

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Specifications for particular types of winding wires –
Part 0-2: General requirements – Enamelled rectangular copper wire

Spécifications pour types particuliers de fils de bobinage –
Partie 0-2: Exigences générales – Fil de section rectangulaire en cuivre émaillé



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CONTENTS

FOREWORD	4
INTRODUCTION	6
1 Scope	7
2 Normative references	7
3 Terms, definitions, general notes and appearance	7
3.1 Terms and definitions	7
3.2 General notes	9
3.2.1 Methods of test	9
3.2.2 Winding wire	9
3.3 Appearance	9
4 Dimensions	9
4.1 Conductor dimensions	9
4.2 Tolerance on conductor dimensions	10
4.3 Rounding of corners	10
4.4 Increase in dimensions due to the insulation and the bonding layer	12
4.4.1 Enamelled wires without a bonding layer	12
4.4.2 Enamelled wires with a bonding layer	12
4.5 Overall dimensions	12
4.5.1 Nominal overall dimensions	12
4.5.2 Minimum overall dimensions	13
4.5.3 Maximum overall dimensions	13
5 Electrical resistance	13
6 Elongation	13
7 Springiness (applicable to nominal proof strength $\leq 80 \text{ N} \cdot \text{mm}^{-2}$)	14
8 Flexibility and adherence	14
8.1 Mandrel winding test	14
8.2 Adherence test	14
9 Heat shock	14
10 Cut-through	15
11 Resistance to abrasion	15
12 Resistance to solvents	15
13 Breakdown voltage	15
14 Continuity of insulation	15
15 Temperature index	15
16 Resistance to refrigerants	16
17 Solderability	16
18 Heat or solvent bonding	16
19 Dielectric dissipation factor	16
20 Resistance to transformer oil	16
21 Loss of mass	16
23 Pin hole test	16
30 Packaging	16

Annex A (informative) Nominal cross-sectional areas for preferred and intermediate sizes	18
Bibliography	27
Table 1 – Conductor tolerances	10
Table 2 – Nominal cross-sectional areas of preferred sizes	11
Table 3 – Corner radii	12
Table 4 – Increases in dimensions	12
Table 5 – Percentage elongation after fracture	13
Table 6 – Proof strength and resistivity	14
Table 7 – Mandrel winding	14
Table 8 – Breakdown voltage	15
Table A.1 – Nominal cross-sectional areas	18

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IEC 60317-0-2:2020

<https://standards.iteh.ai/catalog/standards/sist/5e45dfa5-355c-464c-ad8d-c870fc63c172/iec-60317-0-2-2020>

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SPECIFICATIONS FOR PARTICULAR TYPES OF WINDING WIRES –

Part 0-2: General requirements – Enamelled rectangular copper wire

FOREWORD

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International Standard IEC 60317-0-2 has been prepared by IEC technical committee 55: Winding wires.

This fourth edition cancels and replaces the third edition published in 2013. This edition constitutes a technical revision.

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

- a) revision to Clause 2 to add new normative references for specifications for copper rods;
- b) revision to 3.1 to add a new definition for the term "bonding layer";
- c) revision to 3.2.1 to the conditions specified for tests to be carried out;
- d) revision to 4.5 to add requirements for minimal, nominal and maximal overall dimensions with a bonding layer;
- e) revision to Clause 5 to reference specifications for rectangular and square copper rod;

- f) revision to Clause 6 to take into account nominal proof strength;
- g) revision to 8.2 to the adherence test requirement;
- h) revision to Clause 18 to make reference to the relevant specification sheet

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

FDIS	Report on voting
55/1847/FDIS	55/1865/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.

This International standard is to be read in conjunction with IEC 60851 (all parts). The clause numbers used in this part of IEC 60317 are identical with the respective test numbers of IEC 60851 (all parts).

In case of inconsistencies between IEC 60851 and this part of IEC 60317, the latter prevails.

The numbering of clauses in this standard is not continuous from Clauses 21 and 30 in order to reserve space for possible future wire requirements prior to those for wire packaging.

A list of all parts in the IEC 60317 series, published under the general title *Specifications for particular types of winding wires*, can be found on the IEC website.

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.

INTRODUCTION

This part of IEC 60317 forms an element of a series of standards which deals with insulated wires used for windings in electrical equipment. It is composed of the following series:

- 1) *Winding wires – Test methods* (IEC 60851 series);
- 2) *Specifications for particular types of winding wires* (IEC 60317 series);
- 3) *Packaging of winding wires* (IEC 60264 series).

