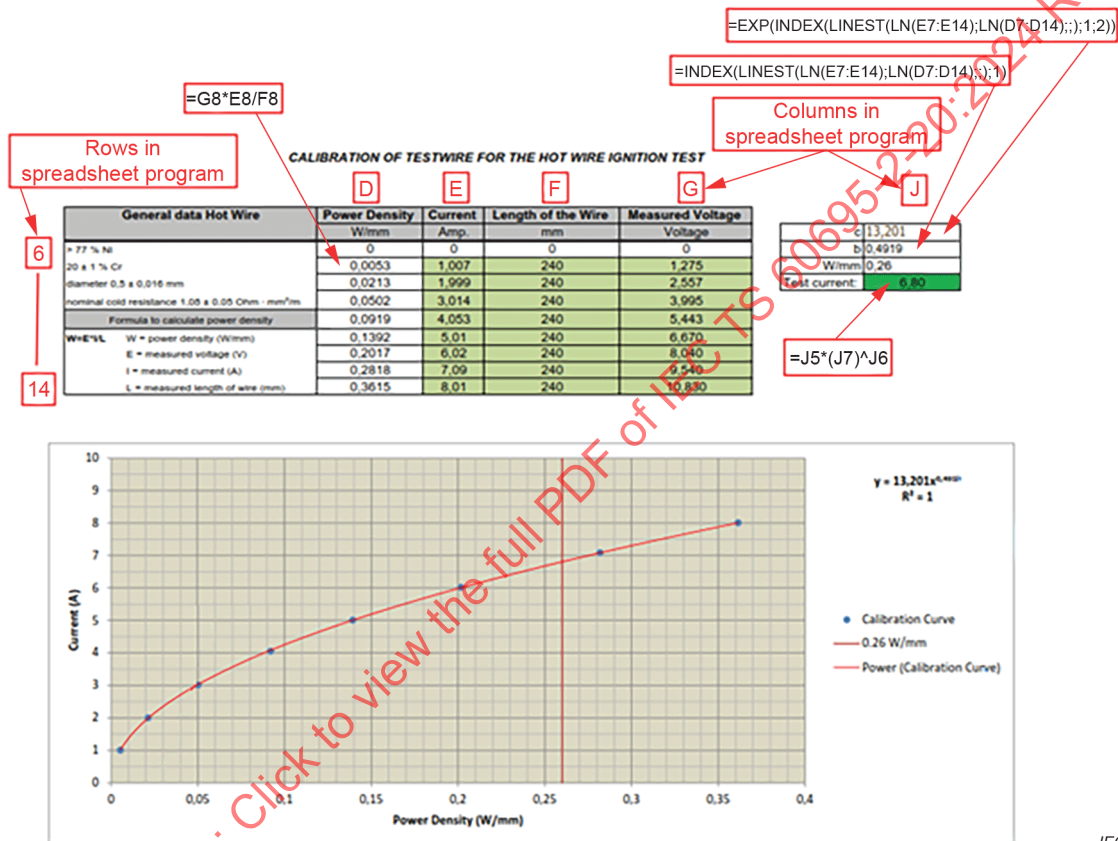


Figure C.1 – Calibration curve in a spreadsheet program used to determine I_c

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.~~

Table D.1 – Results for material 1A

			Laboratory conditions		Test current
Tech.	Lab.	Date tested	°C	%RH	Amp.
1	1	30-8-2017	23,5	62,1	6,7
1	2	8-9-2017	22,2	52,7	6,62
1	3	2-10-2017	23	47	6,96
1	4	2-8-2017	22	54	6,73

			Laboratory conditions		Test current
Tech.	Lab.	Date tested	°C	%RH	Amp.
2	1	31-8-2017	23,4	72,1	6,7
2	2	14-9-2017	22,7	44,3	6,62
2	3	2-10-2017	22	48	6,96
2	4	9-8-2017	22	55	6,73

