

# INTERNATIONAL STANDARD



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

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IEC 60317-0-2

Edition 4.0 2020-06  
REDLINE VERSION

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

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

ICS 29.060.10

ISBN 978-2-8322-8526-8

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**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.

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## 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 thickness of the insulation of a 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 and 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 ~~35~~ 40 °C and a relative humidity from ~~45~~ 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;
- 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 ~~and R 40~~ 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 ~~16,00~~ 31,50 mm;

– thicknesses from 0,80 mm up to and including ~~5,60~~ 10,00 mm.

~~For thicknesses over 5,60 mm up to and including 10 mm and for widths over 16 mm up to and including 25 mm where, for technical reasons, additional sizes may be needed, the R 40 series shall be used.~~ 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		Tolerance
Mm		
Over	Up to and including	± mm
–	3,15	0,030
3,15	6,30	0,050
6,30	12,50	0,070
12,50	16,00	0,100
16,00	22,40	0,130
22,40	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  $\pm 25\%$ .

\*—Dimensions according to R 20 series are printed in larger type.

Table 2 – Nominal cross-sectional areas of preferred sizes

Width mm	Thickness mm																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
	0,80	0,85	0,90	0,95	1,00	1,06	1,12	1,18	1,25	1,32	1,40	1,50	1,60	1,70	1,80	1,90	2,00	2,12	2,24	2,36	2,50	2,65	2,80	3,00	3,15	3,35	3,55	3,75	4,00	4,25	4,50	4,75	5,00	5,30	5,60																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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2,00	1,463	1,626	1,785	1,942	2,100	2,258	2,416	2,574	2,732	2,890	3,048	3,206	3,364	3,522	3,680	3,838	3,996	4,154	4,312	4,470	4,628	4,786	4,944	5,102	5,260	5,418	5,576	5,734	5,892	6,050	6,208	6,366	6,524	6,682	6,840	6,998	7,156	7,314	7,472	7,630	7,788	7,946	8,104	8,262	8,420	8,578	8,736	8,894	9,052	9,210	9,368	9,526	9,684	9,842	10,000	10,158	10,316	10,474	10,632	10,790	10,948	11,106	11,264	11,422	11,580	11,738	11,896	12,054	12,212	12,370	12,528	12,686	12,844	13,002	13,160	13,318	13,476	13,634	13,792	13,950	14,108	14,266	14,424	14,582	14,740	14,898	15,056	15,214	15,372	15,530	15,688	15,846	16,004	16,162	16,320	16,478	16,636	16,794	16,952	17,110	17,268	17,426	17,584	17,742	17,900	18,058	18,216	18,374	18,532	18,690	18,848	19,006	19,164	19,322	19,480	19,638	19,796	19,954	20,112	20,270	20,428	20,586	20,744	20,902	21,060	21,218	21,376	21,534	21,692	21,850	22,008	22,166	22,324	22,482	22,640	22,798	22,956	23,114	23,272	23,430	23,588	23,746	23,904	24,062	24,220	24,378	24,536	24,694	24,852	25,010	25,168	25,326	25,484	25,642	25,800	25,958	26,116	26,274	26,432	26,590	26,748	26,906	27,064	27,222	27,380	27,538	27,696	27,854	28,012	28,170	28,328	28,486	28,644	28,802	28,960	29,118	29,276	29,434	29,592	29,750	29,908	30,066	30,224	30,382	30,540	30,698	30,856	31,014	31,172	31,330	31,488	31,646	31,804	31,962	32,120	32,278	32,436	32,594	32,752	32,910	33,068	33,226	33,384	33,542	33,700	33,858	34,016	34,174	34,332	34,490	34,648	34,806	34,964	35,122	35,280	35,438	35,596	35,754	35,912	36,070	36,228	36,386	36,544	36,702	36,860	37,018	37,176	37,334	37,492	37,650	37,808	37,966	38,124	38,282	38,440	38,598	38,756	38,914	39,072	39,230	39,388	39,546	39,704	39,862	40,020	40,178	40,336	40,494	40,652	40,810	40,968	41,126	41,284	41,442	41,600	41,758	41,916	42,074	42,232	42,390	42,548	42,706	42,864	43,022	43,180	43,338	43,496	43,654	43,812	43,970	44,128	44,286	44,444	44,602	44,760	44,918	45,076	45,234	45,392	45,550	45,708	45,866	46,024	46,182	46,340	46,498	46,656	46,814	46,972	47,130	47,288	47,446	47,604	47,762	47,920	48,078	48,236	48,394	48,552	48,710	48,868	49,026	49,184	49,342	49,500	49,658	49,816	49,974	50,132	50,290	50,448	50,606	50,764	50,922	51,080	51,238	51,396	51,554	51,712	51,870	52,028	52,186	52,344	52,502	52,660	52,818	52,976	53,134	53,292	53,450	53,608	53,766	53,924	54,082	54,240	54,398	54,556	54,714	54,872	55,030	55,188	55,346	55,504	55,662	55,820	55,978	56,136	56,294	56,452	56,610	56,768	56,926	57,084	57,242	57,400	57,558	57,716	57,874	58,032	58,190	58,348	58,506	58,664	58,822	58,980	59,138	59,296	59,454	59,612	59,770	59,928	60,086	60,244	60,402	60,560	60,718	60,876	61,034	61,192	61,350	61,508	61,666	61,824	61,982	62,140	62,298	62,456	62,614	62,772	62,930	63,088	63,246	63,404	63,562	63,720	63,878	64,036	64,194	64,352	64,510	64,668	64,826	64,984	65,142	65,300	65,458	65,616	65,774	65,932	66,090	66,248	66,406	66,564	66,722	66,880	67,038	67,196	67,354	67,512	67,670	67,828	67,986	68,144	68,302	68,460	68,618	68,776	68,934	69,092	69,250	69,408	69,566	69,724	69,882	70,040	70,198	70,356	70,514	70,672	70,830	70,988	71,146	71,304	71,462	71,620	71,778	71,936	72,094	72,252	72,410	72,568	72,726	72,884	73,042	73,200	73,358	73,516	73,674	73,832	73,990	74,148	74,306	74,464	74,622	74,780	74,938	75,096	75,254	75,412	75,570	75,728	75,886	76,044	76,202	76,360	76,518	76,676	76,834	76,992	77,150	77,308	77,466	77,624	77,782	77,940	78,098	78,256	78,414	78,572	78,730	78,888	79,046	79,204	79,362	79,520	79,678	79,836	79,994	80,152	80,310	80,468	80,626	80,784	80,942	81,100	81,258	81,416	81,574	81,732	81,890	82,048	82,206	82,364	82,522	82,680	82,838	82,996	83,154	83,312	83,470	83,628	83,786	83,944	84,102	84,260	84,418	84,576	84,734	84,892	85,050	85,208	85,366	85,524	85,682	85,840	85,998	86,156	86,314	86,472	86,630	86,788	86,946	87,104	87,262	87,420	87,578	87,736	87,894	88,052	88,210	88,368	88,526	88,684	88,842	89,000	89,158	89,316	89,474	89,632	89,790	89,948	90,106	90,264	90,422	90,580	90,738	90,896	91,054	91,212	91,370	91,528	91,686	91,844	92,002	92,160	92,318	92,476	92,634	92,792	92,950	93,108	93,266	93,424	93,582	93,740	93,898	94,056	94,214	94,372	94,530	94,688	94,846	95,004	95,162	95,320	95,478	95,636	95,794	95,952	96,110	96,268	96,426	96,584	96,742	96,900	97,058	97,216	97,374	97,532	97,690	97,848	98,006	98,164	98,322	98,480	98,638	98,796	98,954	99,112	99,270	99,428	99,586	99,744	99,902	100,060	100,218	100,376	100,534	100,692	100,850	101,008	101,166	101,324	101,482	101,640	101,798	101,956	102,114	102,272	102,430	102,588	102,746	102,904	103,062	103,220	103,378	103,536	103,694	103,852	104,010	104,168	104,326	104,484	104,642	104,800	104,958	105,116	105,274	105,432	105,590	105,748	105,906	106,064	106,222	106,380	106,538	106,696	106,854	107,012	107,170	107,328	107,486	107,644	107,802	107,960	108,118	108,276	108,434	108,592	108,750	108,908	109,066	109,224	109,382	109,540	109,698	109,856	110,014	110,172	110,330	110,488	110,646	110,804	110,962	111,120	111,278	111,436	111,594	111,752	111,910	112,068	112,226	112,384	112,542	112,700	112,858	113,016	113,174	113,332	113,490	113,648	113,806	113,964	114,122	114,280	114,438	114,596	114,754	114,912	115,070	115,228	115,386	115,544	115,702	115,860	116,018	116,176	116,334	116,492	116,650	116,808	116,966	117,124	117,282	117,440	117,598	117,756	117,914	118,072	118,230	118,388	118,546	118,704	118,862	119,020	119,178	119,336	119,494	119,652	119,810	119,968	120,126	120,284	120,442	120,600	120,758	120,916	121,074	121,232	121,390	121,548	121,706	121,864	122,022	122,180	122,338	122,496	122,654	122,812	122,970	123,128	123,286	123,444	123,602	123,760	123,918	124,076	124,234	124,392	124,550	124,708	124,866	125,024	125,182	125,340	125,498	125,656	125,814	125,972	126,130	126,288	126,446	126,604	126,762	126,920	127,078	127,236	127,394	127,552	127,710	127,868	128,026	128,184	128,342	128,500	128,658	128,816	128,974	129,132	129,290	129,448	129,606	129,764	129,922	130,080	130,238	130,396	130,554	130,712	130,870	131,028	131,186	131,344	131,502	131,660	131,818	131,976	132,134	132,292	132,450	132,608	132,766	132,924	133,082	133,240	133,398	133,556	133,714	133,872	134,030	134,188	134,346	134,504	134,662	134,820	134,978	135,136	135,294	135,452	135,610	135,768	135,926	136,084	136,242	136,400	136,558	136,716	136,874	137,032	137,190	137,348	137,506	137,664	137,822	137,980	138,138	138,296	138,454	138,612	138,770	138,928	139,086	139,244	139,402	139,560	139,718	139,876	140,034	140,192	140,350	140,508	140,666	140,824	140,982	141,140	141,298	141,456	141,614	141,772	141,930	142,088	142,246	142,404	142,562	142,720	142,878	143,036	143,194	143,352	143,510	143,668	143,826	143,984	144,142	144,300	144,458	144,616	144,774	144,932	145,090	145,248	145,406	145,564	145,722	145,880	146,038	146,196	146,354	146,512	146,670	146,828	146,986	147,144	147,302	147,460	147,618	147,776	147,934	148,092	148,250	148,408	148,566	148,724	148,882	149,040	149,198	149,356	149,514	149,672	149,830	149,988	150,146	150,304	150,462	150,620	150,778	150,936	151,094	151,252	151,410	151,568	151,726	151,884	152,042	152,200	152,358	152,516	152,674	152,832	152,990	153,148	153,306	153,464	153,622	153,780	153,938	154,096	154,254	154,412	154,570	154,728	154,886	155,044	155,202	155,360	155,518	155,676	155,834	155,992	156,150	156,308	156,466	156,624	156,782	156,940	157,098	157,256	157,414	157,572	157,730	157,888	158,046	158,204	158,362	158,520	158,678	158,836	158,994	159,152	159,310	159,468	159,626	159,784	159,942	160,100	160,258	160,416	160,574	160,732	160,890	161,048	161,206	161,364	161,522	161,680	161,838	161,996	162,154	162,312	162,470	162,628	162,786	162,944	163,102	163,260	163,418	163,576	163,734	163,892	164,050	164,208	164,366	164,524	164,682	164,840	164,99

Thickness mm	Width																													
	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	7,10	8,00	9,00	10,0							
	Corner radius (0,5 mm)										Corner radius (0,80 mm)										Corner radius (1,0 mm)									
2,00	1,463	1,626	1,785	2,025	2,285	2,585																								
2,24	1,655	1,842	2,025	2,294	2,585	2,921	3,369																							
2,50	1,863	2,076	2,285	2,585	2,910	3,285	3,785	4,137																						
2,80	2,103	2,346	2,585	2,921	3,285	3,705	4,265	4,677	5,237																					
3,15	2,383	2,661	2,935	3,313	3,723	4,195	4,825	5,307	5,937	6,693																				
3,55	2,703	3,021	3,335	3,761	4,223	4,755	5,465	6,027	6,737	7,589	8,326																			
4,00	3,063	3,426	3,785	4,265	4,785	5,385	6,185	6,837	7,637	8,597	9,451	10,65																		
4,50	3,463	3,876	4,285	4,825	5,410	6,085	6,985	7,737	8,637	9,717	10,70	12,05	13,63																	
5,00	3,863	4,326	4,785	5,385	6,035	6,785	7,785	8,637	9,637	10,84	11,95	13,45	15,20	17,20																
5,60	4,343	4,866	5,385	6,057	6,785	7,625	8,745	9,717	10,84	12,18	13,45	15,13	17,09	19,33	21,54															
6,30	4,903	5,496	6,085	6,841	7,660	8,605	9,865	10,98	12,24	13,75	15,20	17,09	19,30	21,82	24,34	27,49														
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	21,96	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	69,66										
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	78,18	88,26									
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	87,41	98,66	111,2								
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	98,06	110,7	124,7	138,7							
16,0									31,64	35,48	39,45	44,25	49,85	56,25	63,14	71,14	79,14	88,74	99,46	112,3	126,7	142,7	158,7							
18,0										39,96	44,45	49,85	56,15	63,35	71,14	80,14	89,14	99,94	112,1	126,5	142,7	160,7	178,7							
20,0											49,45	55,45	62,45	70,45	79,14	89,14	99,14	111,1	124,7	140,7	158,7	178,7	198,7							
22,4												62,17	70,01	78,97	88,74	99,94	111,1	124,6	139,8	157,7	177,9	200,3	222,7							
25,0													78,20	88,20	99,14	111,6	124,1	139,1	156,2	176,2	198,7	223,7	248,7							
28,0																														
31,5																														

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

Not recommended  
Ratio width/thickness over 8:1

\* 0,5 x nominal thickness

**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

**NOTE** 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. ~~See also note under 4.5.3.~~

### 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.

~~NOTE—When agreed between purchaser and supplier, special tolerances for grade 2 as given in Annex B can be used to calculate special maximum and minimum dimensions.~~

### 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.

## 5 Electrical resistance

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

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 ~~of  $1/58 \Omega \cdot \text{mm}^2 \cdot \text{m}^{-1}$~~  given in Table 6.

