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REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

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

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

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

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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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:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
temperature index
TI

~~numerical value of the Celsius temperature expressed in degrees Celsius characterizing the thermal capability of an insulating material or an insulation system~~

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 insulating materials, the temperature index is derived from the thermal endurance relationship at a given time, normally 20 000 hours. It may be used as basis for determination of the material's temperature class.~~

Note ~~2~~ 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
~~*L*~~
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-storing~~ 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

5.1 Preparation

5.1.1 ~~Enamelled round wire with a nominal conductor diameter of 0,224 mm up to and including 2,65 mm~~ Enamelled non-tape wrapped round wire

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

~~Wire sizes 0,315 mm and 0,28 mm are permitted for use when the specification size range is limited to 0,50 mm and finer.~~

~~NOTE For round enamelled winding wires, in order to avoid undue fragility of the test specimen, experience has shown that nominal conductor diameters of 0,800 mm up to and including 2,65 mm are generally found convenient to handle and test.~~

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.

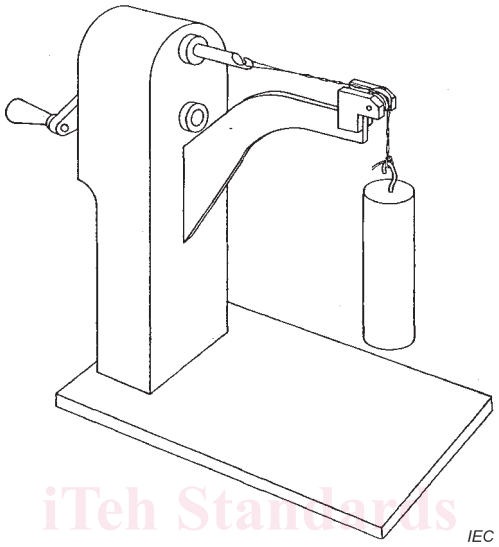


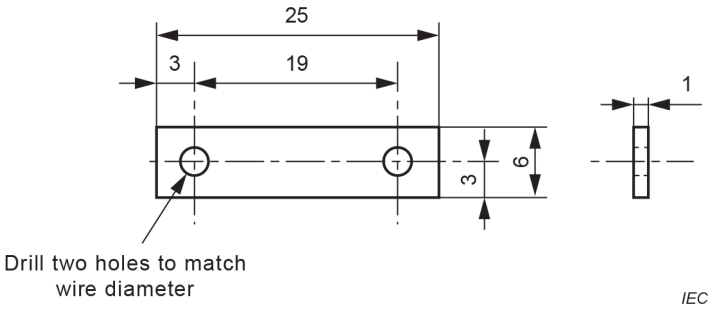
Figure 1 – Device used to form enamelled round wire test specimen

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	~~3,50~~ 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