Technician 1 data

Lab 1, Run 1		Lab 1, Run 2		Lab 2, Run 1		Lab 2, Run 2		Lab 3, Run 1		Lab 3, Run 2		Lab 4, Run 1		Lab 4, Run 2	
IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s
≥120	17	10	-	≥120	10	≥120	10	≥120	10	≥120	11	12	9	≥120	10
≥120	48	10	-	≥120	9	14	11	≥120	10	≥120	13	14	11	≥120	11
≥120	23	≥120	46	≥120	10	≥120	11	≥120	11	≥120	11	13	10	≥120	10
≥120	47	13	-	≥120	10	≥120	10	≥120	12	≥120	11	12	11	13	9
≥120	39	≥120	25	≥120	10	≥120	9	≥120	16	≥120	12	10	10	≥120	9
t _a = ≥120		The required 5 additional tests were not carried out, so PLC cannot be determined				t _a = ≥120		The required 5 additional tests were not carried out, so PLC cannot be determined				t _a = ≥120		t _a = 10	
PLC D-0						PLC D-0						PLC D-0		PLC 4	

Technician 2 data

Lab 1, Run 1		Lab 1, Run 2		Lab 2, Run 1		Lab 2, Run 2		Lab 3, Run 1		Lab 3, Run 2		Lab 4, Run 1		Lab 4, Run 2	
IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s
8	-	≥120	19	≥120	10	≥120	10	≥120	11	≥120	11	12	9	12	10
7	-	≥120	29	11	10	≥120	8	≥120	10	≥120	9	11	9	≥120	10
7	-	≥120	52	≥120	10	≥120	9	≥120	10	≥120	11	11	9	13	10
9	-	≥120	28	≥120	9	≥120	10	≥120	10	≥120	10	10	9	≥120	10
≥120	42	Off spec width	≥120	10	≥120	9	10	10	10	≥120	11	11	9	12	9
Based on run 1, a retest is required, but only 4 of the required 5 additional tests were valid (sample #10 was off spec. width) No PLC level can be assigned		t _a = ≥120				t _a = 10				t _a = 11				t _a = 10	
		PLC D-0				PLC 4				PLC 4				PLC 4	

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Table D.2 – Results for material 1B

			Laboratory conditions		Test current
Tech.	Lab.	Date tested	°C	%RH	Amp.
1	1	30-8-2017	23,1	66,8	6,7
1	2	14-9-2017	22,7	43,6	6,62
1	3	2-10-2017	22	52	6,96
1	4	2-8-2017	22	54	6,73

			Laboratory conditions		Test current
Tech.	Lab.	Date tested	°C	%RH	Amp.
2	1	31-8-2017	23,3	66,1	6,7
2	2	8-9-2017	22,2	52,7	6,62
2	3	2-10-2017	23	47	6,96
2	4	9-8-2017	22	55	6,73

Technician 1 data

Lab 1, Run 1		Lab 1, Run 2		Lab 2, Run 1		Lab 2, Run 2		Lab 3, Run 1		Lab 3, Run 2		Lab 4, Run 1		Lab 4, Run 2	
IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s
≥120	120	≥120	55	22	18	22	19	≥120	20	≥120	18	≥120	20	31	21
22	-	14	-	15	15	≥120	20	≥120	21	≥120	20	≥120	19	≥120	21
≥120	40	≥120	39	19	18	21	18	≥120	23	≥120	21	≥120	20	≥120	22
≥120	118	27	-	21	20	23	18	≥120	20	≥120	20	≥120	19	≥120	21
t _a = 45		t _a = 20				t _a = 21		t _a = ≥120		t _a = 19		The required 5 additional tests were not carried out, so PLC cannot be determined			
PLC 2		PLC 3				PLC 3		PLC D-0		PLC 3		PLC D-0			

Technician 2 data

Lab 1, Run 1		Lab 1, Run 2		Lab 2, Run 1		Lab 2, Run 2		Lab 3, Run 1		Lab 3, Run 2		Lab 4, Run 1		Lab 4, Run 2	
IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s
12	-	65	-	20	18	21	17	12	17	11	18	≥120	19	≥120	19
≥120	120	13	-	24	18	16	16	15	17	≥120	17	25	20	24	18
21	-	≥120	55	28	18	16	16	≥120	20	≥120	19	≥120	20	≥120	20
11	-	≥120	65	16	21	17	17	≥120	21	15	19	≥120	20	≥120	20
10	-	≥120	73	≥120	17	17	17	11	18	≥120	20	≥120	19	≥120	19
t _a = 45		t _a = 21				t _a = 18		t _a = 16		t _a = 16		t _a = 21		t _a = 20	
PLC 2		PLC 3				PLC 3		PLC 3		PLC 3		PLC 3		PLC 3	

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Table D.3 – Results for material 2A