One measurement shall be made.

## 6 Elongation

~~The elongation at fracture shall be in accordance with the values given in Table 5.~~

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/mm<sup>2</sup> 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

When the value of nominal proof strength, plastic extension is specified, the measured proof strength shall be within the tolerances given in Table 6.

**Table 6 – Proof strength and resistivity**

Proof strength		Maximum resistivity $\Omega \cdot \text{mm}^2 \cdot \text{m}^{-1}$
Nominal value $\text{N} \cdot \text{mm}^{-2}$	Tolerance	
80	-0 / +30 %	1/58
120	-0 / +20 %	1/58
150	-0 / +20 %	1/58
180	-0 / +20 %	1/57,5

The proof strength, plastic extension shall be measured at the specified percentage of plastic extension, with the method described in Clause 13 of ISO 6892-1:2016; if not otherwise specified, the percentage shall be 0,2 % ( $R_{p0,2}$ ).

If required by the customer, the test shall be performed according to Clause 10 of ISO 6892-1:2016. Otherwise, the test shall be performed as described in IEC 60851-3.

## 7 Springiness (applicable to nominal proof strength $\leq 80 \text{ N} \cdot \text{mm}^{-2}$ )

The wire shall not exceed the maximum springback of 5°.

## 8 Flexibility and adherence

### 8.1 Mandrel winding test

The coating shall show no crack after the wire has been bent flatwise and edgewise on a mandrel with a diameter as specified in Table 7.

**Table 7 – Mandrel winding**

Wire bent on		Mandrel diameter
Width	Sizes up to and including 10 mm	4 × width
	Sizes over 10 mm	5 × width
Thickness	All sizes	4 × thickness

### 8.2 Adherence test

The wire shall be stretched by 15 % or to the breaking point, whichever is less. The distance of loss of adherence shall be less than 1 × width.

## 9 Heat shock

The coating shall show no crack after the wire has been bent flatwise on a mandrel with a diameter of six times the thickness.

The minimum heat shock temperature is given in the relevant specification sheet.

## 10 Cut-through

Test requirement under consideration.

## 11 Resistance to abrasion

Test inappropriate.

## 12 Resistance to solvents

Using a pencil of hardness "H" and standard solvent, the coating shall not be removed.

## 13 Breakdown voltage

When tested at room temperature, at least four of the five specimens tested shall not break down at a voltage less than or equal to that given in Table 8, and the fifth shall not break down at less than 50 % of the values specified.

When required by the purchaser, the wire shall be tested at elevated temperature.

The elevated temperature is given in the relevant specification sheet.

**Table 8 – Breakdown voltage**

Grade	Minimum breakdown voltage (r.m.s.) V	
	Room temperature	Elevated temperature
1	1 000	750
2	2 000	1 500

Grade	Minimum breakdown voltage (RMS) V			
	Without bonding layer		With bonding layer	
	Room temperature	Elevated temperature	Room temperature	Elevated temperature
1	1 000	750	1 500	1 000
2	2 000	1 500	2 500	2 000

## 14 Continuity of insulation

Test inappropriate.

## 15 Temperature index

The test shall be carried out on a rectangular wire in accordance with IEC 60172, unless otherwise agreed between the purchaser and the supplier.

When required by a purchaser, the supplier of the enamelled wire shall supply evidence that the wire meets the requirements for the temperature index.

NOTE 1 The temperature index requirement based on an extrapolated life of 20 000 h relates to enamelled wires tested unvarnished and not as part of an insulation system.

NOTE 2 Temperature in degrees Celsius corresponding to the temperature index is not necessarily that at which it is recommended that the wire be operated, and this will depend on many factors including the type of equipment involved.

## 16 Resistance to refrigerants

Test inappropriate.

## 17 Solderability

Test inappropriate.

## 18 Heat or solvent bonding

~~Test inappropriate.~~ For requirements, the relevant specification sheet applies.

## 19 Dielectric dissipation factor

For requirements, the relevant specification sheet applies.

## 20 Resistance to transformer oil

For requirements, the relevant specification sheet applies.

## 21 Loss of mass

Test inappropriate.

## 23 Pin hole test

Test inappropriate.

### 30 Packaging

The kind of packaging may influence certain properties of the wire, for example ~~springback~~ **springiness and proof strength**. Therefore, the kind of packaging for example, the type of spool, shall be agreed between the purchaser and the supplier.

The wire shall be evenly and compactly wound on spools or placed in containers. No spool or container shall contain more than one length of wire unless agreed to by the purchaser and the supplier. Marking of the label when there is more than one length and/or identification of the separate lengths in the package shall be agreed to by the purchaser and the supplier.

Where wires are delivered in coils, the dimensions and the maximum weights of such coils shall be agreed between the purchaser and the supplier. Any additional protection for coils shall also be agreed between the purchaser and the supplier.

Labels shall be attached to each packaging unit as agreed between the supplier and the user and shall include the following information:

- a) manufacturer's name and/or trademark;
- b) type of wire and insulation, for instance trade name and/or IEC specification number;
- c) having a bonding layer (if any);
- d) nominal proof strength;
- e) net mass of wire;
- f) nominal dimension(s) of wire and grade of insulation;
- g) date of manufacture.

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**Annex A**  
(informative)

**Nominal cross-sectional areas for preferred and intermediate sizes**

Table A.1 provides nominal cross-sectional areas for preferred and intermediate sizes of rectangular copper bare conductors, from which the user may select intermediate sizes only for technical reasons.

**Table A.1 – Nominal cross-sectional areas**

Nominal width mm	Nominal thickness mm	Radius-on corners mm	Nominal cross-section area mm <sup>2</sup>	Nominal width mm	Nominal thickness mm	Radius-on corners mm	Nominal cross-section area mm <sup>2</sup>	
2,00	0,80	*	1,463	2,50	1,25	0,5	2,910	
	0,85	*	1,545		1,32	0,5	3,085	
	0,90	*	1,626		1,40	0,5	3,285	
	0,95	*	1,706		1,50	0,5	3,535	
	1,00	*	1,785		1,60	0,5	3,785	
	1,06	0,5	1,905		1,70	0,65	3,887	
	2,12	1,12	0,5	2,025	1,80	0,65	4,137	
		1,18	0,5	2,145	2,65	0,80	*	1,983
		1,25	0,5	2,285		0,90	*	2,211
		1,32	0,5	2,425		1,00	*	2,435
		1,40	0,5	2,585		1,12	0,5	2,753
		0,80	*	1,559		1,25	0,5	3,098
0,90		*	1,734	1,40		0,5	3,495	
1,00		*	1,905	1,60	0,5	4,025		
2,24		1,12	0,5	2,160	1,80	0,65	4,407	
		1,25	0,5	2,435	2,80	0,80	*	2,103
		1,40	0,5	2,753		0,85	*	2,225
		0,80	*	1,655		0,90	*	2,346
	0,85	*	1,749	0,95		*	2,466	
	0,90	*	1,842	1,00		*	2,585	
	0,95	*	1,934	1,06		0,5	2,753	
	1,00	*	2,025	1,12	0,5	2,921		
	2,36	1,12	0,5	2,294	1,18	0,5	3,089	
		1,18	0,5	2,429	1,25	0,5	3,285	
		1,25	0,5	2,585	1,32	0,5	3,481	
		1,32	0,5	2,742	1,40	0,5	3,705	
1,40		0,5	2,921	1,50	0,5	3,985		
1,50		0,5	3,145	1,60	0,5	4,265		
1,60		0,5	3,369	1,70	0,65	4,397		
2,50		0,80	*	1,751	1,80	0,65	4,677	
		0,90	*	1,950	1,90	0,65	4,957	
		1,00	*	2,145	2,00	0,65	5,237	
		1,12	0,5	2,429	3,00	0,80	*	2,263
		1,25	0,5	2,735		0,90	*	2,526
	1,40	0,5	3,089	1,00		*	2,785	
	1,60	0,5	3,561	1,12		0,5	3,145	
	0,80	*	1,863	1,25		0,5	3,535	
	0,85	*	1,970	1,40		0,5	3,985	
	2,65	0,90	*	2,076	1,60	0,5	4,585	
		0,95	*	2,181	1,80	0,65	5,037	
		1,00	*	2,285	2,00	0,65	5,637	
1,06		0,5	2,435	3,15	0,80	*	2,383	
1,12		0,5	2,585		0,85	*	2,522	
1,18		0,5	2,736					

\*—0,5 nominal thickness

Table A.1 (2 of 7)

Nominal width mm	Nominal thickness mm	Radius on corners mm	Nominal cross-section area mm <sup>2</sup>	Nominal width mm	Nominal thickness mm	Radius on corners mm	Nominal cross-section area mm <sup>2</sup>
3,15	0,90	*	2,664	3,75	0,80	*	2,863
	0,95	*	2,799		0,90	*	3,204
	1,00	*	2,935		1,00	*	3,535
	1,06	0,5	3,124	1,12	0,5	3,985	
	1,12	0,5	3,313	1,25	0,5	4,473	
	1,18	0,5	3,502	1,40	0,5	5,035	
	1,25	0,5	3,723	1,60	0,5	5,785	
	1,32	0,5	3,943	4,00	1,80	0,65	6,387
	1,40	0,5	4,195		2,00	0,65	7,137
	1,50	0,5	4,510		2,24	0,65	8,037
	1,60	0,5	4,825		2,50	0,8	8,826
	1,70	0,65	4,992		0,80	*	3,063
	1,80	0,65	5,307		0,85	*	3,245
	1,90	0,65	5,622	0,90	*	3,426	
	2,00	0,65	5,937	0,95	*	3,606	
	2,12	0,65	6,315	1,00	*	3,785	
	2,24	0,65	6,693	3,35	1,06	0,5	4,025
3,35	0,80	*	2,543		1,12	0,5	4,265
	0,90	*	2,841		1,18	0,5	4,505
	1,00	*	3,135		1,25	0,5	4,785
	1,12	0,5	3,537		1,32	0,5	5,065
	1,25	0,5	3,973		1,40	0,5	5,385
	1,40	0,5	4,475		1,50	0,5	5,785
	1,60	0,5	5,145		1,60	0,5	6,185
	1,80	0,65	5,667		1,70	0,65	6,437
	2,00	0,65	6,337		1,80	0,65	6,837
	2,24	0,65	7,141	1,90	0,65	7,237	
3,55	0,80	*	2,703	2,00	0,65	7,637	
	0,85	*	2,862	2,12	0,65	8,117	
	0,90	*	3,021	2,24	0,65	8,597	
	0,95	*	3,179	4,25	2,36	0,8	8,894
	1,00	*	3,335		2,50	0,8	9,454
	1,06	0,5	3,548		2,65	0,8	10,05
	1,12	0,5	3,761		2,80	0,8	10,65
	1,18	0,5	3,974		0,80	*	3,263
	1,25	0,5	4,223		0,90	*	3,651
	1,32	0,5	4,471	1,00	*	4,035	
	1,40	0,5	4,755	1,12	0,5	4,545	
	1,50	0,5	5,110	1,25	0,5	5,098	
	1,60	0,5	5,465	1,40	0,5	5,735	
	1,70	0,65	5,672	1,60	0,5	6,585	
	1,80	0,65	6,027	4,00	1,80	0,65	7,287
	1,90	0,65	6,382		2,00	0,65	8,137
	2,00	0,65	6,737		2,24	0,65	9,157
2,12	0,65	7,163	2,50		0,8	10,08	
2,24	0,65	7,589	2,80		0,8	11,35	
2,36	0,8	7,829					
2,50	0,8	8,326					

