IEC 60317-0-3

Edition 4.0 2024-09
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INTERNATIONAL STANDARD

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Specifications for particular types of winding wires – Part 0-3: General requirements – Enamelled round aluminium wire

IEC 60317-0-3:2024-04 RLV(en)

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

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

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Specifications for particular types of winding wires – Part 0-3: General requirements – Enamelled round aluminium wire

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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SPECIFICATIONS FOR PARTICULAR TYPES OF WINDING WIRES –

Part 0-3: General requirements – Enamelled round aluminium wire

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 60317-0-3:2008+AMD1:2013+AMD2:2019 CSV. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

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IEC 60317-0-3 has been prepared by IEC technical committee 55: Winding wires. It is an International Standard.

This fourth edition cancels and replaces the third edition published in 2008, Amendment 1:2013 and Amendment 2:2019. This edition constitutes a technical revision.

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

a) Revision to Clause 7, designating the test as inappropriate;

b) Revision to Clause 10, designating the test as inappropriate.

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

Draft	Report on voting
55/2049/FDIS	55/2054/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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 webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

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INTRODUCTION

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Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights other than those in the patent database. IEC shall not be held responsible for identifying any or all such patent rights.

This part of IEC 60317 is one of a series that deals with insulated wires used for windings in electrical equipment. The series has three groups describing

1) winding wires and test methods (IEC 60851);
2) specifications for particular types of winding wires (IEC 60317);
3) packaging of winding wires (IEC 60264).

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SPECIFICATIONS FOR PARTICULAR TYPES OF WINDING WIRES –

Part 0-3: General requirements – Enamelled round aluminium wire

1 Scope

This part of IEC 60317 specifies the general requirements of enamelled round aluminium winding wires with or without a bonding layer.

The range of nominal conductor diameters is given in 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 60317 (all parts), *Specifications for particular types of winding wires*

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

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

ASTM B233-97, *Standard Specification for Aluminum 1350 Drawing Stock for Electrical Purposes*

EN 1715-2, *Aluminium and aluminium alloys – Drawing stock – Part 2: Specific requirements for electrical applications*

3 Terms, definitions, general notes, and appearance

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions ~~and general notes~~ apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

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

3.1.1
bonding layer
material which is deposited on an enamelled wire, and which has the specific function of bonding wires together

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3.1.2
class
thermal performance of a wire expressed by the temperature index and the heat shock temperature

3.1.3
coating
material which is deposited on a conductor or wire by a suitable means and then dried and/or cured

3.1.4
conductor
bare metal after removal of the insulation

3.1.5
crack
opening in the insulation which exposes the conductor to view at the stated magnification

~~**3.1.6**~~
~~**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
range of thickness of the insulation of a wire

3.1.8
insulation
coating or covering on the conductor with the specific function of withstanding voltage

3.1.9
nominal conductor ~~dimension~~ diameter
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

3.2 General notes

3.2.1 Methods of test

All methods of test to be used for this part of IEC 60317, independent of the class of wire, are given in the IEC 60851 series.

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The clause numbers used in this document are identical with the respective test numbers of the IEC 60851 series.

In case of inconsistencies between the publication on methods of test and this document, IEC 60317-0-3 shall prevail.

Where no specific range of nominal conductor diameters is given for a test, the test applies to all nominal conductor diameters 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 of 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

See the relevant specification sheet.

In addition, 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 diameter in millimetres;
- grade.

EXAMPLE IEC 60317-1 – 0,500 Grade 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, as wound on the original spool or reel.

When agreed upon between the user and supplier, examination using 6× to 10× magnification shall be used for wires with a nominal diameter less than 0,10 mm.

4 Dimensions

4.1 Conductor diameter

The series of preferred nominal conductor diameters shall correspond to series R 20 according to ISO 3. The actual values and their tolerances are given in Table 1 and Table 2.

The series of intermediate diameters from which the user may select intermediate nominal conductor diameters, when required for technical reasons, shall correspond to series R 40 according to ISO 3. The actual values and their tolerances are given in Annex A.

The conductor diameter shall not differ from the nominal diameter by more than the limit given in Table 1 or Table 2.

For intermediate nominal conductor diameters, the minimum increase figure corresponding to the next larger nominal conductor diameter applies.

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Table 1 – Dimensions of enamelled wires (R 20)

