

FINAL VERSION

VERSION FINALE



**Winding wires – Test methods –
Part 3: Mechanical properties**

**Fils de bobinage – Méthodes d'essai –
Partie 3: Propriétés mécaniques**

CONTENTS

1	Scope.....	7
2	Normative references	7
3	Test 6: Elongation	7
3.1	Elongation at fracture	7
3.2	Tensile strength	7
4	Test 7: Springiness.....	8
4.1	Round wire with a nominal conductor diameter from 0,080 mm up to and including 1,600 mm	8
4.1.1	Principle	8
4.1.2	Equipment	8
4.1.3	Procedure.....	9
4.2	Round wire with a nominal conductor diameter over 1,600 mm and rectangular wire	10
4.2.1	Principle	10
4.2.2	Equipment	10
4.2.3	Specimen	11
4.2.4	Procedure.....	11
5	Test 8: Flexibility and adherence	12
5.1	Mandrel winding test	12
5.1.1	Round wire	12
5.1.2	Rectangular wire	13
5.1.3	Covered bunched wire	14
5.2	Stretching test (applicable to enamelled round wire with a nominal conductor diameter over 1,600 mm).....	14
5.3	Jerk test (applicable to enamelled round wire with a nominal conductor diameter up to and including 1,000 mm)	15
5.4	Peel test (applicable to enamelled round wire with a nominal conductor diameter over 1,000 mm).....	15
5.5	Adherence test	17
5.5.1	Enamelled rectangular wire	17
5.5.2	Impregnated fibre covered round and rectangular wire	17
5.5.3	Fibre covered enamelled round and rectangular wire	17
5.5.4	Tape wrapped round and rectangular wire (for adhesive tape only)	18
6	Test 11: Resistance to abrasion (applicable to enamelled round wire)	18
6.1	Principle	18
6.2	Equipment	18
6.3	Procedure	19
7	Test 18: Heat bonding (applicable to enamelled round wire with a nominal conductor diameter over 0,050 mm up to and including 2 000 mm and to enamelled rectangular wire)	20
7.1	Vertical bond retention of a helical coil	20
7.1.1	Nominal conductor diameter up to and including 0,050 mm	20
7.1.2	Nominal conductor diameter over 0,050 mm up to and including 2,000 mm	20
7.2	Bond strength of a twisted coil.....	23
7.2.1	Principle	23
7.2.2	Equipment	23
7.2.3	Specimen	23

7.2.4	Procedure.....	25
7.2.5	Result.....	25
7.3	Enamelled rectangular wire heat bonding	26
Annex A (informative)	Bond strength of heat bonding wires	28
Annex B (informative)	Friction test methods	34
Figure 1	– Test equipment to determine springiness	8
Figure 2	– Construction and details of the mandrel (see Table 1).....	9
Figure 3	– Test equipment to determine springiness	11
Figure 4	– Test equipment for mandrel winding test	14
Figure 5	– Test equipment for jerk test.....	15
Figure 6	– Test equipment for peel test.....	16
Figure 7	– Scraper	17
Figure 8	– Cross-section of the wire after removal of the coating	17
Figure 9	– Test equipment for unidirectional scrape test	19
Figure 10	– Test equipment for bond retention of a helical coil.....	22
Figure 11	– Coil winder	24
Figure 12	– Oval shape coil	25
Figure 13	– Twisting device with a load applied to the twisted coil specimen	25
Figure 14	– Arrangement of supports	26
Figure 15	– Samples for heat bonding.....	27
Figure A.1	– Example of voltage-time graphs of twisted coil specimens with a nominal conductor diameter of 0,300 mm with isothermic graphs	30
Figure A.2	– Example of voltage-time graphs of twisted coil specimens with a nominal conductor diameter of 0,315 mm with isothermic graphs	31
Figure A.3	– Example of voltage-time graphs of twisted coil specimens with a nominal conductor diameter of 0,355 mm with isothermic graphs	32
Figure A.4	– Example of voltage-time graphs of twisted coil specimens with a nominal conductor diameter of 0,500 mm with isothermic graphs	33
Figure B.1	– Static coefficient of friction test apparatus.....	39
Figure B.2	– Dynamic coefficient of friction test apparatus	40
Figure B.3	– Diagram of a typical dynamic coefficient of friction tester	41
Figure B.4	– Material – sapphire (synthetic).....	42
Figure B.5	– Synthetic sapphires mounted on load block	43
Figure B.6	– Load applied perpendicular to wire path.....	43
Figure B.7	– Twisted specimen	44
Table 1	– Mandrels for springiness	9
Table 2	– Magnification to detect cracks	12
Table 3	– Load for peel test	16
Table 4	– Preparation of helical coils	21
Table 5	– Bond retention at elevated temperature.....	22
Table B.1	– Load block weights for dynamic coefficient of friction testing.....	37
Table B.2	– Twisted pair method.....	38

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**WINDING WIRES –
TEST METHODS –****Part 3: Mechanical properties**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

DISCLAIMER

This Consolidated version is not an official IEC Standard and has been prepared for user convenience. Only the current versions of the standard and its amendment(s) are to be considered the official documents.

This Consolidated version of IEC 60851-3 bears the edition number 3.2. It consists of the third edition (2009-01) [documents 55/1043/CDV and 55/1059/RVC], its amendment 1 (2013-07) [documents 55/1392/FDIS and 55/1407/RVD] and its amendment 2 (2019-08) [documents 55/1781/FDIS and 55/1798/RVD]. The technical content is identical to the base edition and its amendments.

This Final version does not show where the technical content is modified by amendments 1 and 2. A separate Redline version with all changes highlighted is available in this publication.

International Standard IEC 60851-3 has been prepared by IEC technical committee 55: Winding wires.

With respect to the previous edition, significant technical changes appear in Subclause 5.3, Jerk test.

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

A list of all the parts in the IEC 60851 series, under the general title *Winding wires – Test methods*, can be found on the IEC website.

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the stability date indicated on the IEC web site 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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication 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

This part of IEC 60851 forms an element of a series of standards, which deals with insulated wires used for windings in electrical equipment. The series has three groups describing

- a) winding wires – Test methods (IEC 60851);
- b) specifications for particular types of winding wires (IEC 60317);
- c) packaging of winding wires (IEC 60264).

WINDING WIRES – TEST METHODS –

Part 3: Mechanical properties

1 Scope

This part of IEC 60851 specifies the following methods of test for winding wires:

- Test 6: Elongation;
- Test 7: Springiness;
- Test 8: Flexibility and adherence;
- Test 11: Resistance to abrasion;
- Test 18: Heat bonding.

For definitions, general notes on methods of test and the complete series of methods of test for winding wires, see IEC 60851-1.

2 Normative references

The following referenced documents are indispensable for the application 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 60851-1, *Winding wires – Test methods – Part 1: General*

IEC 60851-2:1996, *Winding wires – Test methods – Part 2: Determination of dimensions*

ISO 178:2001, *Plastics – Determination of flexural properties*
Amendment 1:2004

3 Test 6: Elongation

3.1 Elongation at fracture

Elongation is the increase in length expressed as a percentage of the original length.

A straight piece of wire shall be elongated to the point of fracture of the conductor at a rate of (5 ± 1) mm/s with an elongation tester or with tensile testing equipment with a free measuring length of between 200 mm and 250 mm. The linear increase at fracture shall be calculated as a percentage of the free measuring length.

Three specimens shall be tested. The three single values shall be reported. The mean value represents elongation at fracture.

3.2 Tensile strength

Tensile strength is the ratio of the force at fracture to initial cross-section.