\*—0,5 nominal thickness

**Table A.1 (3 of 7)**

Nominal width mm	Nominal thickness mm	Radius-on corners mm	Nominal cross-section area mm <sup>2</sup>	Nominal width mm	Nominal thickness mm	Radius-on corners mm	Nominal cross-section area mm <sup>2</sup>		
4,50	0,80	*	3,463	5,00	1,70	0,65	8,137		
	0,85	*	3,670		1,80	0,65	8,637		
	0,90	*	3,876		1,90	0,65	9,137		
	0,95	*	4,081		2,00	0,65	9,637		
	1,00	*	4,285		2,12	0,65	10,24		
	1,06	0,5	4,555		2,24	0,65	10,84		
	1,12	0,5	4,825		2,36	0,8	11,25		
	1,18	0,5	5,095		2,50	0,8	11,95		
	1,25	0,5	5,410		2,65	0,8	12,70		
	1,32	0,5	5,725		2,80	0,8	13,45		
	1,40	0,5	6,085		3,00	0,8	14,45		
	1,50	0,5	6,535		3,15	0,8	15,20		
	1,60	0,5	6,985		3,35	0,8	16,20		
	1,70	0,65	7,287		3,55	0,8	17,20		
	1,80	0,65	7,737		5,30	0,80	*	4,103	
	1,90	0,65	8,187	0,90		*	4,596		
	2,00	0,65	8,637	1,00		*	5,085		
	2,12	0,65	9,177	1,12		0,5	5,721		
	2,24	0,65	9,717	1,25		0,5	6,410		
	2,36	0,8	10,07	1,40		0,5	7,205		
	2,50	0,8	10,70	1,60		0,5	8,265		
	2,65	0,8	11,38	1,80		0,65	9,177		
	2,80	0,8	12,05	2,00		0,65	10,24		
	3,00	0,8	12,95	2,24		0,65	11,51		
	3,15	0,8	13,63	5,60		2,50	0,8	12,70	
	4,75	0,80	*			3,663	2,80	0,8	14,29
		0,90	*			4,101	3,15	0,8	16,15
		1,00	*			4,535	3,55	0,8	18,27
	1,12	0,5	5,105			0,80	*	4,343	
	1,25	0,5	5,723		0,85	*	4,605		
1,40	0,5	6,435	0,90		*	4,866			
1,60	0,5	7,385	0,95		*	5,126			
1,80	0,65	8,188	1,00		*	5,385			
2,00	0,65	9,137	1,06		0,5	5,721			
2,24	0,65	10,28	1,12		0,5	6,057			
2,50	0,8	11,33	1,18		0,5	6,393			
2,80	0,8	12,75	1,25		0,5	6,785			
3,15	0,8	14,41	1,32		0,5	7,177			
5,00	0,80	*	3,863		1,40	0,5	7,625		
	0,85	*	4,095	1,50	0,5	8,185			
	0,90	*	4,326	1,60	0,5	8,745			
	0,95	*	4,556	1,70	0,65	9,157			
	1,00	*	4,785	1,80	0,65	9,717			
	1,06	0,5	5,085	1,90	0,65	10,28			
	1,12	0,5	5,385	2,00	0,65	10,84			
	1,18	0,5	5,685	2,12	0,65	11,51			
	1,25	0,5	6,035	2,24	0,65	12,18			
	1,32	0,5	6,385	2,36	0,8	12,67			
	1,40	0,5	6,785	2,50	0,8	13,45			
	1,50	0,5	7,285	2,65	0,8	14,29			
	1,60	0,5	7,785	2,80	0,8	15,13			

\* — 0,5 nominal thickness

Table A.1 (4 of 7)

Nominal width mm	Nominal thickness mm	Radius-on corners mm	Nominal cross-section area mm <sup>2</sup>	Nominal width mm	Nominal thickness mm	Radius-on corners mm	Nominal cross-section area mm <sup>2</sup>
5,60	3,00	0,8	16,25	6,30	3,75	1,0	22,77
	3,15	0,8	17,09		4,00	1,0	24,34
	3,35	0,8	18,21		4,25	1,0	25,92
	3,55	0,8	19,33		4,50	1,0	27,49
	3,75	1,0	20,14	6,70	0,90	*	5,856
	4,00	1,0	21,54		1,00	*	6,485
6,00	0,80	*	4,663	1,12	0,5	7,289	
	0,90	*	5,226	1,25	0,5	8,160	
	1,00	*	5,785	1,40	0,5	9,165	
	1,12	0,5	6,505	1,60	0,5	10,51	
	1,25	0,5	7,285	1,80	0,65	11,70	
	1,40	0,5	8,185	2,00	0,65	13,04	
	1,60	0,5	9,385	2,24	0,65	14,65	
	1,80	0,65	10,44	2,50	0,8	16,20	
	2,00	0,65	11,64	2,80	0,8	28,21	
	2,24	0,65	13,08	3,15	0,8	20,56	
	2,50	0,8	14,45	3,55	0,8	23,24	
	2,80	0,8	16,25	4,00	1,0	25,94	
	3,15	0,8	18,35	4,50	1,0	29,29	
	3,55	0,8	20,75	7,10	0,90	*	6,216
	4,00	1,0	23,14	0,95	*	6,551	
	6,30	0,80	*	4,903	1,00	*	6,885
0,85		*	5,200	1,06	0,5	7,311	
0,90		*	5,496	1,12	0,5	7,737	
0,95		*	5,791	1,18	0,5	8,163	
1,00		*	6,085	1,25	0,5	8,660	
1,06		0,5	6,463	1,32	0,5	9,157	
1,12		0,5	6,841	1,40	0,5	9,725	
1,18		0,5	7,219	1,50	0,5	10,44	
1,25		0,5	7,660	1,60	0,5	11,15	
1,32		0,5	8,101	1,70	0,65	11,71	
1,40		0,5	8,605	1,80	0,65	12,42	
1,50		0,5	9,235	1,90	0,65	13,13	
1,60		0,5	9,865	2,00	0,65	13,84	
1,70		0,65	10,35	2,12	0,65	14,69	
1,80		0,65	10,98	2,24	0,65	15,54	
1,90		0,65	11,61	2,36	0,8	16,21	
2,00		0,65	12,24	2,50	0,8	17,20	
2,12		0,65	12,99	2,65	0,8	18,27	
2,24		0,65	13,75	2,80	0,8	19,33	
2,36		0,8	14,32	3,00	0,8	20,75	
2,50		0,8	15,20	3,15	0,8	21,82	
2,65		0,8	16,15	3,35	0,8	23,24	
2,80		0,8	17,09	3,55	0,8	24,66	
3,00		0,8	18,35	3,75	1,0	25,77	
3,15		0,8	19,30	4,00	1,0	27,54	
3,35		0,8	20,56	4,25	1,0	29,32	
3,55	0,8	21,82					

\*—0,5 nominal thickness

**Table A.1 (5 of 7)**

Nominal width mm	Nominal thickness mm	Radius-on corners mm	Nominal cross-section area mm <sup>2</sup>	Nominal width mm	Nominal thickness mm	Radius-on corners mm	Nominal cross-section area mm <sup>2</sup>
7,10	4,50	1,0	31,09	8,50	1,12	0,5	9,305
	4,75	1,0	32,87		1,25	0,5	10,41
	5,00	1,0	34,64		1,40	0,5	11,69
			1,60		0,5	13,39	
7,50	1,00	*	7,285	1,80	0,65	14,94	
				2,00	0,65	16,64	
				2,24	0,65	18,68	
				2,50	0,8	20,70	
				2,80	0,8	23,25	
				3,15	0,8	26,23	
				3,55	0,8	29,63	
				4,00	1,0	33,14	
				4,50	1,0	37,39	
				5,00	1,0	41,64	
				5,60	1,0	46,74	
				9,00	1,12	0,5	9,865
					1,18	0,5	10,41
					1,25	0,5	11,04
					1,32	0,5	11,67
					1,40	0,5	12,39
				1,50	0,5	13,29	
				1,60	0,5	14,19	
8,00	1,00	*	7,785	1,70	0,65	14,94	
				1,80	0,65	15,84	
				1,90	0,65	16,74	
				2,00	0,65	17,64	
				2,12	0,65	18,72	
				2,24	0,65	19,80	
				2,36	0,8	20,69	
				2,50	0,8	21,95	
				2,65	0,8	23,30	
				2,80	0,8	24,65	
				3,00	0,8	26,45	
				3,15	0,8	27,80	
				3,35	0,8	29,60	
				3,55	0,8	31,40	
				3,75	1,0	32,89	
				4,00	1,0	35,14	
				4,25	1,0	37,39	
				4,50	1,0	39,64	
				4,75	1,0	41,89	
				5,00	1,0	44,14	
				5,30	1,0	46,84	
				5,60	1,0	49,54	
				9,50	1,25	0,5	11,66
					1,40	0,5	13,09
					1,60	0,5	14,99
					1,80	0,65	16,74
					2,00	0,65	18,64
					2,24	0,65	20,92

\*—0,5 nominal thickness

Table A.1 (6 of 7)

Nominal width mm	Nominal thickness mm	Radius-on corners mm	Nominal cross-section area mm <sup>2</sup>	Nominal width mm	Nominal thickness mm	Radius-on corners mm	Nominal cross-section area mm <sup>2</sup>
9,50	2,50	0,8	23,20	11,20	1,70	0,65	18,68
	2,80	0,8	26,05		1,80	0,65	19,80
	3,15	0,8	29,38		1,90	0,65	20,92
	3,55	0,8	33,18		2,00	0,65	22,04
					2,12	0,65	23,38
	4,00	1,0	37,14		2,24	0,65	24,73
	4,50	1,0	41,89				
	5,00	1,0	46,64		2,36	0,8	25,89
	5,60	1,0	52,34		2,50	0,8	27,45
					2,65	0,8	29,13
10,00	1,25	0,5	12,29	2,80	0,8	30,81	
	1,32	0,5	12,99	3,00	0,8	33,05	
	1,40	0,5	13,79	3,15	0,8	34,73	
	1,50	0,5	14,79	3,35	0,8	36,97	
	1,60	0,5	15,79	3,55	0,8	39,21	
	1,70	0,65	16,64	3,75	1,0	41,14	
	1,80	0,65	17,64	4,00	1,0	43,94	
	1,90	0,65	18,64	4,25	1,0	46,74	
	2,00	0,65	19,64	4,50	1,0	49,54	
	2,12	0,65	20,84	4,75	1,0	52,34	
	2,24	0,65	22,04	5,00	1,0	55,14	
				5,30	1,0	58,50	
	2,36	0,8	23,05	5,60	1,0	61,86	
	2,50	0,8	24,45				
	2,65	0,8	25,95	11,80	1,60	0,5	18,67
	2,80	0,8	27,45				
	3,00	0,8	29,45		1,80	0,65	20,88
	3,15	0,8	30,95		2,00	0,65	23,24
	3,35	0,8	32,95		2,24	0,65	26,07
	3,55	0,8	34,95				
					2,50	0,8	28,95
	3,75	1,0	36,64		2,80	0,8	32,49
	4,00	1,0	39,14		3,15	0,8	36,62
	4,25	1,0	41,64		3,55	0,8	41,34
	4,50	1,0	44,14				
	4,75	1,0	46,64		4,00	1,0	46,34
5,00	1,0	49,14		4,50	1,0	52,24	
5,30	1,0	52,14		5,00	1,0	58,14	
5,60	1,0	55,14		5,60	1,0	65,22	
10,60	1,40	0,5	14,63	12,50	1,60	0,5	19,79
	1,60	0,5	16,75				
					1,70	0,65	20,89
	1,80	0,65	18,72		1,80	0,65	22,14
	2,00	0,65	20,84		1,90	0,65	23,39
	2,24	0,65	23,38		2,00	0,65	24,64
					2,12	0,65	26,14
	2,50	0,8	25,95		2,24	0,65	27,64
	2,80	0,8	29,13				
	3,15	0,8	32,84		2,36	0,8	28,95
	3,55	0,8	37,08		2,50	0,8	30,70
					2,65	0,8	32,58
	4,00	1,0	41,54		2,80	0,8	34,45
	4,50	1,0	46,84		3,00	0,8	36,95
	5,00	1,0	52,14		3,15	0,8	38,83
5,60	1,0	58,50	3,35	0,8	41,33		
			3,55	0,8	43,83		
11,20	1,40	0,5	15,47				
	1,50	0,5	16,59	3,75	1,0	46,02	
	1,60	0,5	17,71	4,00	1,0	49,14	
				4,25	1,0	52,27	

**Table A.1 (7 of 7)**

Nominal width mm	Nominal thickness mm	Radius-on corners mm	Nominal cross-section area mm <sup>2</sup>	Nominal width mm	Nominal thickness mm	Radius-on corners mm	Nominal cross-section area mm <sup>2</sup>		
12,50	4,50	1,0	55,39	14,00	4,75	1,0	65,64		
	4,75	1,0	58,52		5,00	1,0	69,14		
	5,00	1,0	61,64		5,30	1,0	73,34		
	5,30	1,0	65,39		5,60	1,0	77,54		
	5,60	1,0	69,14		15,00	2,00	0,65	29,64	
13,20	1,80	0,65	23,40	2,24		0,65	33,24		
	2,00	0,65	26,04	2,50		0,8	36,95		
	2,24	0,65	29,21			2,80	0,8	41,45	
	2,50	0,8	32,45			3,15	0,8	46,70	
		2,80	0,8			36,41	3,55	0,8	52,70
		3,15	0,8			41,03	4,00	1,0	59,14
		3,55	0,8	46,31		4,50		1,0	66,64
		4,00	1,0	51,94		5,00		1,0	74,14
	4,50		1,0	58,54		5,60		1,0	83,14
	5,00		1,0	65,14		16,00		2,00	0,65
5,60	1,0		73,06	2,12			0,65	33,56	
14,00	1,80		0,65	24,84			2,24	0,65	35,48
	1,90	0,65	26,24	2,36			0,8	37,21	
	2,00	0,65	27,64				2,50	0,8	39,45
	2,12	0,65	29,32		2,65		0,8	41,85	
	2,24	0,65	31,00		2,80		0,8	44,25	
	2,36	0,8	32,49		3,00		0,8	47,45	
		2,50	0,8	34,45	3,15		0,8	49,85	
		2,65	0,8	36,55	3,35		0,8	53,05	
		2,80	0,8	38,65	3,55		0,8	56,25	
		3,00	0,8	41,45	3,75		1,0	59,14	
	3,15	0,8	43,55	4,00			1,0	63,14	
	3,35	0,8	46,35	4,25			1,0	67,14	
	3,55	0,8	49,15	4,50			1,0	71,14	
	3,75	1,0	51,64	4,75		1,0	75,14		
		4,00	1,0	55,14		5,00	1,0	79,14	
4,25		1,0	58,64	5,30		1,0	83,94		
4,50		1,0	62,14	5,60		1,0	88,74		