Nominal conductor diameter	Conductor tolerance	Minimum increase due to the insulation			Maximum overall diameter		
	±	mm			mm		
mm	mm	Grade 1	Grade 2	Grade 3	Grade 1	Grade 2	Grade 3
0,250	0,004	0,017	0,032	0,048	0,281	0,297	0,312
0,280	0,004	0,018	0,033	0,050	0,312	0,329	0,345
0,315	0,004	0,019	0,035	0,053	0,349	0,367	0,384
0,355	0,004	0,020	0,038	0,057	0,392	0,411	0,428
0,400	0,005	0,021	0,040	0,060	0,439	0,459	0,478
0,450	0,005	0,022	0,042	0,064	0,491	0,513	0,533
0,500	0,005	0,024	0,045	0,067	0,544	0,566	0,587
0,560	0,006	0,025	0,047	0,071	0,606	0,630	0,653
0,630	0,006	0,027	0,050	0,075	0,679	0,704	0,728
0,710	0,007	0,028	0,053	0,080	0,762	0,789	0,814
0,800	0,008	0,030	0,056	0,085	0,855	0,884	0,911
0,900	0,009	0,032	0,060	0,090	0,959	0,989	1,018
1,000	0,010	0,034	0,063	0,095	1,062	1,094	1,124
1,120	0,011	0,034	0,065	0,098	1,184	1,217	1,248
1,250	0,013	0,035	0,067	0,100	1,316	1,349	1,381
1,400	0,014	0,036	0,069	0,103	1,468	1,502	1,535
1,600	0,016	0,038	0,071	0,107	1,670	1,706	1,740
1,800	0,018	0,039	0,073	0,110	1,872	1,909	1,944
2,000	0,020	0,040	0,075	0,113	2,074	2,112	2,148
2,240	0,022	0,041	0,077	0,116	2,316	2,355	2,392
2,500	0,025	0,042	0,079	0,119	2,578	2,618	2,656
2,800	0,028	0,043	0,081	0,123	2,880	2,922	2,961
3,150	0,032	0,045	0,084	0,127	3,233	3,276	3,316
3,550	0,036	0,046	0,086	0,130	3,635	3,679	3,721
4,000	0,040	0,047	0,089	0,134	4,088	4,133	4,176
4,500	0,045	0,049	0,092	0,138	4,591	4,637	4,681
5,000	0,050	0,050	0,094	0,142	5,093	5,141	5,186
NOTE The dimensions of intermediate nominal conductor diameters for R 40 series are given in Annex A.							

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Table 2 – Dimensions of enamelled wires with a bonding layer (R 20)

Nominal conductor diameter	Conductor tolerance ±	Minimum increase underlying coating mm		Minimum increase bonding layer	Maximum overall diameter mm	
mm	mm	Grade 1B	Grade 2B	mm	Grade 1B	Grade 2B
0,250	0,004	0,017	0,032	0,013	0,300	0,316
0,280	0,004	0,018	0,033	0,013	0,331	0,348
0,315	0,004	0,019	0,035	0,014	0,369	0,387
0,355	0,004	0,020	0,038	0,015	0,413	0,432
0,400	0,005	0,021	0,040	0,016	0,461	0,481
0,450	0,005	0,022	0,042	0,016	0,514	0,536
0,500	0,005	0,024	0,045	0,017	0,568	0,590
0,560	0,006	0,025	0,047	0,017	0,630	0,654
0,630	0,006	0,027	0,050	0,018	0,704	0,729
0,710	0,007	0,028	0,053	0,019	0,788	0,815
0,800	0,008	0,030	0,056	0,020	0,882	0,911
0,900	0,009	0,032	0,060	0,020	0,987	1,017
1,000	0,010	0,034	0,063	0,021	1,091	1,123
1,120	0,011	0,034	0,065	0,022	1,214	1,247
1,250	0,013	0,035	0,067	0,022	1,346	1,379
1,400	0,014	0,036	0,069	0,023	1,499	1,533
1,600	0,016	0,038	0,071	0,023	1,702	1,738
1,800	0,018	0,039	0,073	0,024	1,905	1,942
2,000	0,020	0,040	0,075	0,025	2,108	2,146
NOTE The dimensions of intermediate nominal conductor diameters for R 40 series are given in Annex A.						

4.2 Out of roundness of conductor

The difference between the minimum and maximum diameter, at any one point, shall not be more than the figure given in column 2 of Table 1 or Table 2.

4.3 Minimum increase in diameter due to the insulation and the bonding layer

4.3.1 Enamelled wires without a bonding layer

The minimum increase in diameter due to the insulation shall not be less than the values given in Table 1.

4.3.2 Enamelled wires with a bonding layer

The minimum increase in diameter due to the insulation including the bonding layer shall not be less than the values given in Table 2.

4.4 Maximum overall diameter

4.4.1 Enamelled wires without a bonding layer

The maximum overall diameter shall not exceed the values given in Table 1.

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4.4.2 Enamelled wires with a bonding layer

The maximum overall diameter shall not exceed the values given in Table 2.

5 Electrical resistance

The aluminium rod being used shall comply with EN 1715-2 and ASTM B233-97.

No resistance values are specified.

By agreement between purchaser and supplier, resistance measurements may be made for nominal conductor diameters up to and including 1,000 mm. In case of such an agreement, the resistance at 20 °C shall be within the limits given in Annex C.

~~NOTE The nominal resistance is given in Annex C.~~

6 Elongation

The elongation at fracture and tensile strength shall not be less than the value given in Table 3.

