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Edition 4.0 2015-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

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

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

IEC 60172:2015-05(en-fr)

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

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

FOREWORD

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

This fourth edition cancels and replaces the third edition published in 1987, Amendment 1:1997 and Amendment 2:2010. This edition constitutes a technical revision.

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

– Revision of Clause 1, Scope, to incorporate appropriate text from former Clause 2, Object;
– Deletion of Clause 2, Object, by placement of its text into existing clauses;
– New Clause 2, Normative references;
– Revision of 5.1.1, 5.3 and 5.4 with corrections to Amendment 2 to the third edition;
– Revision of Clause 7 as to clarify which specimens comply with Table 3 and Table 4;
– Revision of figures with high-resolution photos and graphs.

The text of this standard is based on the following documents:

FDIS	Report on voting
55/1518/FDIS	55/1524/RVD

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

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

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication 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- withdrawn,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, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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.

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

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 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]

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 failure times for a set of specimens at one exposure temperature

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 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

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.

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.

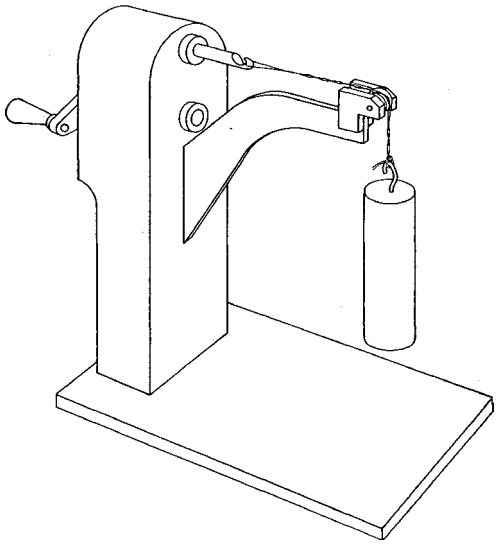
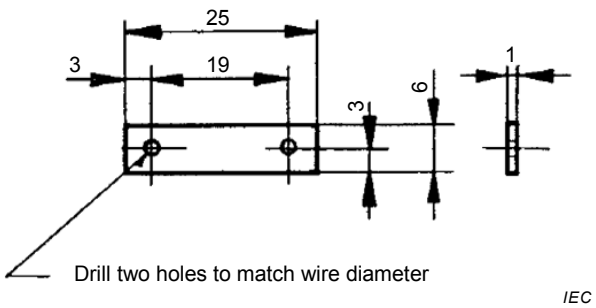


Figure 1 – Device used to form enamelled round wire test specimen

Table 1 – Force and number of twists for specimens

Nominal diameter mm		Force applied to wire pair 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	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.

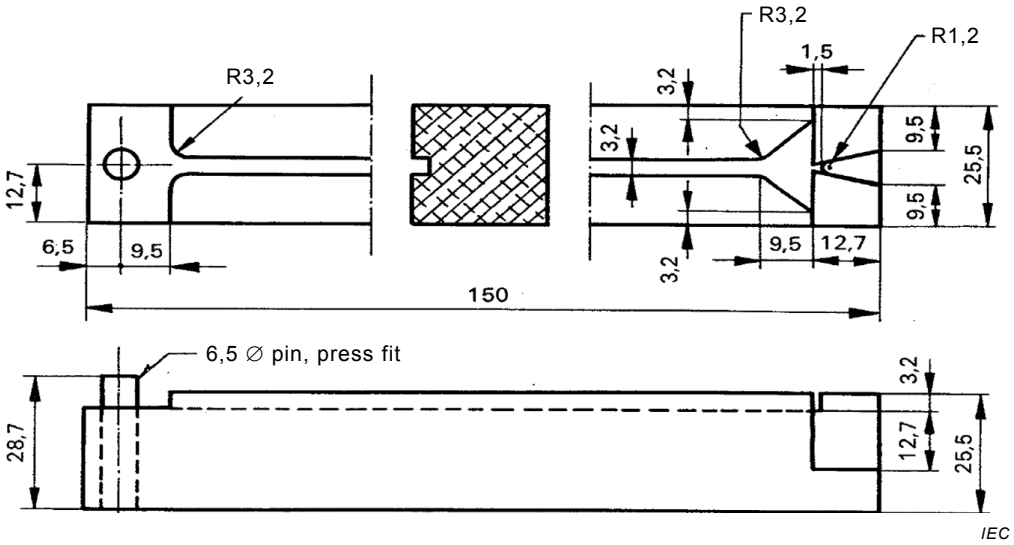


Material: Silicone glass laminate

Dimensions in millimetres

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.