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Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	Nominal width	Nominal thickness	Corner radius	Nominal cross-section area		
mm	mm	mm	mm <sup>2</sup>	mm	mm	mm	mm <sup>2</sup>		
2,00	0,80	*	1,463	2,50	1,18	0,5	2,735		
	0,85	*	1,545		1,25	0,5	2,910		
	0,90	*	1,626		1,32	0,5	3,085		
	0,95	*	1,706		1,40	0,5	3,285		
	1,00	*	1,785		1,50	0,5	3,535		
					1,60	0,5	3,785		
		1,06	0,5		1,905	2,65	1,70	0,65	3,887
		1,12	0,5		2,025		1,80	0,65	4,137
		1,18	0,5		2,145		0,80	*	1,983
		1,25	0,5		2,285		0,90	*	2,211
		1,32	0,5		2,425		1,00	*	2,435
		1,40	0,5		2,585				
	2,12	0,80	*		1,559		1,12	0,5	2,753
		0,90	*		1,734		1,25	0,5	3,098
1,00		*	1,905		1,40	0,5	3,495		
					1,60	0,5	4,025		
		1,12	0,5	2,160		1,80	0,65	4,407	
		1,25	0,5	2,435					
2,24	0,80	*	1,655	2,80	0,80	*	2,103		
	0,85	*	1,749		0,85	*	2,225		
	0,90	*	1,842		0,90	*	2,346		
	0,95	*	1,934		0,95	*	2,466		
	1,00	*	2,025		1,00	*	2,585		
		1,06	0,5		2,160		1,06	0,5	2,753
		1,12	0,5		2,294		1,12	0,5	2,921
		1,18	0,5		2,429		1,18	0,5	3,089
		1,25	0,5		2,585		1,25	0,5	3,285
		1,32	0,5		2,742		1,32	0,5	3,481
		1,40	0,5		2,921		1,40	0,5	3,705
		1,50	0,5		3,145		1,50	0,5	3,985
		1,60	0,5		3,369		1,60	0,5	4,265
2,36	0,80	*	1,751		1,70	0,65	4,397		
	0,90	*	1,950		1,80	0,65	4,677		
	1,00	*	2,145		1,90	0,65	4,957		
					2,00	0,65	5,237		
		1,12	0,5	2,429	3,00	0,80	*	2,263	
		1,25	0,5	2,735		0,90	*	2,526	
	1,40	0,5	3,089	1,00		*	2,785		
	1,60	0,5	3,561						
2,50	0,80	*	1,863			1,12	0,5	3,145	
	0,85	*	1,970			1,25	0,5	3,535	
	0,90	*	2,076		1,40	0,5	3,985		
	0,95	*	2,181		1,60	0,5	4,585		
	1,00	*	2,285						
					1,80	0,65	5,037		
		1,06	0,5	2,435	2,00	0,65	5,637		
		1,12	0,5	2,585					

\* 0,5 × nominal thickness

Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	
mm	mm	mm	mm <sup>2</sup>	mm	mm	mm	mm <sup>2</sup>	
3,15	0,80	*	2,383	3,75	0,80	*	2,863	
	0,85	*	2,522		0,90	*	3,201	
	0,90	*	2,661		1,00	*	3,535	
	0,95	*	2,799		1,12	0,5	3,985	
	1,00	*	2,935		1,25	0,5	4,473	
	1,06	0,5	3,124		1,40	0,5	5,035	
	1,12	0,5	3,313		1,60	0,5	5,785	
	1,18	0,5	3,502		1,80	0,65	6,387	
	1,25	0,5	3,723		2,00	0,65	7,137	
	1,32	0,5	3,943		2,24	0,65	8,037	
	1,40	0,5	4,195	2,50	0,8	8,826		
	1,50	0,5	4,510	4,00	0,80	*	3,063	
	1,60	0,5	4,825		0,85	*	3,245	
	1,70	0,65	4,992		0,90	*	3,426	
	1,80	0,65	5,307		0,95	*	3,606	
	1,90	0,65	5,622		1,00	*	3,785	
	2,00	0,65	5,937		1,06	0,5	4,025	
	2,12	0,65	6,315		1,12	0,5	4,265	
	2,24	0,65	6,693		1,18	0,5	4,505	
	3,35	0,80	*		2,543	1,25	0,5	4,785
		0,90	*		2,841	1,32	0,5	5,065
		1,00	*	3,135	1,40	0,5	5,385	
1,12		0,5	3,537	1,50	0,5	5,785		
1,25		0,5	3,978	1,60	0,5	6,185		
1,40		0,5	4,475	1,70	0,65	6,437		
1,60		0,5	5,145	1,80	0,65	6,837		
1,80		0,65	5,667	1,90	0,65	7,237		
2,00		0,65	6,337	2,00	0,65	7,637		
2,24		0,65	7,141	2,12	0,65	8,117		
3,55	0,80	*	2,703	2,24	0,65	8,597		
	0,85	*	2,862	4,25	0,80	*	3,263	
	0,90	*	3,021		0,90	*	3,651	
	0,95	*	3,179		1,00	*	4,035	
	1,00	*	3,335		1,12	0,5	4,545	
	1,06	0,5	3,548		1,25	0,5	5,098	
	1,12	0,5	3,761		1,40	0,5	5,735	
	1,18	0,5	3,974		1,60	0,5	6,585	
	1,25	0,5	4,223		1,80	0,65	7,287	
	1,32	0,5	4,471		2,00	0,65	8,137	
	1,40	0,5	4,755		2,24	0,65	9,157	
	1,50	0,5	5,110	2,50	0,8	10,08		
	1,60	0,5	5,465	2,80	0,8	11,35		
	1,70	0,65	5,672	4,50	0,80	*	3,063	
	1,80	0,65	6,027		0,85	*	3,245	
	1,90	0,65	6,382		0,90	*	3,426	
	2,00	0,65	6,737		0,95	*	3,606	
	2,12	0,65	7,163		1,00	*	3,785	
	2,24	0,65	7,589		1,06	0,5	4,025	
	2,36	0,8	7,829		1,12	0,5	4,265	
	2,50	0,8	8,326		1,18	0,5	4,505	

\* 0,5 × nominal thickness

Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	
mm	mm	mm	mm <sup>2</sup>	mm	mm	mm	mm <sup>2</sup>	
4,50	0,80	*	3,463	5,00	1,70	0,65	8,137	
	0,85	*	3,670		1,80	0,65	8,637	
	0,90	*	3,876		1,90	0,65	9,137	
	0,95	*	4,081		2,00	0,65	9,637	
	1,00	*	4,285		2,12	0,65	10,24	
					2,24	0,65	10,84	
		1,06	0,5		4,555	2,36	0,8	11,25
		1,12	0,5		4,825	2,50	0,8	11,95
		1,18	0,5		5,095	2,65	0,8	12,70
		1,25	0,5		5,410	2,80	0,8	13,45
		1,32	0,5		5,725	3,00	0,8	14,45
		1,40	0,5		6,085	3,15	0,8	15,20
		1,50	0,5		6,535	3,35	0,8	16,20
		1,60	0,5		6,985	3,55	0,8	17,20
					5,30	0,80	*	4,103
		1,70	0,65	7,287		0,90	*	4,596
		1,80	0,65	7,737		1,00	*	5,085
		1,90	0,65	8,187		1,12	0,5	5,721
		2,00	0,65	8,637		1,25	0,5	6,410
		2,12	0,65	9,177		1,40	0,5	7,205
		2,24	0,65	9,717		1,60	0,5	8,265
						1,80	0,65	9,177
		2,36	0,8	10,07		2,00	0,65	10,24
		2,50	0,8	10,70		2,24	0,65	11,51
		2,65	0,8	11,38		2,50	0,8	12,70
		2,80	0,8	12,05		2,80	0,8	14,29
		3,00	0,8	12,95		3,15	0,8	16,15
		3,15	0,8	13,63		3,55	0,8	18,27
	4,75	0,80	*	3,663	5,60	0,80	*	4,343
		0,90	*	4,107		0,85	*	4,605
		1,00	*	4,535		0,90	*	4,866
						0,95	*	5,126
			1,12	0,5		5,105	1,00	*
		1,25	0,5	5,723		1,06	0,5	5,721
		1,40	0,5	6,435		1,12	0,5	6,057
		1,60	0,5	7,385		1,18	0,5	6,393
						1,25	0,5	6,785
		1,80	0,65	8,187		1,32	0,5	7,177
		2,00	0,65	9,137	1,40	0,5	7,625	
		2,24	0,65	10,28	1,50	0,5	8,185	
					1,60	0,5	8,745	
		2,50	0,8	11,33	1,70	0,65	9,157	
		2,80	0,8	12,75	1,80	0,65	9,717	
		3,15	0,8	14,41	1,90	0,65	10,28	
5,00		0,80	*	3,863	2,00	0,65	10,84	
		0,85	*	4,095	2,12	0,65	11,51	
	0,90	*	4,326	2,24	0,65	12,18		
	0,95	*	4,556	2,36	0,8	12,67		
	1,00	*	4,785	2,50	0,8	13,45		
				2,65	0,8	14,29		
		1,06	0,5	5,085	2,80	0,8	15,13	
		1,12	0,5	5,385				
		1,18	0,5	5,685				
		1,25	0,5	6,035				
		1,32	0,5	6,385				
		1,40	0,5	6,785				
		1,50	0,5	7,285				
		1,60	0,5	7,785				

\* 0,5 × nominal thickness

Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	Nominal width	Nominal thickness	Corner radius	Nominal cross-section area
mm	mm	mm	mm <sup>2</sup>	mm	mm	mm	mm <sup>2</sup>
5,60	3,00	0,8	16,25	6,30	3,75	1,0	22,77
	3,15	0,8	17,09		4,00	1,0	24,34
	3,35	0,8	18,21		4,25	1,0	25,92
	3,55	0,8	19,33		4,50	1,0	27,49
	3,75	1,0	20,14		6,70	0,90	*
	4,00	1,0	21,54	1,00		*	6,485
6,00	0,80	*	4,663	1,12	0,5	7,289	
	0,90	*	5,226	1,25	0,5	8,160	
	1,00	*	5,785	1,40	0,5	9,165	
	1,12	0,5	6,505	1,60	0,5	10,51	
	1,25	0,5	7,285	1,80	0,65	11,70	
	1,40	0,5	8,185	2,00	0,65	13,04	
	1,60	0,5	9,385	2,24	0,65	14,65	
	1,80	0,65	10,44	2,50	0,8	16,20	
	2,00	0,65	11,64	2,80	0,8	18,21	
	2,24	0,65	13,08	3,15	0,8	20,56	
	2,50	0,8	14,45	3,55	0,8	23,24	
	2,80	0,8	16,25	4,00	1,0	25,94	
	3,15	0,8	18,35	4,50	1,0	29,29	
	3,55	0,8	20,75	7,10	0,90	*	6,216
	4,00	1,0	23,14		0,95	*	6,551
4,00	1,0	23,14	1,00		*	6,885	
6,30	0,80	*	4,903	1,06	0,5	7,311	
	0,85	*	5,200	1,12	0,5	7,737	
	0,90	*	5,496	1,18	0,5	8,163	
	0,95	*	5,791	1,25	0,5	8,660	
	1,00	*	6,085	1,32	0,5	9,157	
	1,06	0,5	6,463	1,40	0,5	9,725	
	1,12	0,5	6,841	1,50	0,5	10,44	
	1,18	0,5	7,219	1,60	0,5	11,15	
	1,25	0,5	7,660	1,70	0,65	11,71	
	1,32	0,5	8,101	1,80	0,65	12,42	
	1,40	0,5	8,605	1,90	0,65	13,13	
	1,50	0,5	9,235	2,00	0,65	13,84	
	1,60	0,5	9,865	2,12	0,65	14,69	
	1,70	0,65	10,35	2,24	0,65	15,54	
	1,80	0,65	10,98	2,36	0,8	16,21	
	1,90	0,65	11,61	2,50	0,8	17,20	
	2,00	0,65	12,24	2,65	0,8	18,27	
	2,12	0,65	12,99	2,80	0,8	19,33	
	2,24	0,65	13,75	3,00	0,8	20,75	
	2,36	0,8	14,32	3,15	0,8	21,82	
	2,50	0,8	15,20	3,35	0,8	23,24	
	2,65	0,8	16,15	3,55	0,8	24,66	
	2,80	0,8	17,09	3,75	1,0	25,77	
	3,00	0,8	18,35	4,00	1,0	27,54	
	3,15	0,8	19,30	4,25	1,0	29,32	
	3,35	0,8	20,56				
	3,55	0,8	21,82				

