

INTERNATIONAL STANDARD

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Test procedure for the determination of the temperature index of enamelled and tape wrapped winding wires

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Méthode d'essai pour la détermination de l'indice de température des fils de bobinage émaillés et enveloppés de ruban

IEC 60172:2020
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Méthode d'essai pour la détermination de l'indice de température des fils de bobinage émaillés et enveloppés de ruban

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

TEST PROCEDURE FOR THE DETERMINATION OF THE TEMPERATURE INDEX OF ENAMELLED AND TAPE WRAPPED WINDING WIRES

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International Standard IEC 60172 has been prepared by IEC Technical Committee 55: Winding wires.

This fifth edition cancels and replaces the fourth edition published in 2015. This edition constitutes a technical revision.

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

- revision of 3.1, definition of thermal index;
- revision of 3.3, time to failure;
- revisions to 5.1.1 for clarity and to reduce the range wire size range to which the test applies;
- revisions to 5.1.2 for tape wrapped round and enamelled or tape wrapped rectangular wire for clarity;
- revision to Clause 9 to add the correlation coefficient, r to the report.

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

FDIS	Report on voting
55/1876/FDIS	55/1893/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

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TEST PROCEDURE FOR THE DETERMINATION OF THE TEMPERATURE INDEX OF ENAMELLED AND TAPE WRAPPED WINDING WIRES

1 Scope

This International Standard specifies, in accordance with the provisions of IEC 60216-1, a method for evaluating the temperature index of enamelled wire, varnished or unvarnished with an impregnating agent, and of tape wrapped round and rectangular wire, in air at atmospheric pressure by periodically monitoring changes in response to AC proof voltage tests. This procedure does not apply to fibre-insulated wire or wire covered with tapes containing inorganic fibres.

NOTE The data obtained according to this test procedure provide the designer and development engineer with information for the selection of winding wire for further evaluation of insulation systems and equipment tests.

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 60216-1, *Electrical insulating materials – Thermal endurance properties – Part 1: Ageing procedures and evaluation of test results*

IEC 60216-3, *Electrical insulating materials – Thermal endurance properties – Part 3: Instructions for calculating thermal endurance characteristics*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

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3.1 temperature index TI

number which permits comparison of the temperature/time characteristics of an electrical insulating material, or a simple combination of materials, based on the temperature in degrees Celsius which is obtained by extrapolating the Arrhenius plot of life versus temperature to a lifetime of 20 000 h

Note 1 to entry: In case of insulation systems, the temperature index may be derived from known service experience or from a known comparative functional evaluation of an evaluated and established reference insulation system as basis.

[SOURCE: IEC 60050-212:2010, 212-12-11] modified by merging Note 1 into the definition, and to specify a lifetime of 20 000 h.]

3.2

specimen failure time

number of hours at the exposure temperature that have elapsed at the time a specimen fails the proof test

3.3

time to failure

number of hours to failure calculated from the specimen mean value or logarithmic mean value failure times for a set of specimens at one exposure temperature, in accordance with 8.2

4 Summary of procedure

A set of specimens in accordance with Clause 5 is subjected to a testing cycle. This cycle consists of a heat-exposure period at a temperature given in Clause 6, followed by a proof voltage test at room temperature in accordance with Clause 7.

This cycle is repeated until a sufficient number of specimens has failed. The time to failure is calculated in accordance with Clause 8. The test is carried out at three or more temperatures. A regression line is calculated in accordance with 8.4 and the time to failure values plotted on thermal endurance graph paper as a function of the exposure temperature.

The temperature in degrees Celsius, corresponding to the point of intersection of the regression line with the ordinate of 20 000 h endurance represents the temperature index of the winding wire under test.

5 Test specimens

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5.1 Preparation

5.1.1 Enamelled non-tape wrapped round wire

This procedure applies to enamelled round wires that are not tape wrapped. The thermal index can be determined by evaluating enamelled non-tape wrapped round wire with a nominal conductor diameter of 0,224 mm up to and including 2,65 mm.