Tech.	Lab.	Date tested	Laboratory conditions		Test current
			°C	%RH	Amp.
1	1	30-8-2017	23,5	68,5	6,7
1	2	8-9-2017	22,1	53,5	6,62
1	3	2-10-2017	22	48	6,96
1	4	2-8-2017	22	54	6,73

Tech.	Lab.	Date tested	Laboratory conditions		Test current
			°C	%RH	Amp.
2	1	31-8-2017	23,1	66,9	6,7
2	2	14-9-2017	22,7	42,5	6,62
2	3	2-10-2017	22	50	6,96
2	4	9-8-2017	22	55	6,73

Technician 1 data															
Lab 1, Run 1		Lab 1, Run 2		Lab 2, Run 1		Lab 2, Run 2		Lab 3, Run 1		Lab 3, Run 2		Lab 4, Run 1		Lab 4, Run 2	
IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s
≥120	59	10		10	10	≥120	11	≥120	13	≥120	12	≥120	11	≥120	10
8		9		≥120	10	≥120	11	≥120	12	≥120	11	≥120	11	≥120	11
10		8		≥120	10	10	10	≥120	13	≥120	15	11	11	≥120	14
≥120	21	11		10	10	10	10	≥120	12	≥120	14	15	11	13	11
≥120	23	9		≥120	10	16	11	≥120	13	≥120	12	≥120	10	≥120	11
t _A = 17		t _A = 10		t _A = 11		t _A = ≥120		t _A = ≥120		t _A = 11		The required 5 additional tests were not carried out, so PLC cannot be determined			
PLC 3		PLC 4		PLC 4		PLC D-0		PLC D-0		PLC 4					

Technician 2 data															
Lab 1, Run 1		Lab 1, Run 2		Lab 2, Run 1		Lab 2, Run 2		Lab 3, Run 1		Lab 3, Run 2		Lab 4, Run 1		Lab 4, Run 2	
IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s
10		10		11	11	≥120	11	≥120	12	≥120	10	10	10	≥120	12
8		8		10	10	15	11	≥120	11	≥120	11	≥120	10	11	10
7		8		≥120	11	15	11	≥120	10	≥120	12	≥120	12	13	11
≥120	25	8		≥120	11	≥120	10	9	10	≥120	12	≥120	12	≥120	10
8		10		11	11	≥120	12	≥120	10	10	11	≥120	11	14	12
t _A = 12		t _A = 9		t _A = 11		t _A = 12		t _A = 10		t _A = 11		t _A = ≥120		t _A = 12	
PLC 4		PLC 4		PLC 4		PLC 4		PLC 4		PLC 4		PLC 4		PLC 4	

IEC.

Table D.4 – Results for material 2B

Tech.	Lab.	Date tested	Laboratory conditions		Test current
			°C	%RH	Amp.
1	1	30-8-2017	23	68,5	6,7
1	2	1-9-2017	22,6	44,2	6,62
1	3	2-10-2017	23	47	6,96
1	4	2-8-2017	22	54	6,73

Tech.	Lab.	Date tested	Laboratory conditions		Test current
			°C	%RH	Amp.
2	1	31-8-2017	23,4	56,7	6,7
2	2	8-9-2017	22,2	53,2	6,62
2	3	2-10-2017	22	52	6,96
2	4	9-8-2017	22	55	6,73

Technician 1 data															
Lab 1, Run 1		Lab 1, Run 2		Lab 2, Run 1		Lab 2, Run 2		Lab 3, Run 1		Lab 3, Run 2		Lab 4, Run 1		Lab 4, Run 2	
IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s
16		16		27	22	25	22	≥120	22	≥120	30	23	22	≥120	21
13		≥120	42	20	20	31	21	≥120	23	≥120	26	22	21	≥120	22
14		≥120	35	20	25	22	≥120	25	≥120	27	25	22	≥120	24	
13		≥120	33	≥120	21	26	22	19	22	≥120	25	≥120	20	≥120	23
17		11		26	19	25	20	20	24	23	29	≥120	19	≥120	19
t _A = 15		t _A = 16		t _A = 26		t _A = 26		t _A = 22		t _A = 22		t _A = 22		t _A = ≥120	
PLC 3		PLC 3		PLC 3		PLC 3		PLC 3		PLC 3		PLC 3		PLC D-0	