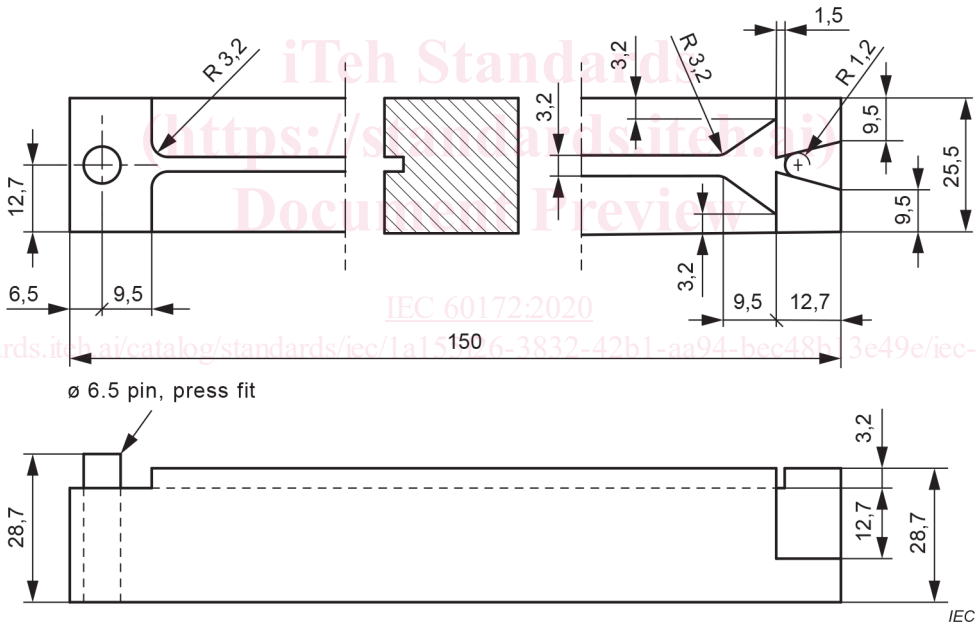


Material: Silicone glass laminate

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

Figure 3 – Twist forming jig

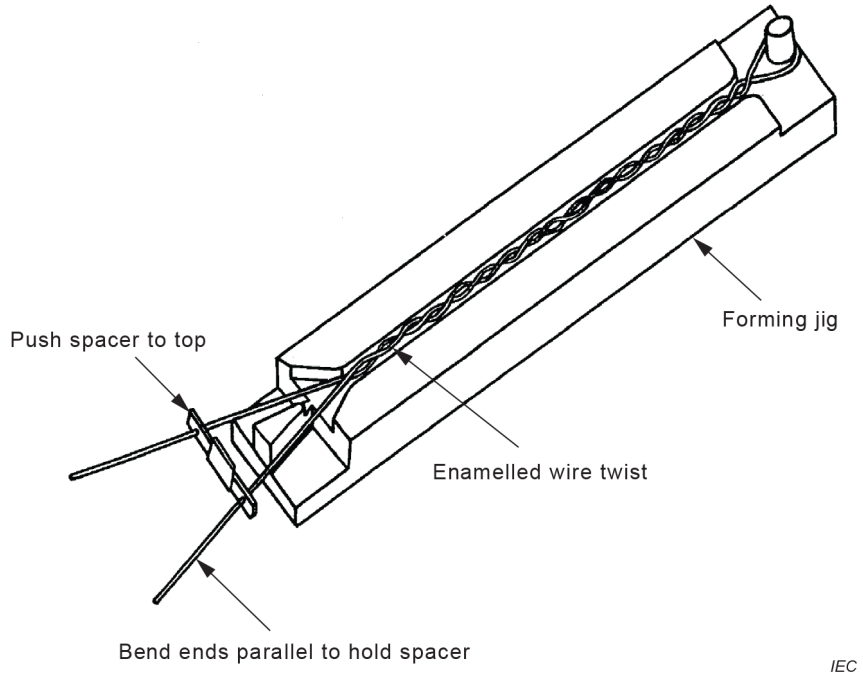


Figure 4 – Test specimen set up in forming jig

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.

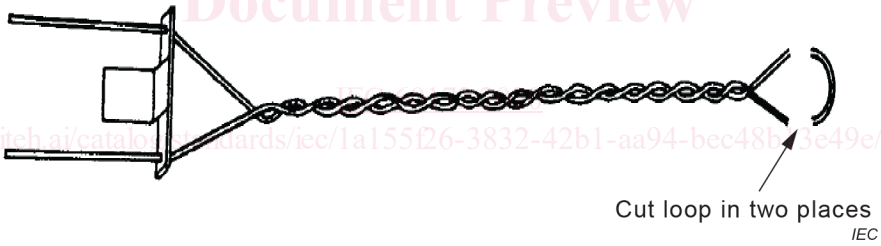


Figure 5 – Test specimen formed with loop cut

~~e)~~ In order to ensure homogeneity of the ~~batch~~ 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

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

~~NOTE This procedure applies to any convenient dimension of round or rectangular wire. However, selecting wires having dimensions that minimize the bending force needed to shape the test specimen will make the procedure easier to perform. Wire with high stiffness will yield specimens with poor wire-to-wire contact areas.~~

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.