\* 0,5 × nominal thickness

Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	Nominal width	Nominal thickness	Corner radius	Nominal cross-section area		
mm	mm	mm	mm <sup>2</sup>	mm	mm	mm	mm <sup>2</sup>		
7,10	4,50	1,0	31,09	8,50	1,12	0,5	9,305		
	4,75	1,0	32,87		1,25	0,5	10,41		
	5,00	1,0	34,64		1,40	0,5	11,69		
7,50	1,00	*	7,285		1,60	0,5	13,39		
		1,12	0,5		8,185	1,80	0,65	14,94	
		1,25	0,5		9,160	2,00	0,65	16,64	
		1,40	0,5		10,29	2,24	0,65	18,68	
		1,60	0,5		11,79	2,50	0,8	20,70	
		1,80	0,65		13,14	2,80	0,8	23,25	
	2,00	0,65	14,64		3,15	0,8	26,23		
	2,24	0,65	16,44		3,55	0,8	29,63		
	2,50	0,8	18,20		4,00	1,0	33,14		
	2,80	0,8	20,45	4,50	1,0	37,39			
	3,15	0,8	23,08	5,00	1,0	41,64			
	3,55	0,8	26,08	5,60	1,0	46,74			
	8,00	1,00	*	7,785	9,00	1,12	0,5	9,865	
			1,06	0,5		8,265	1,18	0,5	10,41
			1,12	0,5		8,745	1,25	0,5	11,04
			1,18	0,5		9,225	1,32	0,5	11,67
			1,25	0,5		9,785	1,40	0,5	12,39
			1,32	0,5		10,35	1,50	0,5	13,29
1,40		0,5	10,99	1,60		0,5	14,19		
1,50		0,5	11,79	1,70		0,65	14,94		
1,60		0,5	12,59	1,80		0,65	15,84		
1,70		0,65	13,24	1,90		0,65	16,74		
1,80		0,65	14,04	2,00		0,65	17,64		
1,90		0,65	14,84	2,12		0,65	18,72		
2,00		0,65	15,64	2,24	0,65	19,80			
2,12		0,65	16,60	2,36	0,8	20,69			
2,24		0,65	17,56	2,50	0,8	21,95			
2,36		0,8	18,33	2,65	0,8	23,30			
2,50		0,8	19,45	2,80	0,8	24,65			
2,65		0,8	20,65	3,00	0,8	26,45			
2,80		0,8	21,85	3,15	0,8	27,80			
3,00		0,8	23,45	3,35	0,8	29,60			
3,15		0,8	24,65	3,55	0,8	31,40			
3,35		0,8	26,25	3,75	1,0	32,89			
3,55		0,8	27,85	4,00	1,0	35,14			
3,75		1,0	29,14	4,25	1,0	37,39			
4,00	1,0	31,14	4,50	1,0	39,64				
4,25	1,0	33,14	4,75	1,0	41,89				
4,50	1,0	35,14	5,00	1,0	44,14				
4,75	1,0	37,14	5,30	1,0	46,84				
5,00	1,0	39,14	5,60	1,0	49,54				
5,30	1,0	41,54	9,50	1,25	0,5	11,66			
5,60	1,0	43,94		1,40	0,5	13,09			
				1,60	0,5	14,99			
				1,80	0,65	16,74			
			2,00	0,65	18,64				
			2,24	0,65	20,92				

\* 0,5 × nominal thickness

Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	Nominal width	Nominal thickness	Corner radius	Nominal cross-section area		
mm	mm	mm	mm <sup>2</sup>	mm	mm	mm	mm <sup>2</sup>		
9,50	2,50	0,8	23,20	11,20	1,70	0,65	18,68		
	2,80	0,8	26,05		1,80	0,65	19,80		
	3,15	0,8	29,38		1,90	0,65	20,92		
	3,55	0,8	33,18		2,00	0,65	22,04		
					2,12	0,65	23,38		
					2,24	0,65	24,73		
		4,00	1,0		37,14				
		4,50	1,0		41,89				
		5,00	1,0		46,64				
		5,60	1,0		52,34				
10,00	1,25	0,5	12,29		2,36	0,8	25,88		
	1,32	0,5	12,99		2,50	0,8	27,45		
	1,40	0,5	13,79		2,65	0,8	29,13		
	1,50	0,5	14,79		2,80	0,8	30,81		
	1,60	0,5	15,79		3,00	0,8	33,05		
					3,15	0,8	34,73		
					3,35	0,8	36,97		
					3,55	0,8	39,21		
		1,70	0,65	16,64		3,75	1,0	41,14	
		1,80	0,65	17,64		4,00	1,0	43,94	
		1,90	0,65	18,64		4,25	1,0	46,74	
		2,00	0,65	19,64		4,50	1,0	49,54	
		2,12	0,65	20,84		4,75	1,0	52,34	
		2,24	0,65	22,04		5,00	1,0	55,14	
						5,30	1,0	58,50	
						5,60	1,0	61,86	
		2,36	0,8	23,05	11,80	1,60	0,5	18,67	
		2,50	0,8	24,45					
		2,65	0,8	25,95			1,80	0,65	20,88
		2,80	0,8	27,45			2,00	0,65	23,24
	3,00	0,8	29,45			2,24	0,65	26,07	
	3,15	0,8	30,95						
	3,35	0,8	32,95			2,50	0,8	28,95	
	3,55	0,8	34,95			2,80	0,8	32,49	
						3,15	0,8	36,62	
						3,55	0,8	41,34	
	3,75	1,0	36,64						
	4,00	1,0	39,14		4,00	1,0	46,34		
	4,25	1,0	41,64		4,50	1,0	52,24		
	4,50	1,0	44,14		5,00	1,0	58,14		
	4,75	1,0	46,64		5,60	1,0	65,22		
	5,00	1,0	49,14	12,50	1,60	0,5	19,79		
	5,30	1,0	52,14						
	5,60	1,0	55,14			1,70	0,65	20,89	
						1,80	0,65	22,14	
						1,90	0,65	23,39	
						2,00	0,65	24,64	
						2,12	0,65	26,14	
						2,24	0,65	27,64	
						2,36	0,8	28,95	
					2,50	0,8	30,70		
					2,65	0,8	32,58		
					2,80	0,8	34,45		
					3,00	0,8	36,95		
					3,15	0,8	38,83		
					3,35	0,8	41,33		
					3,55	0,8	43,83		
					3,75	1,0	46,02		
					4,00	1,0	49,14		
					4,25	1,0	52,27		
10,60	1,40	0,5	14,63	11,20	1,40	0,5	15,47		
	1,60	0,5	16,75		1,50	0,5	16,59		
	1,80	0,65	18,72		1,60	0,5	17,71		
	2,00	0,65	20,84						
2,24	0,65	23,38							
	2,50	0,8	25,95						
	2,80	0,8	29,13						
	3,15	0,8	32,84						
	3,55	0,8	37,08						
	4,00	1,0	41,54						
	4,50	1,0	46,84						
	5,00	1,0	52,14						
	5,60	1,0	58,50						

Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	Nominal width	Nominal thickness	Corner radius	Nominal cross-section area
mm	mm	mm	mm <sup>2</sup>	mm	mm	mm	mm <sup>2</sup>
12,50	4,50	1,0	55,39	16,00	2,36	0,8	37,21
	4,75	1,0	58,52		2,50	0,8	39,45
	5,00	1,0	61,64		2,65	0,8	41,85
	5,30	1,0	65,39		2,80	0,8	44,25
	5,60	1,0	69,14		3,00	0,8	47,45
13,20	1,80	0,65	23,40		3,15	0,8	49,85
		0,65	26,04		3,35	0,8	53,05
		0,65	29,21		3,55	0,8	56,25
		0,8	32,45		3,75	1,0	59,14
		0,8	36,41		4,00	1,0	63,14
	2,80	0,8	36,41		4,25	1,0	67,14
		0,8	41,03		4,50	1,0	71,14
		0,8	46,31		4,75	1,0	75,14
		1,0	51,94		5,00	1,0	79,14
		1,0	58,54		5,30	1,0	83,94
14,00	1,80	0,65	24,84		5,60	1,0	88,74
		0,65	26,24	17,00	2,24	0,8	37,72
		0,65	27,64		2,50	0,8	41,95
		0,65	29,32		2,80	0,8	47,05
		0,65	31,00		3,15	0,8	53,00
	0,8	32,49	3,55		0,8	59,80	
	2,36	0,8	32,49		4,00	1,0	67,14
		0,8	34,45		4,50	1,0	75,64
		0,8	36,55		5,00	1,0	84,14
		0,8	38,65		5,60	1,0	94,34
0,8		41,45	6,30		1,25	105,8	
0,8		43,55	7,10	1,25	119,4		
0,8		46,35	8,00	1,25	134,7		
0,8		49,15	9,00	1,25	151,7		
1,0		51,64	10,0	1,25	168,7		
1,0		55,14	18,00	2,36	0,8	41,93	
1,0	58,64	2,50		0,8	44,45		
1,0	62,14	2,65		0,8	47,15		
1,0	65,64	2,80		0,8	49,85		
1,0	69,14	3,00		0,8	53,45		
1,0	73,34	3,15		0,8	56,15		
1,0	77,54	3,35		0,8	59,75		
15,00	2,00	0,65		29,64	3,55	0,8	63,35
		0,65		33,24	3,75	1,0	66,64
		0,8		36,95	4,00	1,0	71,14
		0,8	41,45	4,25	1,0	75,64	
		0,8	46,70	4,50	1,0	80,14	
	3,15	0,8	46,70	4,75	1,0	84,64	
		0,8	52,70	5,00	1,0	89,14	
		1,0	59,14	5,30	1,0	94,54	
		1,0	66,64	5,60	1,0	99,94	
		1,0	74,14	6,00	1,25	106,7	
16,00	2,00	0,65	31,64	6,30	1,25	112,1	
		0,65	33,56	6,70	1,25	119,3	
		0,65	35,48	7,10	1,25	126,5	
		1,0	39,14	7,50	1,25	133,7	
		1,0	43,14	8,00	1,25	142,7	
	2,12	1,0	43,14	8,50	1,25	151,7	
		1,0	47,14	9,00	1,25	160,7	
		1,25	51,14	9,50	1,25	169,7	
		1,25	55,14	10,0	1,25	178,7	
		1,25	59,14				



Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	Nominal width	Nominal thickness	Corner radius	Nominal cross-section area
mm	mm	mm	mm <sup>2</sup>	mm	mm	mm	mm <sup>2</sup>
26,50	6,30	1,25	165,6	30,00	4,00	1,0	119,1
	7,10	1,25	186,8		4,50	1,0	134,1
	8,00	1,25	210,7		5,00	1,0	149,1
	9,00	1,25	237,2		5,60	1,0	167,1
	10,0	1,25	263,7		6,30	1,25	187,7
28,00	3,55	0,8	98,85	7,10	1,25	211,7	
	3,75	1,0	104,1	8,00	1,25	238,7	
	4,00	1,0	111,1	9,00	1,25	268,7	
	4,25	1,0	118,1	10,0	1,25	298,7	
	4,50	1,0	125,1	31,50	4,00	1,0	125,1
	4,75	1,0	132,1		4,25	1,0	133,0
	5,00	1,0	139,1		4,50	1,0	140,9
	5,30	1,0	147,5		4,75	1,0	148,8
	5,60	1,0	155,9		5,00	1,0	156,6
	6,00	1,25	166,7		5,30	1,0	166,1
	6,30	1,25	175,1		5,60	1,0	175,5
	6,70	1,25	186,3		6,00	1,25	187,7
	7,10	1,25	197,5		6,30	1,25	197,1
	7,50	1,25	208,7		6,70	1,25	209,7
	8,00	1,25	222,7	7,10	1,25	222,3	
	8,50	1,25	236,7	7,50	1,25	234,9	
	9,00	1,25	250,7	8,00	1,25	250,7	
	9,50	1,25	264,7	8,50	1,25	266,4	
	10,0	1,25	278,7	9,00	1,25	282,2	
				9,50	1,25	297,9	
			10,0	1,25	313,7		

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**Annex B**  
(informative)

**Special tolerances**

**Table B.1 — Tolerances for calculating special maximum and minimum dimensions of grade 2 rectangular wire**

Nominal width or thickness of the conductor mm		Tolerances on nominal overall dimensions for grade 2 ± mm	
Over	Up to and including	Width	Thickness
–	2,00	–	0,03
2,00	3,15	0,06	0,03
3,15	5,60	0,06	0,05
5,60	6,30	0,06	–
6,30	12,50	0,08	–
12,50	16,00	0,10	–

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## Bibliography

IEC 60264 (all parts), *Packaging of winding wires*

IEC 60317 (all parts), *Specifications for particular types of winding wires*

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# 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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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**SPECIFICATIONS FOR PARTICULAR TYPES OF WINDING WIRES –****Part 0-2: General requirements – Enamelled rectangular copper wire**

## 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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- 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.

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 and 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;
- 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	0,030
3,15	6,30	0,050
6,30	12,50	0,070
12,50	16,00	0,100
16,00	22,40	0,130
22,40	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 ±25 %.



**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.

## 5 Electrical resistance

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

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/mm<sup>2</sup> 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

When the value of nominal proof strength, plastic extension is specified, the measured proof strength shall be within the tolerances given in Table 6.

**Table 6 – Proof strength and resistivity**

Proof strength		Maximum resistivity
Nominal value	Tolerance	
N·mm <sup>-2</sup>		Ω·mm <sup>2</sup> ·m <sup>-1</sup>
80	-0 / +30 %	1/58
120	-0 / +20 %	1/58
150	-0 / +20 %	1/58
180	-0 / +20 %	1/57,5

The proof strength, plastic extension shall be measured at the specified percentage of plastic extension, with the method described in Clause 13 of ISO 6892-1:2016; if not otherwise specified, the percentage shall be 0,2 % (R<sub>p0,2</sub>).

If required by the customer, the test shall be performed according to Clause 10 of ISO 6892-1:2016. Otherwise, the test shall be performed as described in IEC 60851-3.

**7 Springiness (applicable to nominal proof strength ≤ 80 N·mm<sup>-2</sup>)**

The wire shall not exceed the maximum springback of 5°.

**8 Flexibility and adherence**

**8.1 Mandrel winding test**

The coating shall show no crack after the wire has been bent flatwise and edgewise on a mandrel with a diameter as specified in Table 7.

**Table 7 – Mandrel winding**

	Wire bent on	Mandrel diameter
Width	Sizes up to and including 10 mm	4 × width
	Sizes over 10 mm	5 × width
Thickness	All sizes	4 × thickness

**8.2 Adherence test**

The wire shall be stretched by 15 % or to the breaking point, whichever is less. The distance of loss of adherence shall be less than 1 × width.