Technician 2 data															
Lab 1, Run 1		Lab 1, Run 2		Lab 2, Run 1		Lab 2, Run 2		Lab 3, Run 1		Lab 3, Run 2		Lab 4, Run 1		Lab 4, Run 2	
IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s
6		27		26	20	25	17	≥120	21	18	21	≥120	22	19	19
11		≥120	37	18	18	34	18	≥120	22	≥120	23	20	18	≥120	22
11		10		19	19	24	19	26	23	≥120	21	22	20	≥120	23
7		13		≥120	18	23	19	≥120	21	≥120	20	26	20	≥120	19
23		21		24	19	23	18	13	20	15	20	≥120	22	≥120	19
t _A = 17		t _A = 21		t _A = 26		t _A = 21		t _A = 19		t _A = 22		The required 5 additional tests were not carried out, so PLC cannot be determined			
PLC 3		PLC 3		PLC 3		PLC 3		PLC 3		PLC 3					

IEC.

Table D.5 – Results for material 3

Tech.	Lab.	Date tested	Laboratory conditions		Test current
			°C	%RH	Amp.
1	1	30-8-2017	22,9	69,1	6,7
1	2	14-9-2017	22,6	43,9	6,62
1	3	2-10-2017	22	51	6,96
1	4	2-8-2017	22	54	6,73

Tech.	Lab.	Date tested	Laboratory conditions		Test current
			°C	%RH	Amp.
2	1	31-8-2017	23,4	55,2	6,7
2	2	14-9-2017	22,2	45,4	6,62
2	3	2-10-2017	22	49	6,96
2	4	9-8-2017	22	45	6,73

Technician 1 data															
Lab 1, Run 1		Lab 1, Run 2		Lab 2, Run 1		Lab 2, Run 2		Lab 3, Run 1		Lab 3, Run 2		Lab 4, Run 1		Lab 4, Run 2	
IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s
≥ 120	31	16		14	14	18	17	≥ 120	19	≥ 120	19	17		13	
19		10		18		17		≥ 120	19	≥ 120	25	20		12	
19		16		18		18		≥ 120	21	≥ 120	20	17		16	
15		13		16		16		15	21	≥ 120	18	17		16	
20		11		15		14		≥ 120	20	≥ 120	21	15		20	
t _A = 21		t _A = 13		t _A = 16		t _A = 17		t _A = 2120		t _A = 17		t _A = 15			
PLC 3		PLC 4		PLC 3		PLC 3		PLC D-0		PLC 3		PLC 3			

Technician 2 data															
Lab 1, Run 1		Lab 1, Run 2		Lab 2, Run 1		Lab 2, Run 2		Lab 3, Run 1		Lab 3, Run 2		Lab 4, Run 1		Lab 4, Run 2	
IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s
19		19		17	17	13		≥ 120	21	14	18	14		11	
9		14		13		15		≥ 120	20	13	16	16		21	20
18		17		17		17		15	18	17	18	15		18	
≥ 120	61	11		13		15		19	19	14	17	12		17	
11		18		14		14		≥ 120	20	≥ 120	19	11		10	
t _A = 20		t _A = 15		t _A = 15		t _A = 19		t _A = 15		t _A = 14		t _A = 15			
PLC 3		PLC 3		PLC 3		PLC 3		PLC 3		PLC 3		PLC 4		PLC 3	

IEC.

Table D.6 – Results for material 4

Tech.	Lab.	Date tested	Laboratory conditions		Test current
			°C	%RH	Amp.
1	1	30-8-2017	22,8	68,8	6,7
1	2	14-9-2017	22,3	45,1	6,62
1	3	2-10-2017	22	50	6,96
1	4	2-8-2017	22	54	6,73

Tech.	Lab.	Date tested	Laboratory conditions		Test current
			°C	%RH	Amp.
2	1	31-8-2017	23,4	54,7	6,7
2	2	14-9-2017	22,7	44	6,62
2	3	2-10-2017	23	47	6,96
2	4	9-8-2017	22	55	6,73

Technician 1 data															
Lab 1, Run 1		Lab 1, Run 2		Lab 2, Run 1		Lab 2, Run 2		Lab 3, Run 1		Lab 3, Run 2		Lab 4, Run 1		Lab 4, Run 2	
IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s
23		20		21		≥ 120		15		15		17		16	
26		20		21		17		16		15		14		15	
21		21		14		21		17		18		17		15	
21		21		18		18		15		13		16		16	
21		20		18		31		20		17		15		16	
t _A = 22		t _A = 20		t _A = 18		t _A = 22		t _A = 17		t _A = 16		t _A = 16		t _A = 16	
PLC 3		PLC 3		PLC 3		PLC 3		PLC 3		PLC 3		PLC 3		PLC 3	