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SPECIFICATIONS FOR PARTICULAR TYPES OF WINDING WIRES –

Part 0-2: General requirements – Enamelled rectangular copper wire

1 Scope

This part of IEC 60317 specifies the general requirements of enamelled rectangular copper winding wires.

The range of nominal conductor dimensions is given in 4.1 and the relevant specification sheet.

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 60172, *Test procedure for the determination of the temperature index of enamelled and tape wrapped winding wires*

IEC 60851 (all parts), *Winding wires – Test methods*

IEC 60851-3, *Winding wires – Test methods – Part 3: Mechanical properties*

ISO 3, *Preferred numbers – Series of preferred numbers*

ISO 1190-1, *Copper and copper alloys – Code of designation – Part 1: Designation of materials*

ISO 6892-1:2016, *Metallic materials – Tensile testing – Part 1: Method of test at room temperature*

EN 1977, *Copper and copper alloys – Copper drawing stock (wire rod)*

ASTM B49, *Standard Specification for Copper Rod for Electrical Purposes*

3 Terms, definitions, general notes and appearance

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6892-1:2016 and 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>

3.1.1

class

thermal performance of a wire expressed by the temperature index and the heat shock temperature

3.1.2

coating

material which is deposited on a conductor or wire by a suitable means and then dried and/or cured

3.1.3

conductor

bare metal after removal of the insulation

3.1.4

crack

opening in the insulation which exposes the conductor to view at the stated magnification

3.1.5

dual coating

insulation composed of two different materials, an underlying and a superimposed coating

3.1.6

enamelled wire

wire coated with an insulation of cured resin

3.1.7

grade

<enamelled rectangular copper wire> range of increase in the overall diameter of the wire due to the enamel

3.1.8

insulation

coating or covering on the conductor with the specific function of withstanding voltage

3.1.9

nominal conductor dimension

designation of the conductor size in accordance with the IEC 60317 series

3.1.10

normal vision

20/20 vision, with corrective lenses, if necessary

3.1.11

winding wire

wire used for winding a coil to provide a magnetic field

3.1.12

wire

conductor coated or covered with an insulation

3.1.13

bonding layer

material that is deposited on an enamelled wire on which has the specific function of bonding wires together

3.2 General notes

3.2.1 Methods of test

All methods of test to be used for this document are given in IEC 60851 (all parts).

The clause numbers used in this document are identical to the corresponding test numbers in IEC 60851 (all parts).

In case of inconsistencies between the publication on methods of test and this document, IEC 60317-0-2 shall prevail.

Where no specific range of nominal conductor dimensions is given for a test, the test applies to all nominal conductor dimensions covered by the specification sheet.

Unless otherwise specified, all tests shall be carried out at a temperature from 15 °C to 40 °C and a relative humidity from 25 % to 75 %. Before measurements are made, the specimens shall be preconditioned under these atmospheric conditions for a time sufficient to allow the specimens to reach stability.

The wire to be tested shall be removed from the packaging in such a way that the wire will not be subjected to tension or unnecessary bends. Before each test, sufficient wire should be discarded to ensure that any damaged wire is not included in the test specimens.

3.2.2 Winding wire

When reference is made to a winding wire according to a standard of the IEC 60317 series mentioned under Clause 2, the following information is given in the description:

- reference to IEC specification: [IEC 60317-0-2:2020](https://standards.iteh.ai/catalog/standards/sist/5e45dfa5-355c-464c-ad8d-8706111751f6/iec-60317-0-2-2020)
- nominal conductor dimensions in millimetres (width × thickness);
- grade;
- nominal proof strength minimum (and maximum) value.

EXAMPLE: IEC 60317-17 – 4,00 × 1,00 Grade 1 $R_{p0.2} = 120 \text{ N} \cdot \text{mm}^{-2}$

3.3 Appearance

The film coating shall be essentially smooth and continuous, free from streaks, blisters and foreign material when examined with normal vision, in accordance with good commercial practice, as wound on the original spool or reel.

4 Dimensions

4.1 Conductor dimensions

The dimensions for width and thickness of conductors of winding wires with rectangular cross-section, recommended in this document, are taken from the R 20 series in ISO 3.

Preferred sizes are combinations of width and thickness, both in accordance with the R 20 series.

Intermediate sizes are combinations of width or thickness in accordance with the R 20 series with the other dimension in accordance with the R 40 series.

This document covers:

- widths from 2,00 mm up to and including 31,50 mm;

– thicknesses from 0,80 mm up to and including 10,00 mm.

The ratio width/thickness shall be within the specified limits. Combinations of R 40 and R 40 are not allowed in the case of additional sizes.