NOTE For round enamelled winding wires, experience has shown that nominal conductor diameters of 0,800 mm up to and including 1,60 mm are generally found convenient to handle and test.

Wires with a nominal conductor diameter between 0,280 mm and 0,500 mm are permitted for use when the specification range of diameters is limited to 0,500 mm and finer.

The grade of insulation used for determining the thermal index shall be grade 2 or grade 2B for self-bonding winding wires.

Specimens shall be prepared as follows:

- a) A wire specimen approximately 400 mm in length shall be twisted together over a distance of 125 mm with a device as shown in Figure 1. The force (weight) applied to the wire pair while being twisted and the number of twists are specified in Table 1.

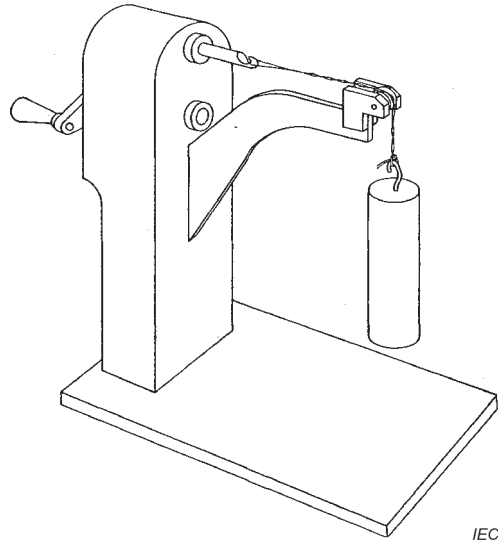


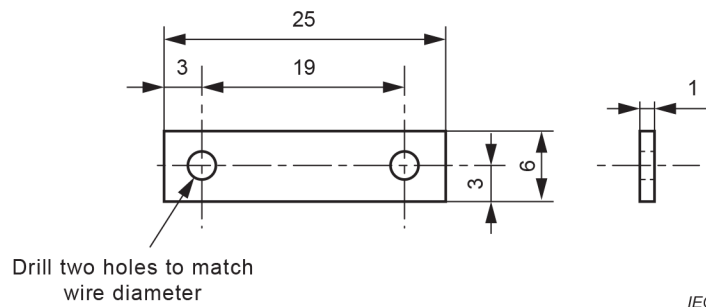
Figure 1 – Device used to form enamelled round wire test specimen

Table 1 – Force and number of twists for specimens

Nominal diameter mm		Force applied to wire pairs N	Number of twists per 125 mm
Over	Up to and including		
0,224	0,25	0,85	33
0,25	0,35	1,7	23
0,35	0,50	3,4	16
0,50	0,75	7,0	12
0,75	1,05	13,5	8
1,05	1,50	27,0	6
1,50	2,15	54,0	4
2,15	2,65	108,0	3

b) Spacers may be prepared as shown in Figure 2. Such thermally stable insulating materials as ceramic or silicone glass fibre laminate may be used. The spacers are marked with a suitable identifying letter or number.