Technician 2 data															
Lab 1, Run 1		Lab 1, Run 2		Lab 2, Run 1		Lab 2, Run 2		Lab 3, Run 1		Lab 3, Run 2		Lab 4, Run 1		Lab 4, Run 2	
IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s	IT/s	DT/s
20		20		27		25		26		23		17		15	
21		19		19		19		24		29		13		17	
19		20		16		15		24		22		15		15	
16		19		20		14		25		26		16		16	
19		19		17		≥ 120		28		22		15		15	
t _A = 19		t _A = 19		t _A = 20		t _A = 18		t _A = 25		t _A = 24		t _A = 15		t _A = 16	
PLC 3		PLC 3		PLC 3		PLC 3		PLC 3		PLC 3		PLC 3		PLC 3	

IEC.

D.3 – Evaluation of test results

Due to a slightly different set up of the test connection points towards the heater wire, the results of lab 1 are slightly different from the results of the other labs. The evaluation of the test

~~results of the round robin are based on the decision tree (Figure 7) and the evaluation as described in Clause 10.~~

~~NOTE—The lab 1 results were obtained in accordance with the standard. The results from 3 labs are quite consistent, only one lab has some slightly higher **times to ignite, *IT*** and **times to drip, *DT***. After consulting the labs, we learned that this can be explained by the way of clamping the winded specimen into the connection points. If the test instructions are followed as drafted, each lab that performs the test, will put the same amount of energy into the test bar that will lead to a consistent first **time to drip, *DT*** and/or **time to ignite, *IT***.~~

~~In principle the classification was based on only the first 5 specimens (specimen no. 1 to 5). In some cases, it was possible to also classify the remaining test specimens (specimen no. 6 to 10). In case with the first 5 test specimens leading to a retest, an additional classification was therefore not possible anymore.~~

~~In Table D.7, the PLC classes which have been found in this round robin and evaluated as described above, are presented for the materials used.~~

Table D.7 – Occurrence of PLC classes in the round robin

Sample	Thkn. mm	PLC-0	PLC-D-0	PLC-1	PLC-2	PLC-3	PLC-4	PLC-5
1A	0,75	-	5	-	-	-	4	-
1B	1,5	-	2	-	2	9	-	-
2A	0,75	-	2	-	-	1	11	-
2B	1,5	-	4	-	-	11	-	-
3	1,5	-	1	-	-	11	2	-
4	0,75	-	-	-	-	16	-	-

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Bibliography

- [1] IEC 60695-1-10, *Fire hazard testing – Part 1-10: Guidance for assessing the fire hazard of electrotechnical products – General guidelines*
- [2] IEC 60695-1-11, *Fire hazard testing – Part 1-11: Guidance for assessing the fire hazard of electrotechnical products – Fire hazard assessment*
- [3] IEC 60695-1-30, *Fire hazard testing – Part 1-30: Guidance for assessing the fire hazard of electrotechnical products – Preselection testing process – General guidelines*
- [4] IEC 60695-4:2021, *Fire hazard testing – Part 4: Terminology concerning fire tests for electrotechnical products*
- [5] DIN 17470:1984, *Heizleiterlegierungen; Technische Lieferbedingungen für Rund- und Flachdrähte*
- [6] JIS C 2520:1999, *Wires and rolled wires for electrical heating*
- [7] ASTM D3874, *Standard Test Method for Ignition of Materials by Hot Wire Sources*

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TECHNICAL SPECIFICATION



**Fire hazard testing –
Part 2-20: Glowing/hot wire based test methods – Hot-wire ignition (HWI) test
method – Apparatus, verification, test method and guidance**