The ratio width/thickness shall be greater than or equal to 1,4:1 and shall not exceed 8:1.

The actual values of dimensions are given in Table 2.

The nominal cross-sectional areas for preferred sizes are given in Table 2, and the nominal cross-sectional areas for intermediate sizes are given in Table A.1.

4.2 Tolerance on conductor dimensions

The conductor dimensions shall not differ from the nominal values by more than the tolerance given in Table 1.

Table 1 – Conductor tolerances

Nominal width or thickness of the conductor mm		Tolerance ± mm
Over	Up to and including	
3,15	3,15	0,030
6,30	6,30	0,050
12,50	12,50	0,070
16,00	16,00	0,100
22,40	22,40	0,130
31,50	31,50	0,150

4.3 Rounding of corners

The arc shall merge smoothly into the flat surfaces of the conductor and the strip shall be free from sharp, rough and projecting edges. The conductor shall have radiused corners complying with Table 3. The specified radii shall be maintained within $\pm 25\%$.

Table 2 – Nominal cross-sectional areas of preferred sizes

Width	Thickness																		
	mm																		
	0,80	0,90	1,00	1,12	1,25	1,40	1,60	1,80	2,00	2,24	2,50	2,80	3,15	3,55	4,00	4,50	5,00	5,60	6,30
	Corner radius																		
	0,80	0,90	1,00	1,12	1,25	1,40	1,60	1,80	2,00	2,24	2,50	2,80	3,15	3,55	4,00	4,50	5,00	5,60	6,30
2,00	1,463	1,626	1,785	2,025	2,285	2,585	2,921	3,313	3,723	4,155	4,615	5,105	5,625	6,175	6,755	7,365	7,995	8,645	9,315
2,24	1,655	1,842	2,025	2,294	2,585	2,921	3,369	3,855	4,375	4,935	5,535	6,165	6,825	7,515	8,235	8,985	9,765	10,575	11,415
2,50	1,863	2,076	2,285	2,585	2,910	3,285	3,785	4,317	4,885	5,495	6,145	6,835	7,565	8,335	9,145	9,995	10,875	11,785	12,725
2,80	2,103	2,346	2,585	2,921	3,285	3,705	4,265	4,875	5,535	6,245	6,995	7,785	8,615	9,485	10,395	11,345	12,335	13,365	14,435
3,15	2,383	2,661	2,935	3,313	3,723	4,195	4,825	5,507	6,245	7,035	7,875	8,765	9,705	10,695	11,735	12,825	13,965	15,155	16,395
3,55	2,703	3,021	3,335	3,761	4,223	4,755	5,465	6,227	7,055	7,955	8,915	9,935	10,995	12,105	13,265	14,475	15,735	17,045	18,405
4,00	3,063	3,426	3,785	4,265	4,785	5,385	6,185	7,037	7,957	8,947	9,997	11,107	12,277	13,507	14,797	16,147	17,557	19,027	20,557
4,50	3,463	3,876	4,285	4,825	5,410	6,085	6,985	7,937	8,957	10,047	11,207	12,437	13,737	15,107	16,547	18,057	19,637	21,287	23,007
5,00	3,863	4,326	4,785	5,385	6,035	6,785	7,785	8,837	9,957	11,147	12,417	13,767	15,197	16,707	18,297	19,967	21,717	23,547	25,457
5,60	4,343	4,866	5,385	6,057	6,785	7,625	8,745	9,917	11,167	12,497	13,907	15,397	16,977	18,647	20,397	22,227	24,137	26,127	28,197
6,30	4,903	5,496	6,085	6,841	7,660	8,605	9,865	11,245	12,705	14,245	15,865	17,565	19,345	21,205	23,145	25,165	27,265	29,445	31,705
7,10		6,216	6,885	7,737	8,660	9,725	11,15	12,42	13,84	15,54	17,20	19,33	21,82	24,66	27,54	31,09	34,64		
8,00			7,785	8,745	9,785	10,99	12,59	14,04	15,64	17,56	19,45	21,85	24,65	27,85	31,14	35,14	39,14	43,94	
9,00				9,865	11,04	12,39	14,19	15,84	17,64	19,80	21,95	24,65	27,80	31,40	35,14	39,64	44,14	49,54	55,36
10,0					12,29	13,79	15,79	17,64	19,64	22,04	24,45	27,45	30,95	34,95	39,14	44,14	49,14	55,14	61,66
11,2						15,47	17,71	19,80	22,04	24,73	27,45	30,81	34,73	39,21	43,94	49,54	55,14	61,86	69,22
12,5							19,79	22,14	24,64	27,64	30,70	34,45	38,83	43,83	49,14	55,39	61,64	69,14	77,41
14,0								24,84	27,64	31,00	34,45	38,65	43,55	49,15	55,14	62,14	69,14	77,54	86,86
16,0									31,64	35,48	39,45	44,25	49,85	56,25	63,14	71,14	79,14	88,74	99,46
18,0										39,96	44,45	49,85	56,15	63,35	71,14	80,14	89,14	99,94	112,1
20,0											49,45	55,45	62,45	70,45	79,14	89,14	99,14	111,1	124,7
22,4												62,17	70,01	78,97	88,74	99,94	111,1	124,6	139,8
25,0													78,20	88,20	99,14	111,6	124,1	139,1	156,2
28,0														98,85	111,1	125,1	139,1	155,9	175,1
31,5															125,1	140,9	156,6	175,5	197,1
* 0,5 x nominal thickness																			