Dimensions in millimetres

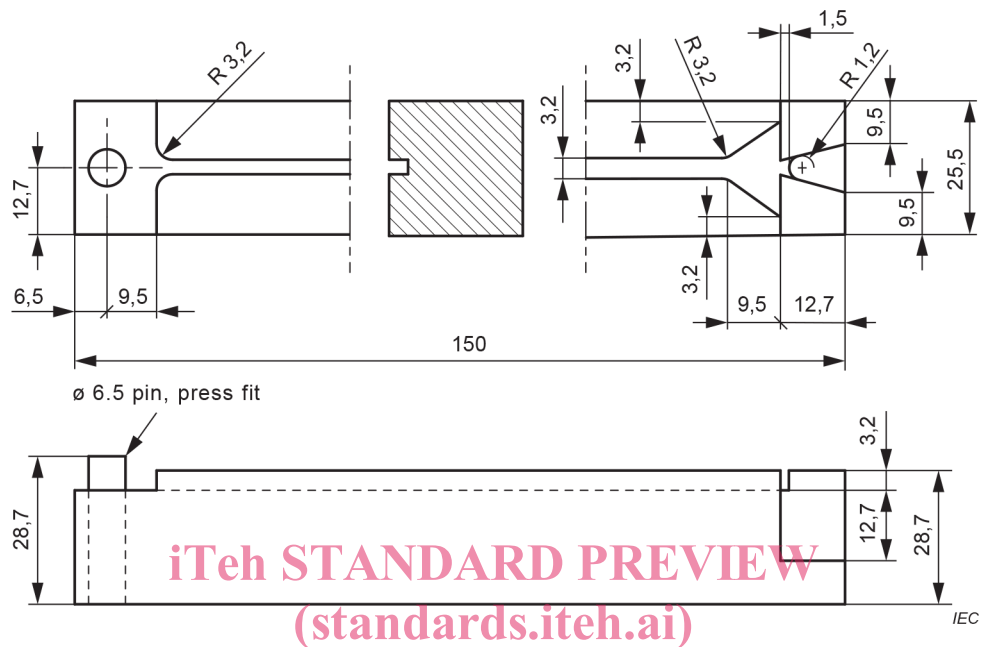


Material: Silicone glass laminate

Figure 2 – Spacer

- c) The test specimens may be shaped in a jig, an engineering drawing of which is shown in Figure 3. A specimen is placed in the jig and a spacer, placed on the parallel leads of the twisted pair, is brought up to the face of the jig as shown in Figure 4. The leads are then bent parallel to hold the spacer in position. The forming jig provides more uniform test specimens. If a specimen holder is used, the spacers are unnecessary.

Dimensions in millimetres



R = Radius of bend

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Figure 3 – Twist forming jig
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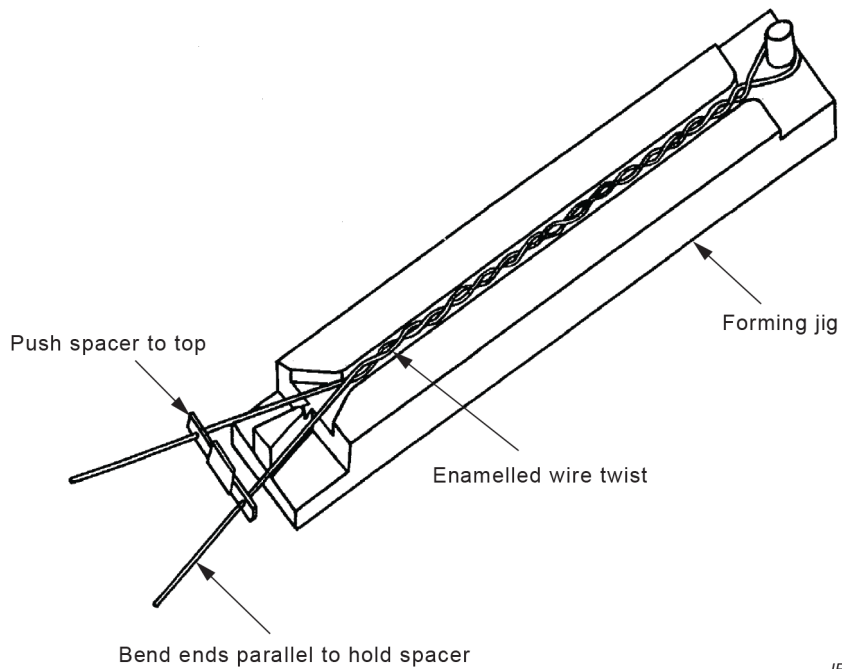


Figure 4 – Test specimen set up in forming jig

- d) The loop at the end of the twisted section shall be cut at two places (not one) to provide the maximum spacing between the cut ends as shown in Figure 5. Any bending of the wires, at this end or the other untwisted end, to ensure adequate separation between the wires shall avoid sharp bends or damage to the insulation.