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CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references	7
3 Terms and definitions	7
4 Principle.....	9
5 Apparatus.....	10
5.1 Test chamber.....	10
5.2 Heater wire	10
5.3 Power supply and test circuit	11
5.4 Test specimen fixture.....	11
5.5 Test specimen winding and pressing.....	11
5.6 Conditioning chamber	13
5.7 Timing device	13
5.8 Micrometer.....	13
5.9 Measuring scale.....	13
6 Test specimens	13
6.1 Test specimen preparation.....	13
6.2 Test specimen dimensions.....	13
7 Conditioning	14
7.1 Requirements	14
7.2 Test specimen conditioning.....	14
7.3 Heater wire conditioning	15
7.4 Test conditions	15
8 Test procedure	15
8.1 Verification of the heater wire	15
8.1.1 General	15
8.1.2 Test circuit for the verification.....	15
8.1.3 Determination of the test current, I_C	15
8.1.4 Calculation of test current, I_C	16
8.2 Determination of time to ignite, IT	17
9 Observations and measurement	19
10 Evaluation of test results – Assigning an HWI PLC classification	19
11 Test report.....	19
Annex A (informative) Guidance on how to effectively wind the heater wire on to the test specimen	20
Annex B (normative) Hot Wire Ignition test (HWI) – Performance level category (PLC) classes	21
B.1 General.....	21
B.2 Reporting a classification	21
Annex C (informative) Calibration curve to determine test current (I_C) in a spreadsheet program.....	22
Bibliography.....	23
Figure 1 – Test fixture arrangement (example).....	9

Figure 2 – Test specimen winding pattern	10
Figure 3 – Test specimen fixture (example).....	11
Figure 4 – Heater wire winding device (Example).....	12
Figure 5 – Test circuit for the heater wire verification	15
Figure 6 – Heater wire marking and connection	16
Figure 7 – Calibration curve	17
Figure 8 – Decision tree	18
Figure A.1 – Illustration of type a) behaviour.....	20
Figure A.2 – Illustration of type b) behaviour.....	20
Figure C.1 – Calibration curve in a spreadsheet program used to determine I_C	22
Table 1 – Nominal thickness tolerances	14
Table 2 – Heater wire verification lengths	16
Table B.1 – Hot Wire Ignition test (HWI) – Performance level category (PLC) classes	21

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIRE HAZARD TESTING –

**Part 2-20: Glowing/hot wire based test methods –
Hot-wire ignition (HWI) 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.
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- 9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

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

This fourth edition cancels and replaces the third edition published in 2021. This edition constitutes a technical revision.

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

- a) Removed all text which was related to drip or dripping, since in this 4th edition only ignition is taken into consideration for determination of the classification level;
- b) Title changed: "Hot wire coil test method" is now "Hot wire ignition (HWI) test method".

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

Draft	Report on voting
89/1583/DTS	89/1593/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/publications.

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 ignition test method – Apparatus, verification, test method and guidance*

Part 2-21: *Glowing/hot-wire based test methods – Fire containment test on finished units*

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.

NOTE The following print types are used:

- Terms in **bold** in the text are defined in Clause 3.

Future documents in this series will carry the new general title as cited above. Titles of existing documents in this series will be updated at the time of the next edition.

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, or
- revised.

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.

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 60695-1-10 [1]¹, together with its companion IEC 60695-1-11 [2], provides 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 electrotechnical 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.

The test method provided in this document 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:

- c) 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
- d) visible indentation of the test specimen by the heater wire.

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

¹ Numbers in square brackets refer to the bibliography.

FIRE HAZARD TESTING –

Part 2-20: Glowing/hot wire based test methods – Hot-wire ignition (HWI) 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.

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**.

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.

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 13943:2017, *Fire safety – Vocabulary*

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

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_c

arithmetic mean of **times to ignite**, *IT*, 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·s⁻¹ or 0,2 m·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]

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 ignition

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

[SOURCE: ISO 13943:2017, definition 3.217]

3.9 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]