**9 Heat shock**

The coating shall show no crack after the wire has been bent flatwise on a mandrel with a diameter of six times the thickness.

The minimum heat shock temperature is given in the relevant specification sheet.

## 10 Cut-through

Test requirement under consideration.

## 11 Resistance to abrasion

Test inappropriate.

## 12 Resistance to solvents

Using a pencil of hardness "H" and standard solvent, the coating shall not be removed.

## 13 Breakdown voltage

When tested at room temperature, at least four of the five specimens tested shall not break down at a voltage less than or equal to that given in Table 8, and the fifth shall not break down at less than 50 % of the values specified.

When required by the purchaser, the wire shall be tested at elevated temperature.

The elevated temperature is given in the relevant specification sheet.

**Table 8 – Breakdown voltage**

Grade	Minimum breakdown voltage (RMS)			
	V			
	Without bonding layer		With bonding layer	
	Room temperature	Elevated temperature	Room temperature	Elevated temperature
1	1 000	750	1 500	1 000
2	2 000	1 500	2 500	2 000

## 14 Continuity of insulation

Test inappropriate.

## 15 Temperature index

The test shall be carried out on a rectangular wire in accordance with IEC 60172, unless otherwise agreed between the purchaser and the supplier.

When required by a purchaser, the supplier of the enamelled wire shall supply evidence that the wire meets the requirements for the temperature index.

NOTE 1 The temperature index requirement based on an extrapolated life of 20 000 h relates to enamelled wires tested unvarnished and not as part of an insulation system.

NOTE 2 Temperature in degrees Celsius corresponding to the temperature index is not necessarily that at which it is recommended that the wire be operated, and this will depend on many factors including the type of equipment involved.

## **16 Resistance to refrigerants**

Test inappropriate.

## **17 Solderability**

Test inappropriate.

## **18 Heat or solvent bonding**

For requirements, the relevant specification sheet applies.

## **19 Dielectric dissipation factor**

For requirements, the relevant specification sheet applies.

## **20 Resistance to transformer oil**

For requirements, the relevant specification sheet applies.

## **21 Loss of mass**

Test inappropriate.

## **23 Pin hole test**

Test inappropriate.

## **30 Packaging**

The kind of packaging may influence certain properties of the wire, for example springiness and proof strength. Therefore, the kind of packaging for example, the type of spool, shall be agreed between the purchaser and the supplier.

The wire shall be evenly and compactly wound on spools or placed in containers. No spool or container shall contain more than one length of wire unless agreed to by the purchaser and the supplier. Marking of the label when there is more than one length and/or identification of the separate lengths in the package shall be agreed to by the purchaser and the supplier.

Where wires are delivered in coils, the dimensions and the maximum weights of such coils shall be agreed between the purchaser and the supplier. Any additional protection for coils shall also be agreed between the purchaser and the supplier.

Labels shall be attached to each packaging unit as agreed between the supplier and the user and shall include the following information:

- a) manufacturer's name and/or trademark;
- b) type of wire and insulation, for instance trade name and/or IEC specification number;
- c) having a bonding layer (if any);
- d) nominal proof strength;

- e) net mass of wire;
- f) nominal dimension(s) of wire and grade of insulation;
- g) date of manufacture.

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**Annex A**  
(informative)

**Nominal cross-sectional areas for preferred and intermediate sizes**

Table A.1 provides nominal cross-sectional areas for preferred and intermediate sizes of rectangular copper bare conductors, from which the user may select intermediate sizes only for technical reasons.

**Table A.1 – Nominal cross-sectional areas**

Nominal width mm	Nominal thickness mm	Corner radius mm	Nominal cross-section area mm <sup>2</sup>	Nominal width mm	Nominal thickness mm	Corner radius mm	Nominal cross-section area mm <sup>2</sup>		
2,00	0,80	*	1,463	2,50	1,18	0,5	2,735		
	0,85	*	1,545		1,25	0,5	2,910		
	0,90	*	1,626		1,32	0,5	3,085		
	0,95	*	1,706		1,40	0,5	3,285		
	1,00	*	1,785		1,50	0,5	3,535		
	1,06	0,5	1,905		1,60	0,5	3,785		
	1,12	0,5	2,025		2,65	1,70	0,65	3,887	
	1,18	0,5	2,145			1,80	0,65	4,137	
	1,25	0,5	2,285			0,80	*	1,983	
	1,32	0,5	2,425			0,90	*	2,211	
	1,40	0,5	2,585			1,00	*	2,435	
	2,12	0,80	*			1,559	1,12	0,5	2,753
		0,90	*			1,734	1,25	0,5	3,098
		1,00	*			1,905	1,40	0,5	3,495
1,12		0,5	2,160	1,60		0,5	4,025		
1,25		0,5	2,435	1,80		0,65	4,407		
1,40		0,5	2,753			2,80	0,80	*	2,103
2,24		0,80	*				1,655	0,85	*
	0,85	*	1,749	0,90			*	2,346	
	0,90	*	1,842	0,95			*	2,466	
	0,95	*	1,934	1,00	*		2,585		
	1,00	*	2,025	1,06	0,5		2,753		
	1,12	0,5	2,294	1,12	0,5		2,921		
	1,18	0,5	2,429	1,18	0,5	3,089			
1,25	0,5	2,585	1,25	0,5	3,285				
1,32	0,5	2,742	1,32	0,5	3,481				
1,40	0,5	2,921	1,40	0,5	3,705				
1,50	0,5	3,145	1,50	0,5	3,985				
1,60	0,5	3,369	1,60	0,5	4,265				
2,36	0,80	*	1,751	3,00	1,70	0,65	4,397		
	0,90	*	1,950		1,80	0,65	4,677		
	1,00	*	2,145		1,90	0,65	4,957		
	1,12	0,5	2,429		2,00	0,65	5,237		
	1,25	0,5	2,735		0,80	*	2,263		
	1,40	0,5	3,089		0,90	*	2,526		
	1,60	0,5	3,561		1,00	*	2,785		
2,50	0,80	*	1,863	1,12	0,5	3,145			
	0,85	*	1,970	1,25	0,5	3,535			
	0,90	*	2,076	1,40	0,5	3,985			
	0,95	*	2,181	1,60	0,5	4,585			
	1,00	*	2,285	1,80	0,65	5,037			
	1,06	0,5	2,435		2,00	0,65	5,637		
	1,12	0,5	2,585						

\* 0,5 × nominal thickness

Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	
mm	mm	mm	mm <sup>2</sup>	mm	mm	mm	mm <sup>2</sup>	
3,15	0,80	*	2,383	3,75	0,80	*	2,863	
	0,85	*	2,522		0,90	*	3,201	
	0,90	*	2,661		1,00	*	3,535	
	0,95	*	2,799		1,12	0,5	3,985	
	1,00	*	2,935		1,25	0,5	4,473	
	1,06	0,5	3,124		1,40	0,5	5,035	
	1,12	0,5	3,313		1,60	0,5	5,785	
	1,18	0,5	3,502		1,80	0,65	6,387	
	1,25	0,5	3,723		2,00	0,65	7,137	
	1,32	0,5	3,943		2,24	0,65	8,037	
	1,40	0,5	4,195		2,50	0,8	8,826	
	1,50	0,5	4,510		4,00	0,80	*	3,063
	1,60	0,5	4,825	0,85		*	3,245	
	1,70	0,65	4,992	0,90		*	3,426	
	1,80	0,65	5,307	0,95		*	3,606	
	1,90	0,65	5,622	1,00		*	3,785	
	2,00	0,65	5,937	1,06		0,5	4,025	
	2,12	0,65	6,315	1,12		0,5	4,265	
	2,24	0,65	6,693	1,18		0,5	4,505	
	3,35	0,80	*	2,543		1,25	0,5	4,785
		0,90	*	2,841		1,32	0,5	5,065
		1,00	*	3,135		1,40	0,5	5,385
		1,12	0,5	3,537		1,50	0,5	5,785
		1,25	0,5	3,973	1,60	0,5	6,185	
1,40		0,5	4,475	1,70	0,65	6,437		
1,60		0,5	5,145	1,80	0,65	6,837		
1,80		0,65	5,667	1,90	0,65	7,237		
2,00		0,65	6,337	2,00	0,65	7,637		
2,24		0,65	7,141	2,12	0,65	8,117		
3,55		0,80	*	2,703	2,24	0,65	8,597	
		0,85	*	2,862	2,36	0,8	8,891	
	0,90	*	3,021	2,50	0,8	9,451		
	0,95	*	3,179	2,65	0,8	10,05		
	1,00	*	3,335	2,80	0,8	10,65		
	1,06	0,5	3,548	4,25	0,80	*	3,263	
	1,12	0,5	3,761		0,90	*	3,651	
	1,18	0,5	3,974		1,00	*	4,035	
	1,25	0,5	4,223		1,12	0,5	4,545	
	1,32	0,5	4,471		1,25	0,5	5,098	
	1,40	0,5	4,755		1,40	0,5	5,735	
	1,50	0,5	5,110		1,60	0,5	6,585	
	1,60	0,5	5,465		1,80	0,65	7,287	
	1,70	0,65	5,672		2,00	0,65	8,137	
	1,80	0,65	6,027		2,24	0,65	9,157	
	1,90	0,65	6,382		2,50	0,8	10,08	
	2,00	0,65	6,737		2,80	0,8	11,35	
	2,12	0,65	7,163					
	2,24	0,65	7,589					
	2,36	0,8	7,829					
	2,50	0,8	8,326					

\* 0,5 × nominal thickness

Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	Nominal width	Nominal thickness	Corner radius	Nominal cross-section area		
mm	mm	mm	mm <sup>2</sup>	mm	mm	mm	mm <sup>2</sup>		
4,50	0,80	*	3,463	5,00	1,70	0,65	8,137		
	0,85	*	3,670		1,80	0,65	8,637		
	0,90	*	3,876		1,90	0,65	9,137		
	0,95	*	4,081		2,00	0,65	9,637		
	1,00	*	4,285		2,12	0,65	10,24		
					2,24	0,65	10,84		
		1,06	0,5		4,555				
		1,12	0,5		4,825		2,36	0,8	11,25
		1,18	0,5		5,095		2,50	0,8	11,95
		1,25	0,5		5,410		2,65	0,8	12,70
		1,32	0,5		5,725		2,80	0,8	13,45
		1,40	0,5		6,085		3,00	0,8	14,45
		1,50	0,5		6,535		3,15	0,8	15,20
		1,60	0,5		6,985		3,35	0,8	16,20
						3,55	0,8	17,20	
		1,70	0,65	7,287	5,30	0,80	*	4,103	
		1,80	0,65	7,737		0,90	*	4,596	
		1,90	0,65	8,187		1,00	*	5,085	
		2,00	0,65	8,637					
		2,12	0,65	9,177			1,12	0,5	5,721
		2,24	0,65	9,717			1,25	0,5	6,410
							1,40	0,5	7,205
		2,36	0,8	10,07			1,60	0,5	8,265
		2,50	0,8	10,70					
		2,65	0,8	11,38			1,80	0,65	9,177
		2,80	0,8	12,05			2,00	0,65	10,24
		3,00	0,8	12,95			2,24	0,65	11,51
		3,15	0,8	13,63					
	4,75	0,80	*	3,663			2,50	0,8	12,70
		0,90	*	4,101		2,80	0,8	14,29	
		1,00	*	4,535		3,15	0,8	16,15	
						3,55	0,8	18,27	
			1,12	0,5	5,105	5,60	0,80	*	4,343
		1,25	0,5	5,723	0,85		*	4,605	
		1,40	0,5	6,435	0,90		*	4,866	
		1,60	0,5	7,385	0,95		*	5,126	
					1,00		*	5,385	
		1,80	0,65	8,187					
		2,00	0,65	9,137			1,06	0,5	5,721
		2,24	0,65	10,28			1,12	0,5	6,057
							1,18	0,5	6,393
		2,50	0,8	11,33			1,25	0,5	6,785
		2,80	0,8	12,75			1,32	0,5	7,177
		3,15	0,8	14,41			1,40	0,5	7,625
5,00		0,80	*	3,863			1,50	0,5	8,185
		0,85	*	4,095			1,60	0,5	8,745
	0,90	*	4,326						
	0,95	*	4,556		1,70	0,65	9,157		
	1,00	*	4,785		1,80	0,65	9,717		
					1,90	0,65	10,28		
		1,06	0,5	5,085		2,00	0,65	10,84	
		1,12	0,5	5,385		2,12	0,65	11,51	
		1,18	0,5	5,685		2,24	0,65	12,18	
		1,25	0,5	6,035					
		1,32	0,5	6,385		2,36	0,8	12,67	
		1,40	0,5	6,785		2,50	0,8	13,45	
		1,50	0,5	7,285		2,65	0,8	14,29	
		1,60	0,5	7,785		2,80	0,8	15,13	