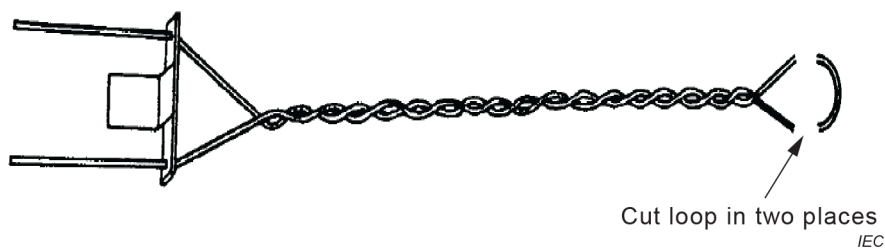


Figure 5 – Test specimen formed with loop cut

In order to ensure homogeneity of the set of test specimens, it is recommended that test specimens be subjected to, and withstand without breakdown, a test voltage three times the value given in Table 2 for 1 s prior to starting thermal exposure cycling.

Table 2 – Proof voltage for round enamelled wire

Increase in diameter due to the insulation (mm)		Voltage (rms)
Over	Up to and including	
–	0,015	300
0,015	0,024	300
0,024	0,035	400
0,035	0,050	500
0,050	0,070	700
0,070	0,090	1 000
0,090	0,130	1 200

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5.1.2 Tape wrapped round wire and enamelled or tape wrapped rectangular wire

This procedure applies to any convenient dimension of tape wrapped round or tape wrapped or enamelled rectangular wire.

It is recommended to select a wire having dimensions that minimize the bending force necessary to shape the test specimen, since wire with high stiffness will yield specimens with poor wire-to-wire contact areas.

Specimens shall be prepared as follows:

- a) Two straight specimens of wire each of 250 mm length shall be cut from the supply spool.
- b) 10 mm to 15 mm of the insulation shall be removed from one end of each piece of wire to provide for electrical connection.
- c) Each specimen shall be formed in a jig, as shown in Figure 6. This produces a straight centre section of about 150 mm with bent ends, which provide the necessary flare at both ends of the final specimen.