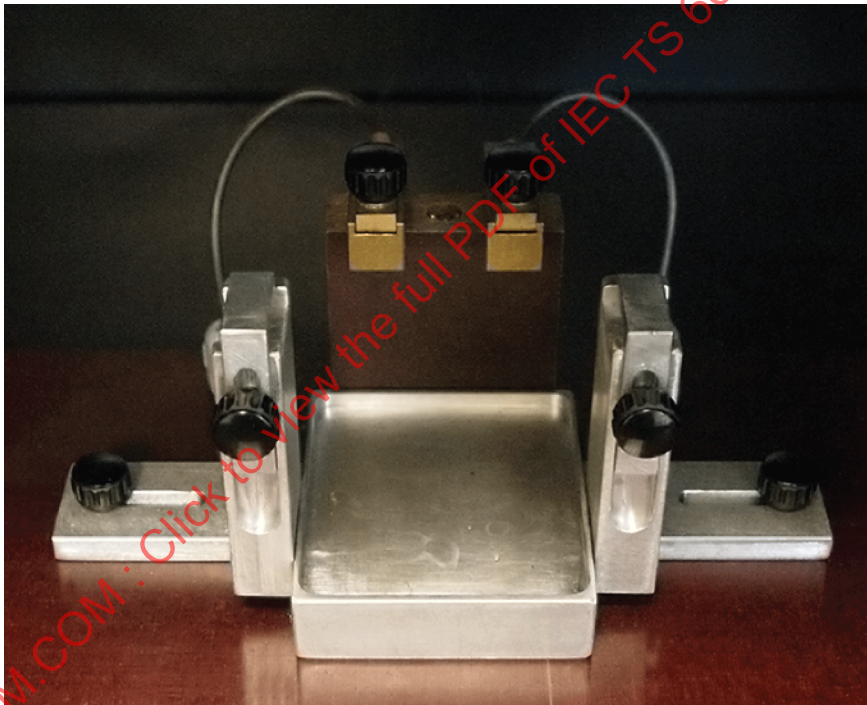
3.10 time to ignite

IT

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

4 Principle

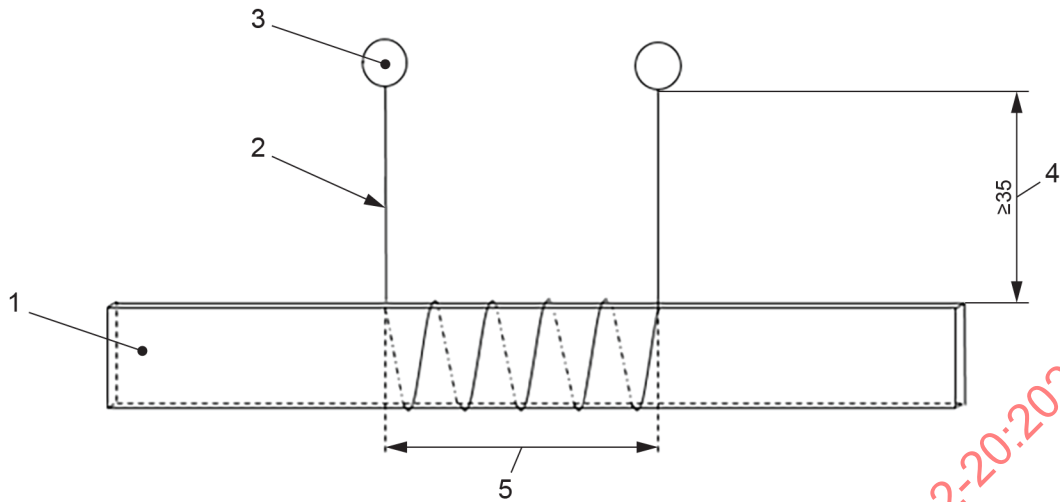
A rectangular bar-shaped test specimen is supported horizontally on a test fixture (an example of a test fixture is shown in Figure 1 and Figure 3). The centre portion is wound with a coil of heater wire as shown in Figure 2. A constant current is applied to the coil, which rapidly heats up and the behaviour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



IEC

Figure 1 – Test fixture arrangement (example)

Dimension in millimetres



IEC

Key

- 1 Test specimen
- 2 Heater wire
- 3 Electrical connection point
- 4 Distance to electrical connection points (≥ 35 mm)
- 5 Distance between all 5 windings (30,5 to 32,5 mm)

Figure 2 – Test specimen winding pattern

5 Apparatus

5.1 Test chamber

The test chamber consists of a laboratory fume hood/chamber having an inside volume of at least 0,5 m³. The test chamber shall provide a **draught-free environment**. The test 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 test chamber (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, 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 The Nickel/Chromium wire is also known as NCHW1 according to JIS C 2520 and NiCr8020 according to DIN 17470 Werkstoffnummer 2.4869, or as specified in ASTM D3874.

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 for measuring the current through the test circuit with an accuracy of $\pm 0,2 \%$;
- 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.
- c) A voltmeter shall be provided to measure the voltage using small probes as shown in Figure 5.