R = Radius of bend

Dimensions in millimetres

Figure 3 – Twist forming jig

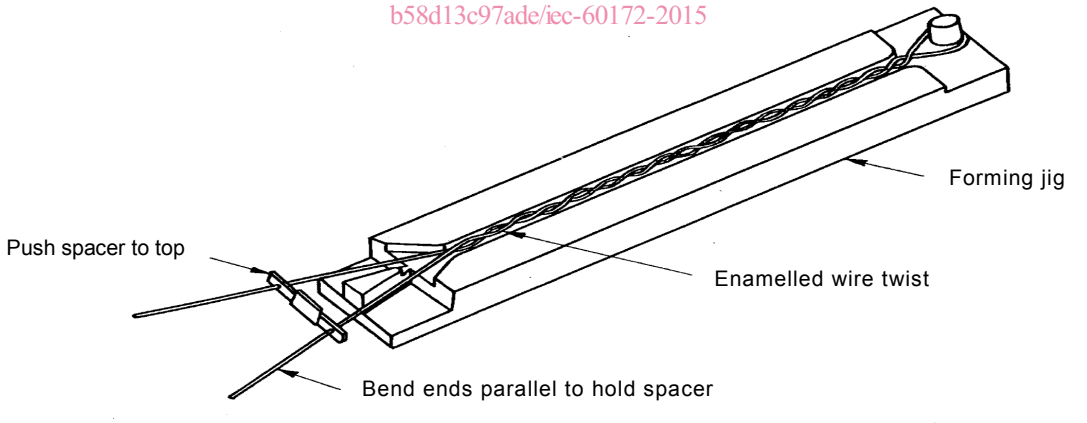


Figure 4 – Test specimen set up in forming jig

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.

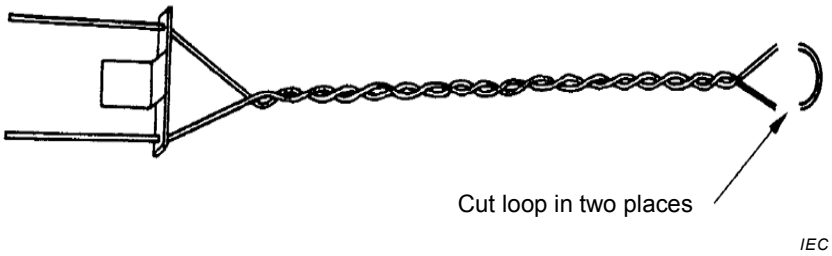


Figure 5 – Test specimen formed with loop cut

e) In order to ensure homogeneity of the batch of test specimens, it is recommended that test specimens be subjected to a test voltage three times the value given in Table 2 for 1 s.

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

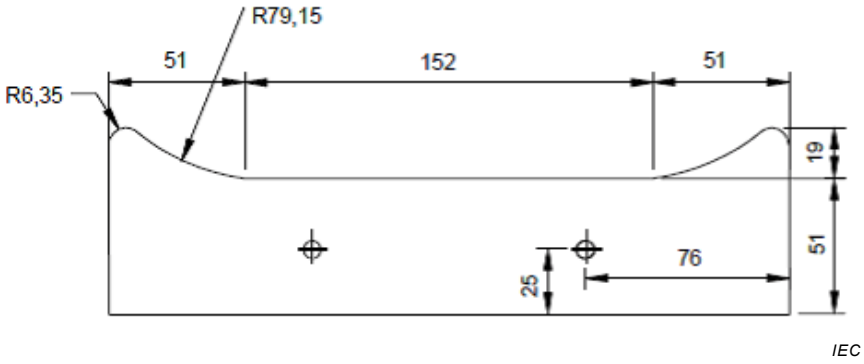
NOTE This procedure applies to any convenient dimension of round or rectangular wire. However, selecting wires having dimensions that minimize the bending force needed to shape the test specimen will make the procedure easier to perform. Wire with high stiffness will yield specimens with poor wire-to-wire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

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.

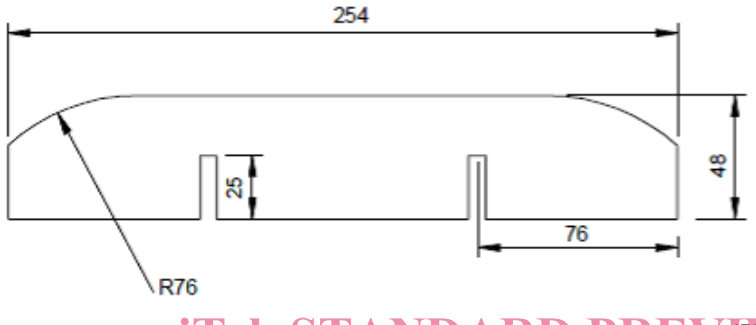
c) Each specimen shall be formed in a jig, as shown in Figure 6. This produces a straight centre section of about 150 mm with bent ends, which provide the necessary flare at both ends of the final specimen.