Dimensions in millimetres

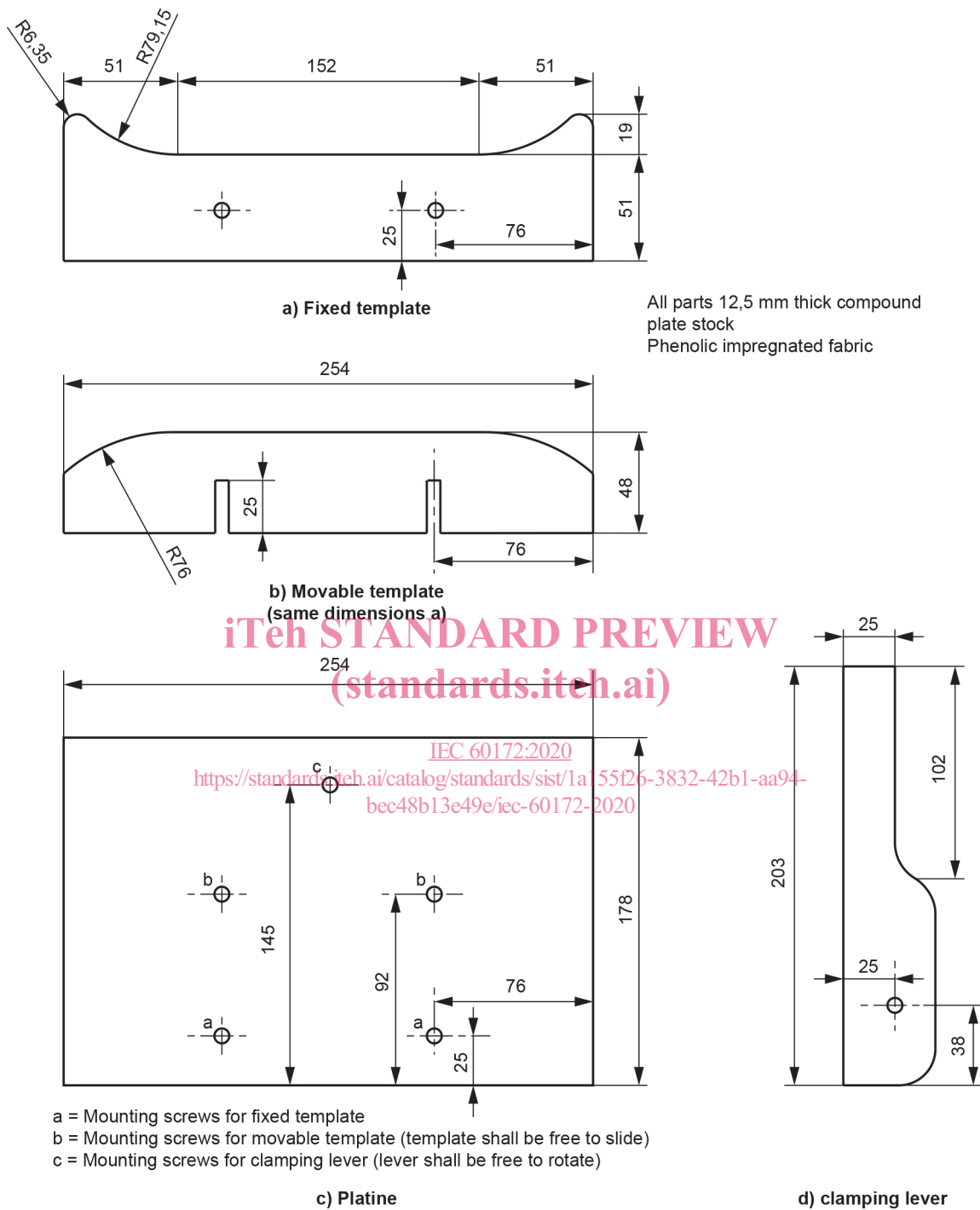
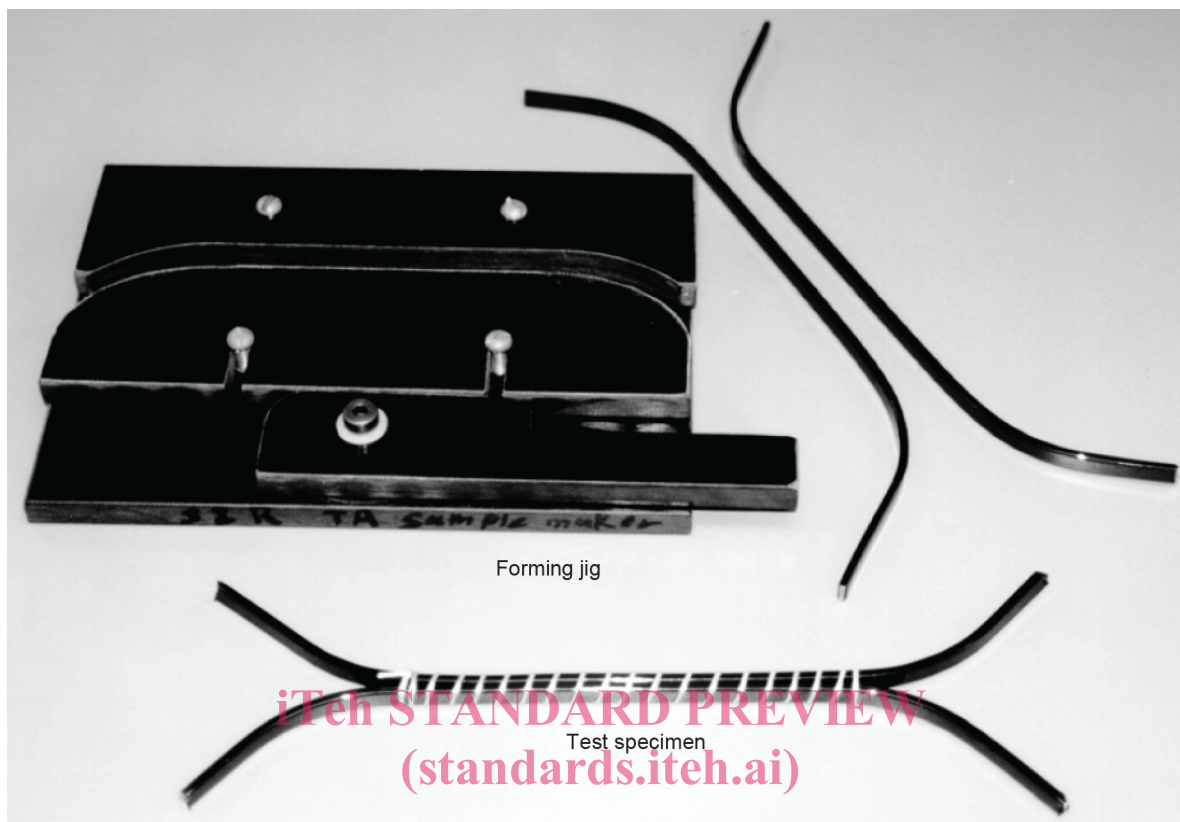