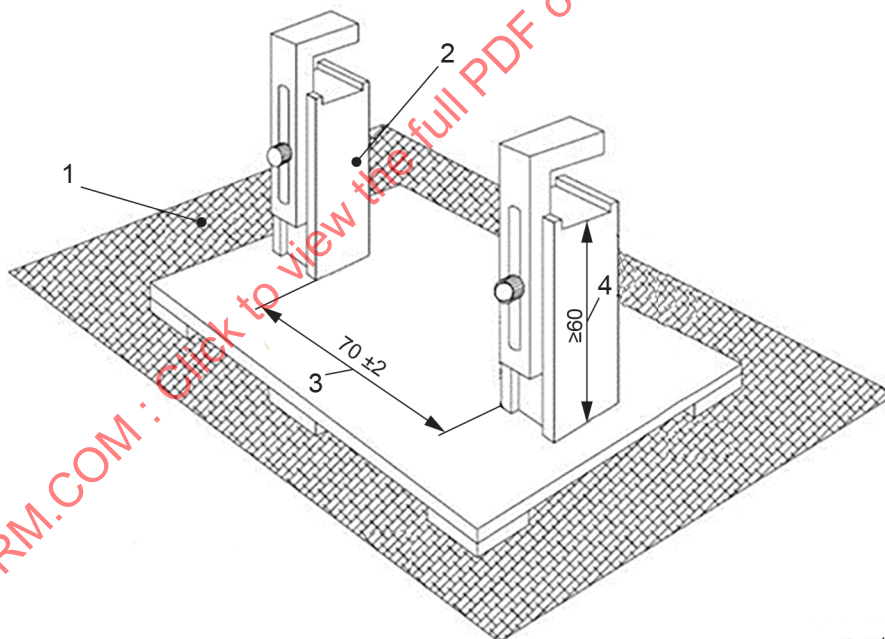
The test circuit shall be provided with an on-off switch for cutting off the test circuit current (for safety reasons).

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 $70 \text{ mm} \pm 2 \text{ mm}$ apart shall be provided with hold-down clamps to support the test specimen in a horizontal and flat position.

Dimensions in millimetres



IEC

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.

Five windings shall be applied using a force of $(5,40 \pm 0,02)$ N, equally distributed, with a pitch of $(6,3 \pm 0,2)$ mm. In practice the five windings on the test specimen shall be evenly spread over the test specimen which shall result in a distance of between 30,5 mm and 32,5 mm as shown in Figure 2. An example of a winding device is shown in Figure 4.

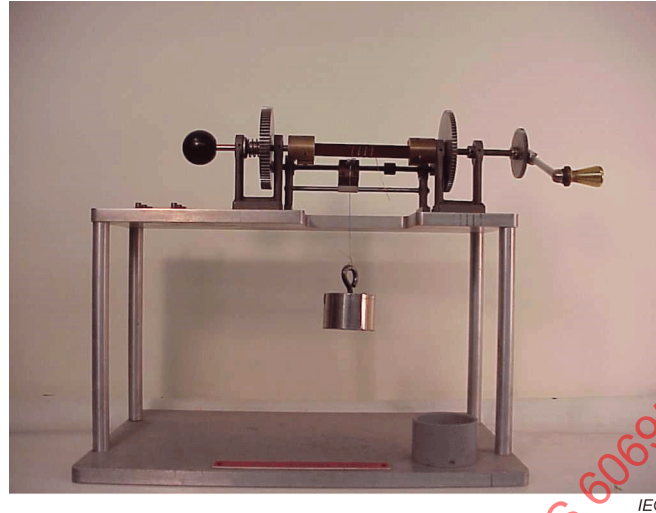


Figure 4 – Heater wire winding device (Example)

If winding is done manually, the first winding point at the test bar shall be calculated according to Formula (1) and marked on the test specimen.

$$(125,0 \text{ mm} - 30,5 \text{ mm})/2 \quad (1)$$

For a test bar of 125,0 mm in length, knowing that the total distance between the 5 windings should be between 30,5 mm and 32,5 mm, the first winding point shall start at 47,25 mm from one of the test bar ends.

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 $23\text{ °C} \pm 2\text{ °C}$ at a relative humidity of $50\% \pm 10\%$.

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.

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 $125\text{ mm} \pm 5\text{ mm}$ long by $13,0\text{ mm} \pm 0,5\text{ mm}$ 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.

Test specimens having thickness up to 3,0 mm shall be tested using the nominal 260 mm length of wire.

For test specimens having thickness more than 3,0 mm and up to 8,0 mm the length of the wire to be used shall be 280 mm.

For test specimens having thickness more than 8,0 mm and up to 13,0 mm the length of the wire to be used shall be 350 mm.

NOTE 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.