\* 0,5 × nominal thickness

Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	
mm	mm	mm	mm <sup>2</sup>	mm	mm	mm	mm <sup>2</sup>	
5,60	3,00	0,8	16,25	6,30	3,75	1,0	22,77	
	3,15	0,8	17,09		4,00	1,0	24,34	
	3,35	0,8	18,21		4,25	1,0	25,92	
	3,55	0,8	19,33		4,50	1,0	27,49	
	3,75	1,0	20,14	6,70	0,90	*	5,856	
	4,00	1,0	21,54		1,00	*	6,485	
6,00	0,80	*	4,663		1,12	0,5	7,289	
	0,90	*	5,226		1,25	0,5	8,160	
	1,00	*	5,785		1,40	0,5	9,165	
					1,60	0,5	10,51	
		1,12	0,5	6,505				
		1,25	0,5	7,285		1,80	0,65	11,70
		1,40	0,5	8,185		2,00	0,65	13,04
		1,60	0,5	9,385		2,24	0,65	14,65
						2,50	0,8	16,20
		1,80	0,65	10,44		2,80	0,8	18,21
		2,00	0,65	11,64		3,15	0,8	20,56
		2,24	0,65	13,08		3,55	0,8	23,24
						4,00	1,0	25,94
		2,50	0,8	14,45		4,50	1,0	29,29
	2,80	0,8	16,25	7,10	0,90	*	6,216	
	3,15	0,8	18,35		0,95	*	6,551	
	3,55	0,8	20,75		1,00	*	6,885	
	4,00	1,0	23,14			1,06	0,5	7,311
6,30	0,80	*	4,903			1,12	0,5	7,737
	0,85	*	5,200			1,18	0,5	8,163
	0,90	*	5,496			1,25	0,5	8,660
	0,95	*	5,791			1,32	0,5	9,157
	1,00	*	6,085			1,40	0,5	9,725
					1,50	0,5	10,44	
		1,06	0,5	6,463		1,60	0,5	11,15
		1,12	0,5	6,841				
		1,18	0,5	7,219		1,70	0,65	11,71
		1,25	0,5	7,660		1,80	0,65	12,42
		1,32	0,5	8,101		1,90	0,65	13,13
		1,40	0,5	8,605		2,00	0,65	13,84
		1,50	0,5	9,235		2,12	0,65	14,69
		1,60	0,5	9,865		2,24	0,65	15,54
	1,70	0,65	10,35		2,36	0,8	16,21	
	1,80	0,65	10,98		2,50	0,8	17,20	
	1,90	0,65	11,61		2,65	0,8	18,27	
	2,00	0,65	12,24		2,80	0,8	19,33	
	2,12	0,65	12,99		3,00	0,8	20,75	
	2,24	0,65	13,75		3,15	0,8	21,82	
					3,35	0,8	23,24	
	2,36	0,8	14,32		3,55	0,8	24,66	
	2,50	0,8	15,20					
	2,65	0,8	16,15		3,75	1,0	25,77	
	2,80	0,8	17,09		4,00	1,0	27,54	
	3,00	0,8	18,35		4,25	1,0	29,32	
	3,15	0,8	19,30					
	3,35	0,8	20,56					
	3,55	0,8	21,82					

\* 0,5 × nominal thickness

Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	Nominal width	Nominal thickness	Corner radius	Nominal cross-section area		
mm	mm	mm	mm <sup>2</sup>	mm	mm	mm	mm <sup>2</sup>		
7,10	4,50	1,0	31,09	8,50	1,12	0,5	9,305		
	4,75	1,0	32,87		1,25	0,5	10,41		
	5,00	1,0	34,64		1,40	0,5	11,69		
7,50	1,00	*	7,285		1,60	0,5	13,39		
		1,12	0,5		8,185	1,80	0,65	14,94	
		1,25	0,5		9,160	2,00	0,65	16,64	
		1,40	0,5		10,29	2,24	0,65	18,68	
		1,60	0,5		11,79	2,50	0,8	20,70	
		1,80	0,65		13,14	2,80	0,8	23,25	
	2,00	0,65	14,64		3,15	0,8	26,23		
	2,24	0,65	16,44		3,55	0,8	29,63		
	2,50	0,8	18,20		4,00	1,0	33,14		
	2,80	0,8	20,45	4,50	1,0	37,39			
	3,15	0,8	23,08	5,00	1,0	41,64			
	3,55	0,8	26,08	5,60	1,0	46,74			
	8,00	1,00	*	7,785	9,00	1,12	0,5	9,865	
			1,06	0,5		8,265	1,18	0,5	10,41
			1,12	0,5		8,745	1,25	0,5	11,04
1,18			0,5	9,225		1,32	0,5	11,67	
1,25			0,5	9,785		1,40	0,5	12,39	
1,32			0,5	10,35		1,50	0,5	13,29	
1,40		0,5	10,99	1,60		0,5	14,19		
1,50		0,5	11,79	1,70		0,65	14,94		
1,60		0,5	12,59	1,80		0,65	15,84		
1,70		0,65	13,24	1,90		0,65	16,74		
1,80		0,65	14,04	2,00		0,65	17,64		
1,90		0,65	14,84	2,12		0,65	18,72		
2,00		0,65	15,64	2,24	0,65	19,80			
2,12		0,65	16,60	2,36	0,8	20,69			
2,24		0,65	17,56	2,50	0,8	21,95			
2,36	0,8	18,33	2,65	0,8	23,30				
2,50	0,8	19,45	2,80	0,8	24,65				
2,65	0,8	20,65	3,00	0,8	26,45				
2,80	0,8	21,85	3,15	0,8	27,80				
3,00	0,8	23,45	3,35	0,8	29,60				
3,15	0,8	24,65	3,55	0,8	31,40				
3,35	0,8	26,25	3,75	1,0	32,89				
3,55	0,8	27,85	4,00	1,0	35,14				
3,75	1,0	29,14	4,25	1,0	37,39				
4,00	1,0	31,14	4,50	1,0	39,64				
4,25	1,0	33,14	4,75	1,0	41,89				
4,50	1,0	35,14	5,00	1,0	44,14				
4,75	1,0	37,14	5,30	1,0	46,84				
5,00	1,0	39,14	5,60	1,0	49,54				
5,30	1,0	41,54	9,50	1,25	0,5	11,66			
5,60	1,0	43,94		1,40	0,5	13,09			
				1,60	0,5	14,99			
				1,80	0,65	16,74			
			2,00	0,65	18,64				
			2,24	0,65	20,92				

\* 0,5 × nominal thickness

Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	
mm	mm	mm	mm <sup>2</sup>	mm	mm	mm	mm <sup>2</sup>	
9,50	2,50	0,8	23,20	11,20	1,70	0,65	18,68	
	2,80	0,8	26,05		1,80	0,65	19,80	
	3,15	0,8	29,38		1,90	0,65	20,92	
	3,55	0,8	33,18		2,00	0,65	22,04	
					2,12	0,65	23,38	
					2,24	0,65	24,73	
		4,00	1,0		37,14	2,36	0,8	25,88
		4,50	1,0		41,89	2,50	0,8	27,45
		5,00	1,0		46,64	2,65	0,8	29,13
		5,60	1,0		52,34	2,80	0,8	30,81
10,00	1,25	0,5	12,29	3,00	0,8	33,05		
	1,32	0,5	12,99	3,15	0,8	34,73		
	1,40	0,5	13,79	3,35	0,8	36,97		
	1,50	0,5	14,79	3,55	0,8	39,21		
	1,60	0,5	15,79					
		1,70	0,65	16,64	3,75	1,0	41,14	
		1,80	0,65	17,64	4,00	1,0	43,94	
		1,90	0,65	18,64	4,25	1,0	46,74	
		2,00	0,65	19,64	4,50	1,0	49,54	
		2,12	0,65	20,84	4,75	1,0	52,34	
	2,24	0,65	22,04	5,00	1,0	55,14		
				5,30	1,0	58,50		
				5,60	1,0	61,86		
	2,36	0,8	23,05	11,80	1,60	0,5	18,67	
	2,50	0,8	24,45					
	2,65	0,8	25,95		1,80	0,65	20,88	
	2,80	0,8	27,45		2,00	0,65	23,24	
	3,00	0,8	29,45		2,24	0,65	26,07	
	3,15	0,8	30,95					
	3,35	0,8	32,95		2,50	0,8	28,95	
	3,55	0,8	34,95		2,80	0,8	32,49	
					3,15	0,8	36,62	
					3,55	0,8	41,34	
	3,75	1,0	36,64					
	4,00	1,0	39,14	4,00	1,0	46,34		
	4,25	1,0	41,64	4,50	1,0	52,24		
	4,50	1,0	44,14	5,00	1,0	58,14		
	4,75	1,0	46,64	5,60	1,0	65,22		
	5,00	1,0	49,14					
	5,30	1,0	52,14	12,50	1,60	0,5	19,79	
	5,60	1,0	55,14					
10,60	1,40	0,5	14,63		1,70	0,65	20,89	
	1,60	0,5	16,75		1,80	0,65	22,14	
					1,90	0,65	23,39	
					2,00	0,65	24,64	
					2,12	0,65	26,14	
					2,24	0,65	27,64	
		2,50	0,8		25,95	2,36	0,8	28,95
		2,80	0,8		29,13	2,50	0,8	30,70
		3,15	0,8	32,84	2,65	0,8	32,58	
		3,55	0,8	37,08	2,80	0,8	34,45	
				3,00	0,8	36,95		
	4,00	1,0	41,54	3,15	0,8	38,83		
	4,50	1,0	46,84	3,35	0,8	41,33		
	5,00	1,0	52,14	3,55	0,8	43,83		
	5,60	1,0	58,50					
11,20	1,40	0,5	15,47					
	1,50	0,5	16,59	3,75	1,0	46,02		
	1,60	0,5	17,71	4,00	1,0	49,14		
				4,25	1,0	52,27		

Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	
mm	mm	mm	mm <sup>2</sup>	mm	mm	mm	mm <sup>2</sup>	
12,50	4,50	1,0	55,39	16,00	2,36	0,8	37,21	
	4,75	1,0	58,52		2,50	0,8	39,45	
	5,00	1,0	61,64		2,65	0,8	41,85	
	5,30	1,0	65,39		2,80	0,8	44,25	
	5,60	1,0	69,14		3,00	0,8	47,45	
13,20	1,80	0,65	23,40		3,15	0,8	49,85	
		0,65	26,04		3,35	0,8	53,05	
		0,65	29,21		3,55	0,8	56,25	
	2,50	0,8	32,45		3,75	1,0	59,14	
		0,8	36,41		4,00	1,0	63,14	
		0,8	41,03		4,25	1,0	67,14	
		0,8	46,31		4,50	1,0	71,14	
		4,00	1,0		51,94	4,75	1,0	75,14
			1,0		58,54	5,00	1,0	79,14
			1,0		65,14	5,30	1,0	83,94
	14,00	1,80	0,65		24,84	5,60	1,0	88,74
			0,65	26,24	17,00	2,24	0,8	37,72
			0,65	27,64		2,50	0,8	41,95
0,65		29,32	2,80	0,8		47,05		
0,65		31,00	3,15	0,8		53,00		
2,36		0,8	32,49	3,55		0,8	59,80	
		0,8	34,45	4,00		1,0	67,14	
		0,8	36,55			4,50	1,0	75,64
		0,8	38,65		5,00	1,0	84,14	
		0,8	41,45	5,60	1,0	94,34		
	0,8	43,55	6,30	1,25	105,8			
	0,8	46,35		1,25	119,4			
0,8	49,15	1,25		134,7				
3,75	1,0	51,64		1,25	151,7			
	1,0	55,14	10,0	1,25	168,7			
	1,0	58,64	18,00	2,36	0,8	41,93		
	1,0	62,14		2,50	0,8	44,45		
	1,0	65,64		2,65	0,8	47,15		
	1,0	69,14		2,80	0,8	49,85		
	1,0	73,34		3,00	0,8	53,45		
	1,0	77,54		3,15	0,8	56,15		
	15,00	2,00		0,65	29,64	3,35	0,8	59,75
				0,65	33,24	3,55	0,8	63,35
		2,50		0,8	36,95	3,75	1,0	66,64
0,8				41,45	4,00		1,0	71,14
0,8				46,70	4,25		1,0	75,64
4,00	1,0	59,14	4,50	1,0	80,14			
	1,0	66,64	4,75	1,0	84,64			
	1,0	74,14	5,00	1,0	89,14			
16,00	2,00	0,65	31,64	5,30	1,0		94,54	
		0,65	33,56	5,60	1,0		99,94	
		0,65	35,48	6,00	1,25		106,7	
	2,12	1,25	112,1					
		1,25	119,3					
		1,25	126,5					
		1,25	133,7					
		1,25	142,7					
2,24	1,25	151,7	6,30	1,25	160,7			
	1,25	160,7		1,25	169,7			
	1,25	169,7		10,0	1,25	178,7		
	1,25	178,7						

Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	
mm	mm	mm	mm <sup>2</sup>	mm	mm	mm	mm <sup>2</sup>	
19,00	2,50	0,8	46,95	22,40	3,75	1,0	83,14	
	2,80	0,8	52,65		4,00	1,0	88,74	
	3,15	0,8	59,30		4,25	1,0	94,34	
	3,55	0,8	66,90		4,50	1,0	99,94	
	4,00	1,0	75,14		4,75	1,0	105,5	
	4,50	1,0	84,64		5,00	1,0	111,1	
	5,00	1,0	94,14		5,30	1,0	117,9	
	5,60	1,0	105,5		5,60	1,0	124,6	
	6,30	1,25	118,4		6,00	1,25	133,1	
	7,10	1,25	133,6		6,30	1,25	139,8	
	8,00	1,25	150,7		6,70	1,25	148,7	
	9,00	1,25	169,7		7,10	1,25	157,7	
	10,0	1,25	188,7		7,50	1,25	166,7	
	20,00	2,50	0,8		49,45	8,00	1,25	177,9
2,65		0,8	52,45	8,50	1,25	189,1		
2,80		0,8	55,45	9,00	1,25	200,3		
3,00		0,8	59,45	9,50	1,25	211,5		
3,15		0,8	62,45	10,0	1,25	222,7		
3,35		0,8	66,45	23,60	3,15	0,8	73,79	
3,55		0,8	70,45		3,55	0,8	83,23	
3,75		1,0	74,14		4,00	1,0	93,54	
4,00		1,0	79,14		4,50	1,0	105,3	
4,25		1,0	84,14		5,00	1,0	117,1	
4,50		1,0	89,14		5,60	1,0	131,3	
4,75		1,0	94,14		6,30	1,25	147,3	
5,00		1,0	99,14		7,10	1,25	166,2	
5,30		1,0	105,1		8,00	1,25	187,5	
5,60	1,0	111,1	9,00		1,25	211,1		
6,00	1,25	118,7	10,0		1,25	234,7		
6,30	1,25	124,7	25,00		3,15	0,8	78,20	
6,70	1,25	132,7			3,35	0,8	83,20	
7,10	1,25	140,7			3,55	0,8	88,20	
7,50	1,25	148,7		3,75	1,0	92,89		
8,00	1,25	158,7		4,00	1,0	99,14		
8,50	1,25	168,7		4,25	1,0	105,4		
9,00	1,25	178,7		4,50	1,0	111,6		
9,50	1,25	188,7		4,75	1,0	117,9		
10,0	1,25	198,7		5,00	1,0	124,1		
21,20	2,80	0,8		58,81	5,30	1,0	131,6	
	3,15	0,8		66,23	5,60	1,0	139,1	
	3,55	0,8		74,71	6,00	1,25	148,7	
	4,00	1,0		83,94	6,30	1,25	156,2	
	4,50	1,0		94,54	6,70	1,25	166,2	
	5,00	1,0	105,1	7,10	1,25	176,2		
	5,60	1,0	117,9	7,50	1,25	186,2		
	6,30	1,25	132,2	8,00	1,25	198,7		
	7,10	1,25	149,2	8,50	1,25	211,2		
	8,00	1,25	168,3	9,00	1,25	223,7		
	9,00	1,25	189,5	9,50	1,25	236,2		
	10,0	1,25	210,7	10,0	1,25	248,7		
	22,40	2,80	0,8	62,17	26,50	3,55	0,8	93,53
		3,00	0,8	66,65		4,00	1,0	105,1
3,15		0,8	70,01	4,50		1,0	118,4	
3,35		0,8	74,49	5,00		1,0	131,6	
3,55		0,8	78,97	5,60		1,0	147,5	

Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	Nominal width	Nominal thickness	Corner radius	Nominal cross-section area	
mm	mm	mm	mm <sup>2</sup>	mm	mm	mm	mm <sup>2</sup>	
26,50	6,30	1,25	165,6	30,00	4,00	1,0	119,1	
	7,10	1,25	186,8		4,50	1,0	134,1	
	8,00	1,25	210,7		5,00	1,0	149,1	
	9,00	1,25	237,2		5,60	1,0	167,1	
	10,0	1,25	263,7					
28,00	3,55	0,8	98,85		6,30	1,25	187,7	
					7,10	1,25	211,7	
					8,00	1,25	238,7	
					9,00	1,25	268,7	
					10,0	1,25	298,7	
					31,50	4,00	1,0	125,1
						4,25	1,0	133,0
						4,50	1,0	140,9
						4,75	1,0	148,8
						5,00	1,0	156,6
						5,30	1,0	166,1
						5,60	1,0	175,5
						6,00	1,25	187,7
						6,30	1,25	197,1
						6,70	1,25	209,7
					7,10	1,25	222,3	
					7,50	1,25	234,9	
					8,00	1,25	250,7	
					8,50	1,25	266,4	
					9,00	1,25	282,2	
				9,50	1,25	297,9		
				10,0	1,25	313,7		

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## COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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### SPÉCIFICATIONS POUR TYPES PARTICULIERS DE FILS DE BOBINAGE –

#### Partie 0-2: Exigences générales – Fil de section rectangulaire en cuivre émaillé

##### AVANT-PROPOS

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- 8) L'attention est attirée sur les références normatives citées dans cette publication. L'utilisation de publications référencées est obligatoire pour une application correcte de la présente publication.
- 9) L'attention est attirée sur le fait que certains des éléments de la présente Publication de l'IEC peuvent faire l'objet de droits de brevet. L'IEC ne saurait être tenue pour responsable de ne pas avoir identifié de tels droits de brevets et de ne pas avoir signalé leur existence.

La Norme internationale IEC 60317-0-2 a été établie par le comité d'études 55 de l'IEC: Fils de bobinage.

Cette quatrième édition annule et remplace la troisième édition parue en 2013. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

- a) révision de l'Article 2 afin d'ajouter de nouvelles références normatives pour les spécifications relatives au fil machine en cuivre;
- b) révision du 3.1 afin d'ajouter une nouvelle définition pour le terme "couche d'adhérence";

- c) révision du 3.2.1 afin de modifier les conditions spécifiées pour les essais à effectuer;
- d) révision du 4.5 afin d'ajouter les exigences relatives aux dimensions extérieures minimales, nominales et maximales avec une couche d'adhérence;
- e) révision de l'Article 5 concernant les spécifications relatives au fil machine en cuivre de sections rectangulaire et carrée;
- f) révision de l'Article 6 afin de tenir compte de la limite conventionnelle d'élasticité nominale;
- g) révision du 8.2 concernant l'exigence de l'essai d'adhérence;
- h) révision de l'Article 18 afin de faire référence à la feuille de spécifications correspondante.

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
55/1847/FDIS	55/1865/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette Norme internationale.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

La présente Norme internationale doit être lue conjointement avec l'IEC 60851 (toutes les parties). Les numéros d'articles utilisés dans la présente partie de l'IEC 60317 sont identiques aux numéros des essais correspondants de la série IEC 60851 (toutes les parties).

En cas de divergences entre l'IEC 60851 et la présente partie de l'IEC 60317, cette dernière prévaut.

La numérotation des articles dans la présente norme n'est pas continue entre les Articles 21 et 30 afin de permettre l'introduction d'éventuelles futures exigences concernant les fils avant celles concernant le conditionnement des fils.

Une liste de toutes les parties de la série IEC 60317, publiées sous le titre général *Spécifications pour types particuliers de fils de bobinage*, peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "<http://webstore.iec.ch>" dans les données relatives au document recherché. A cette date, le document sera

- reconduit,
- supprimé,
- remplacé par une édition révisée, ou
- amendé.

## INTRODUCTION

La présente partie de l'IEC 60317 appartient à une série de normes traitant des fils isolés utilisés pour les enroulements des appareils électriques. L'ensemble est composé des trois séries de normes suivantes:

- 1) *Fils de bobinage – Méthodes d'essai* (série IEC 60851);
- 2) *Spécifications pour types particuliers de fils de bobinage* (série IEC 60317);
- 3) *Conditionnement des fils de bobinage* (série IEC 60264).

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## SPÉCIFICATIONS POUR TYPES PARTICULIERS DE FILS DE BOBINAGE –

### Partie 0-2: Exigences générales – Fil de section rectangulaire en cuivre émaillé

#### 1 Domaine d'application

La présente partie de l'IEC 60317 spécifie les exigences générales relatives aux fils de bobinage de section rectangulaire en cuivre émaillés.

La gamme des dimensions nominales des conducteurs est indiquée en 4.1 et dans la feuille de spécifications correspondante.

#### 2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

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

IEC 60851 (toutes les parties), *Fils de bobinage – Méthodes d'essai*

IEC 60851-3, *Fils de bobinage – Méthodes d'essai – Partie 3: Propriétés mécaniques*

ISO 3, *Nombres normaux – Séries de nombres normaux*

ISO 1190-1, *Cuivre et alliages de cuivre – Code de désignation – Partie 1: Désignation des matériaux*

ISO 6892-1:2016, *Matériaux métalliques – Essai de traction – Partie 1: Méthode d'essai à température ambiante*

EN 1977, *Cuivre et alliages de cuivre – Fil machine en cuivre*

ASTM B49, *Standard Specification for Copper Rod for Electrical Purposes* (disponible en anglais seulement)

#### 3 Termes, définitions, notes générales et aspect

##### 3.1 Termes et définitions

Pour les besoins du présent document, les termes et définitions donnés dans l'ISO 6892-1:2016 ainsi que les suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse <http://www.electropedia.org/>
- ISO Online browsing platform: disponible à l'adresse <http://www.iso.org/obp>

**3.1.1**  
**classe**

performance thermique d'un fil exprimée par l'indice de température et la température de choc thermique

**3.1.2**  
**revêtement**

matériau qui est déposé sur un conducteur ou sur un fil par des moyens appropriés, puis séché et/ou cuit

**3.1.3**  
**conducteur**

métal nu après enlèvement de l'isolant

**3.1.4**  
**craquelure**

fente dans l'isolant qui rend le conducteur visible sous un grossissement donné

**3.1.5**  
**double revêtement**

isolant constitué de deux matériaux différents, l'un en sous-couche et l'autre en surcouche

**3.1.6**  
**fil émaillé**

fil revêtu d'un isolant fait d'une résine cuite

**3.1.7**  
**grade**

gamme d'accroissement du diamètre extérieur du fil dû à l'émail

**3.1.8**  
**isolant**

revêtement ou enveloppe sur le conducteur dont la fonction spécifique est de supporter la tension électrique

**3.1.9**  
**dimension nominale du conducteur**

désignation de la taille du conducteur selon la série IEC 60317

**3.1.10**  
**vision normale**

vision de 20/20 avec port de lentilles correctives, si nécessaire

**3.1.11**  
**fil de bobinage**

fil utilisé pour fabriquer un bobinage qui fournit un champ magnétique

**3.1.12**  
**fil**

conducteur revêtu ou enveloppé d'un isolant

### 3.1.13

#### **couche d'adhérence**

matériau qui est déposé sur un fil émaillé et dont la fonction spécifique est de relier des fils ensemble

## 3.2 Notes générales

### 3.2.1 Méthodes d'essai

Toutes les méthodes d'essai à utiliser dans le présent document sont décrites dans l'IEC 60851 (toutes les parties).

Les numéros d'articles utilisés dans le présent document sont identiques aux numéros des essais correspondants de l'IEC 60851 (toutes les parties).

En cas de divergences entre la publication relative aux méthodes d'essai et le présent document, l'IEC 60317-0-2 doit prévaloir.

Dans le cas où aucune gamme spécifique de dimensions nominales du conducteur n'est indiquée pour un essai, cet essai s'applique à l'ensemble des dimensions nominales du conducteur couvertes par la feuille de spécifications correspondante.

Sauf spécification contraire, tous les essais doivent être effectués à une température comprise entre 15 °C et 40 °C et avec une humidité relative comprise entre 25 % et 75 %. Avant de procéder aux mesurages, les éprouvettes doivent être préconditionnées dans ces conditions atmosphériques pendant une durée suffisante afin qu'elles deviennent stables.

Le fil à soumettre à l'essai doit être retiré de son conditionnement de telle manière qu'il ne soit soumis à aucune tension ni à des pliages inutiles. Avant chaque essai, il convient d'éliminer une longueur de fil suffisante afin de s'assurer que les éprouvettes ne comportent aucun fil endommagé.

### 3.2.2 Fil de bobinage

Lorsqu'il est fait référence à un fil de bobinage, conformément à une norme de la série IEC 60317 indiquée à l'Article 2, les informations suivantes sont fournies dans la description:

- la référence de la spécification IEC correspondante;
- les dimensions nominales du conducteur en millimètres (largeur × épaisseur);
- le grade;
- la valeur minimale (et maximale) de limite conventionnelle d'élasticité nominale.

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

## 3.3 Aspect

Le film de revêtement doit être essentiellement lisse et continu, ne pas comporter de rayures, cloques, ni corps étrangers lors d'un examen visuel réalisé avec une vision normale, conformément aux bonnes pratiques commerciales, lorsqu'il est enroulé sur la bobine ou le touret d'origine.

## 4 Dimensions

### 4.1 Dimensions du conducteur

Les dimensions concernant les largeurs et les épaisseurs des conducteurs des fils de bobinage de section rectangulaire, recommandées dans le présent document, correspondent à la série R 20 de l'ISO 3.

Les dimensions préférentielles combinent une largeur et une épaisseur, toutes deux conformes à la série R 20.

Les dimensions intermédiaires combinent une largeur et une épaisseur conformes à la série R 20 avec l'autre dimension conforme à la série R 40.

Le présent document concerne:

- les largeurs de 2,00 mm et jusques y compris 31,50 mm;
- les épaisseurs de 0,80 mm jusques et y compris 10,00 mm.

Le rapport largeur/épaisseur doit être compris dans les limites spécifiées. Les combinaisons série R 40 – série R 40 ne sont pas admises en cas de tailles supplémentaires.

Le rapport largeur/épaisseur doit être supérieur ou égal à 1,4:1 et ne doit pas être supérieur à 8:1.

Les valeurs réelles des dimensions sont indiquées dans le Tableau 2.

Les sections nominales des dimensions préférentielles sont indiquées dans le Tableau 2 et les sections nominales des dimensions intermédiaires sont indiquées dans le Tableau A.1.

#### 4.2 Tolérance sur les dimensions du conducteur

Les dimensions du conducteur ne doivent pas s'écarter des valeurs nominales au-delà de la tolérance indiquée dans le Tableau 1.

**Tableau 1 – Tolérances relatives au conducteur**

Largeur ou épaisseur nominale du conducteur mm		Tolérance
Supérieure à	Jusques et y compris	± mm
–	3,15	0,030
3,15	6,30	0,050
6,30	12,50	0,070
12,50	16,00	0,100
16,00	22,40	0,130
22,40	31,50	0,150

#### 4.3 Arrondi des angles

L'arrondi doit se raccorder progressivement aux surfaces planes du conducteur et le méplat ne doit présenter aucune aspérité, ni rugosité ou bavure. Les rayons d'arrondi du conducteur doivent être conformes aux valeurs indiquées dans le Tableau 3. Les rayons spécifiés doivent respecter une tolérance de ± 25 %.