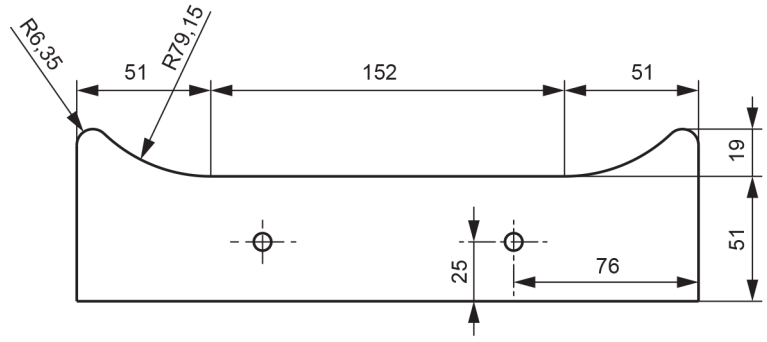
Specimens shall be prepared as follows:

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.

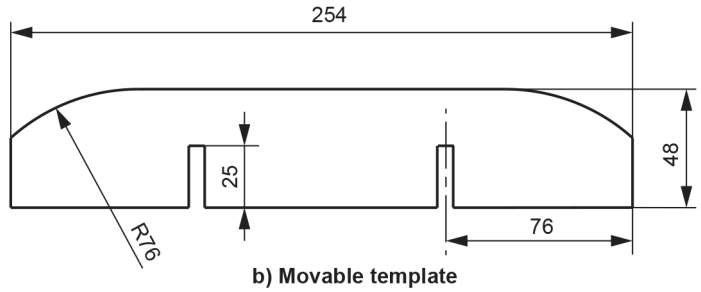
c) Each specimen shall be formed in a jig, as shown in Figure 6. This produces a straight centre section of about 150 mm with bent ends, which provide the necessary flare at both ends of the final specimen.

Dimensions in millimetres

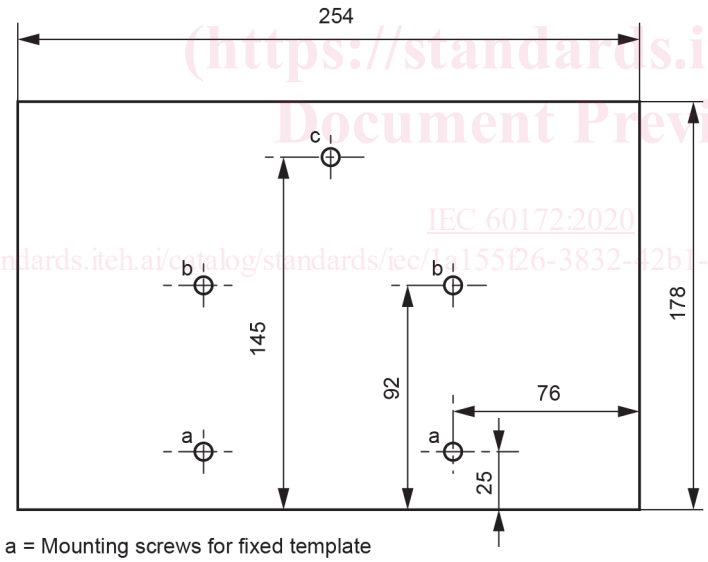


a) Fixed template

All parts 12,5 mm thick compound plate stock
Phenolic impregnated fabric

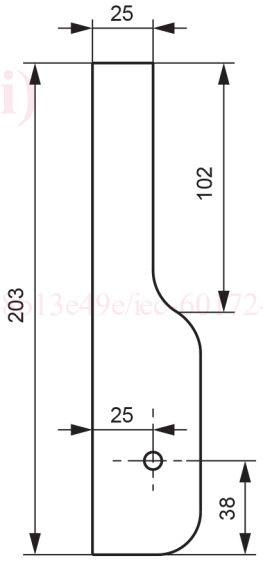


b) Movable template
(same dimensions a)



a = Mounting screws for fixed template
b = Mounting screws for movable template (template shall be free to slide)
c = Mounting screws for clamping lever (lever shall be free to rotate)

c) Platine



d) clamping lever

IEC

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