Not recommended
Ratio width/thickness smaller than 1,4:1Not recommended
Ratio width/thickness over 8:1

Table 3 – Corner radii

Nominal thickness of conductor mm		Corner radius mm
Over	Up to and including	
–	1,00	0,5 × nominal thickness
1,00	1,60	0,50*
1,60	2,24	0,65**
2,24	3,55	0,80
3,55	5,60	1,00
5,60	10,00	1,25

If agreed between purchaser and supplier, the corner radii for wires with a width greater than 4,8 mm may be:

* 0,5 mm × t, where t is the nominal thickness of the conductor;

** 0,80 mm.

4.4 Increase in dimensions due to the insulation and the bonding layer

4.4.1 Enamelled wires without a bonding layer

The increase in width or thickness due to the insulation shall be as given in Table 4.

Table 4 – Increases in dimensions

Grade	Increase in dimensions mm		
	Minimum	Nominal	Maximum
1	0,06	0,085	0,11
2	0,12	0,145	0,17

4.4.2 Enamelled wires with a bonding layer

The increase in dimensions due to the bonding layer for grades 1B and 2B shall be (0,04 ± 0,01) mm.

4.5 Overall dimensions

4.5.1 Nominal overall dimensions

4.5.1.1 Nominal overall dimensions without a bonding layer

The nominal overall dimensions shall be calculated as the sum of the nominal bare conductor and the nominal increase in dimension due to the insulation.

4.5.1.2 Nominal overall dimensions with a bonding layer

The nominal overall dimensions shall be calculated as the sum of the nominal bare conductor, the nominal increase in dimension due to the insulation, and the nominal increase in dimension due to the bonding layer.

4.5.2 Minimum overall dimensions

4.5.2.1 Minimum overall dimensions without a bonding layer

The minimum overall dimensions shall be calculated as the sum of the minimum bare conductor and the minimum increase in dimension due to the insulation.

4.5.2.2 Minimum overall dimensions with a bonding layer

The minimum overall dimensions shall be calculated as the sum of the minimum bare conductor, the minimum increase in dimension due to the insulation, and the minimum increase in dimension due to the bonding layer.

4.5.3 Maximum overall dimensions

4.5.3.1 Maximum overall dimensions without a bonding layer

The maximum overall dimensions shall be calculated as the sum of the maximum bare conductor and the maximum increase in dimension due to the insulation.

4.5.3.2 Maximum overall dimensions with a bonding layer

The maximum overall dimensions shall be calculated as the sum of the maximum bare conductor, the maximum increase in dimension due to the insulation, and the maximum increase in dimension due to the bonding layer.

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5 Electrical resistance (standards.iteh.ai)

The copper rod being used shall comply with at least one of EN 1977, ISO 1190-1 or ASTM B49.

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The resistance of the wire shall be expressed as the DC resistance at 20 °C. The method used shall provide an accuracy of 0,5 %.

The maximum value of resistance shall be not greater than the value calculated for the minimum tolerated cross-sectional area of the conductor resulting from the minimum dimensions in thickness and width and the maximum for the corner radius, and with a resistivity given in Table 6.

One measurement shall be made.

6 Elongation

The percentage elongation after fracture shall be measured according to Clause 20 of ISO 6892-1:2016. When the nominal proof strength, plastic extension is not specified or a nominal proof strength, plastic extension of 80 N/mm² is required, the limits of Table 5 apply. Otherwise, the measurement is performed for reference only.

Table 5 – Percentage elongation after fracture

Nominal thickness of the conductor mm		Minimum elongation %
Over	Up to and including	
–	2,50	30
2,50	5,60	32
5,60	10,00	35