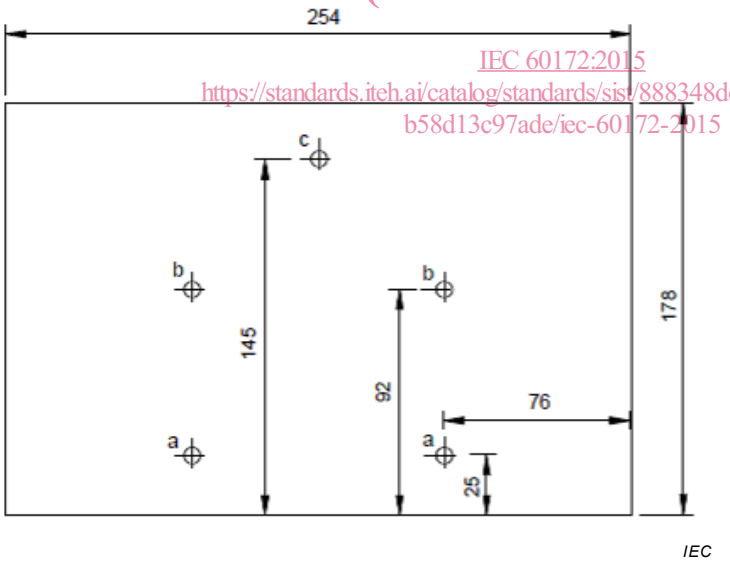
a) Fixed template

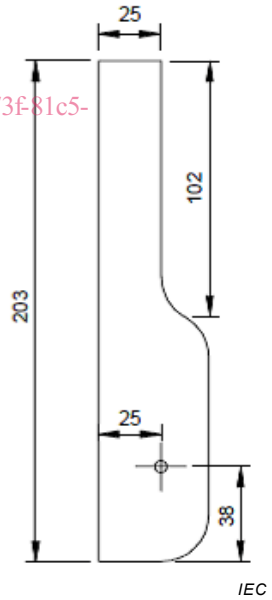
All parts 12,5 mm thick compound plate stock

Phenolic impregnated fabric



b) Movable template (same dimensions as a))





a mounting screws for fixed template

b mounting screws for movable template (template shall be free to slide)

c mounting screw for clamping lever (lever shall be free to rotate)

c) Platine

d) Clamping lever

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.

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 testing the specimen shall be proof-tested at 1 000 V a.c.

5.2 Varnish impregnation

Experience has shown that 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 (see note). 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 connection for the proof testing as shown in Figure 9. The holder shall be designed for at least ten specimens to decrease handling time.

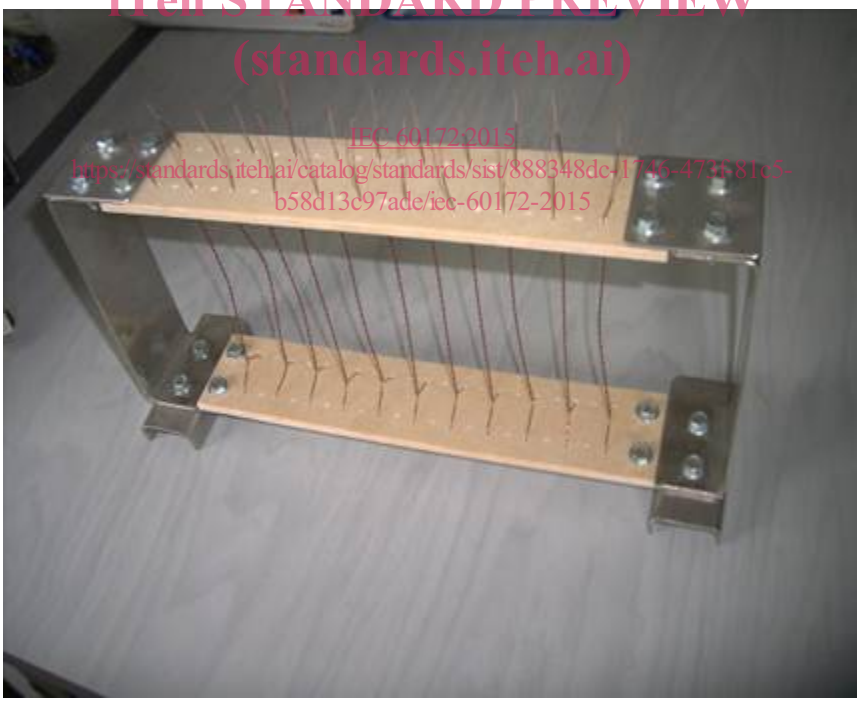


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Figure 8 – Specimen holder