Figure 6 – Jig for bending large magnet wire, dielectric test specimen

- d) The two formed specimens shall be placed together back-to-back and tightly wrapped with glass yarn over the straight centre section of the specimen, as shown in Figure 7.



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Figure 7 – Forming jig and test specimen

Care shall be taken that the centre section shows a close contact between the two pieces.

After tying, further bending of the ends shall be avoided. Pre-annealing of the specimen prior to testing or impregnating will remove stress and craze marks and therefore may be desirable with certain material.

- e) Prior to starting the thermal exposure cycles, the specimen shall be proof-tested at 1 000 V AC.

5.2 Varnish impregnation

Insulated wire according to IEC 60317 and impregnating agents according to IEC 60455-3-5 or IEC 60464-3-2 can affect one another during the thermal ageing process.

NOTE 1 Testing varnished specimens will allow for evaluation of the compatibility of the wire insulation with an impregnating agent. Thus, the temperature indices of different combinations can be compared.

Interaction between wire insulation and such agent may increase or decrease the relative thermal life of this combination compared with the life of the wire tested without impregnation. Therefore, with impregnated specimens, this test procedure may give an indication of the thermal endurance of a combination of wire insulation and impregnating agent.

If such impregnation is required, the following procedure shall be applied:

With the specimen in the vertical position, it shall be immersed in the impregnating agent for (60 ± 10) s. It shall be removed slowly and uniformly at a rate of about 1 mm/s. It shall be drained horizontally for 10 min to 15 min and cured horizontally according to the manufacturer's recommendation or to an agreed schedule. If more than one treatment is to be given, immerse, drain and cure the specimen vertically reversing the specimen for each subsequent treatment.

NOTE 2 Some impregnating agents, such as high viscosity or thixotropic products require alternative processing methods.

5.3 Notes on number of test specimens

The accuracy of the test results depends largely upon the number of test specimens aged at each temperature. A greater number of test specimens is required to achieve an acceptable degree of accuracy if there is a wide spread in results among the specimens exposed at each temperature.

Experience has shown that twenty specimens without impregnation and ten specimens with impregnation give results with an acceptable tolerance. A minimum of ten specimens shall be used.

5.4 Specimen holder

5.4.1 For specimens according to 5.1.1

Since individual handling of the twisted specimens may result in premature failures, it is recommended that the specimens be placed in a suitable holder, as shown in Figure 8. The holder should be designed in a manner that will protect the twisted specimens from external mechanical damage and warping. The holder will be so constructed as to allow the ends of the twist to protrude from the holder to make electrical connections for proof testing. The holder shall be designed for at least ten specimens to decrease handling time.



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Figure 8 – Specimen holder

5.4.2 For specimens according to 5.1.2

The specimen shall be hung in the oven. No special holder is required.