Table 3 – Elongation

Nominal conductor diameter mm		Elongation minimum	Tensile strength minimum
Over	Up to and including	%	$N \cdot mm^{-2}$
–	0,400	10	90
0,400	1,000	12	90
1,000	2,000	15	80
2,000	5,000	15	70

7 Springiness

~~Test appropriate but no requirements specified.~~

Test inappropriate.

8 Flexibility and adherence

8.1 Mandrel winding test (nominal conductor diameters up to and including 1,600 mm)

The coating shall show no crack after the wire has been wound on a mandrel as specified in Table 4.

Table 4 – Mandrel winding

Nominal conductor diameter mm		Mandrel diameter
Over	Up to and including	
–	1,600	$3d$[a]

[a] d is the nominal diameter of the wire.

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8.2 Stretching test (nominal conductor diameters over ~~1,000~~ 1, 600 mm)

The coating shall show no crack after the wire has been elongated 15 %.

8.3 Jerk test (nominal conductor diameters up to and including 1,000 mm)

The coating shall show no crack or loss of adhesion.

8.4 Peel test (nominal conductor diameters over 1,000 mm)

Test appropriate but no requirements specified.

9 Heat shock

9.1 Nominal conductor diameters up to and including 1,600 mm

The coating shall show no crack. The mandrel diameter shall be as specified in Table 5. The minimum heat shock temperature is given in the relevant specification sheet.

Table 5 – Heat shock

Nominal conductor diameter mm		Mandrel diameter
Over	Up to and including	
–	1,600	$3d$[a]
[a] d is the nominal diameter of the wire.		

9.2 Nominal conductor diameters over 1,600 mm

The coating shall show no crack after having been elongated 15 %. The minimum heat shock temperature is given in the relevant specification sheet.

10 Cut-through

Test inappropriate.

11 Resistance to abrasion

For requirements, see the relevant specification sheet.

12 Resistance to solvents

Following immersion in standard solvent, the coating shall not be removed using a pencil of hardness "H".

Using a pencil of hardness "H" the coating shall not be removed.

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13 Breakdown voltage

13.1 General

The wire shall meet the requirements given in 13.2 and 13.3, respectively, when tested at room temperature and at elevated temperature when this is required by the purchaser.

The elevated temperature is given in the relevant specification sheet.

13.2 Nominal conductor diameters up to and including 2,500 mm

At least four of the five specimens tested shall not break down at a voltage less than or equal to that given in Table 6.

For intermediate nominal conductor diameters, the figure of the next larger nominal conductor diameter applies.

Table 6 – Breakdown voltage

Nominal conductor diameter mm	Minimum breakdown voltage (RMS value) V					
	Grade 1 and grade 1B		Grade 2 and grade 2B		Grade 3	
	Room temperature	Elevated temperature	Room temperature	Elevated temperature	Room temperature	Elevated temperature
0,250	2 100	1 600	3 900	2 900	5 500	4 100
0,280	2 200	1 700	4 000	3 000	5 800	4 400
0,315	2 200	1 700	4 100	3 100	6 100	4 600
0,355	2 300	1 700	4 300	3 200	6 400	4 800
0,400	2 300	1 700	4 400	3 300	6 600	5 000
0,450	2 300	1 700	4 400	3 300	6 800	5 100
0,500	2 400	1 800	4 600	3 500	7 000	5 300
0,560	2 500	1 900	4 600	3 500	7 100	5 300
0,630	2 600	2 000	4 800	3 600	7 100	5 300
0,710	2 600	2 000	4 800	3 600	7 200	5 400
0,800	2 600	2 000	4 900	3 700	7 400	5 600
0,900	2 700	2 000	5 000	3 700	7 600	5 700
1,000 up to and including 2,500	2 700	2 000	5 000	3 800	7 600	5 700

13.3 Nominal conductor diameters over 2,500 mm

At least four of the five specimens tested shall not break down at a voltage less than or equal to that given in Table 7.

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Table 7 – Breakdown voltage

Nominal conductor diameter mm	Minimum breakdown voltage (RMS value) V					
	Grade 1 and grade 1B		Grade 2 and grade 2B		Grade 3	
	Room temperature	Elevated temperature	Room temperature	Elevated temperature	Room temperature	Elevated temperature
~~Over~~ Greater than 2,500 up to and including 5,000	1 300	1 000	2 500	1 900	3 800	2 900

14 Continuity of insulation (nominal conductor diameters up to and including 1,600 mm)

The number of faults per 30 m of wire shall not exceed the values given in Table 8.

Table 8 – Continuity of insulation

Nominal conductor diameter mm		Maximum number of faults per 30 m		
Over	Up to and including	Grade 1 and grade 1B	Grade 2 and grade 2B	Grade 3
–	1,600	25	10	5

15 Temperature index

The test shall be carried out in accordance with IEC 60172.

The temperature index shall not be less than that given in the relevant specification sheet and the time to failure at the lowest test temperature shall not be less than 5 000 h.

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

For requirements, see the relevant specification sheet.

17 Solderability

Test inappropriate.

18 Heat or solvent bonding

For requirements, see the relevant specification sheet.

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19 Dielectric dissipation factor

For requirements, see the relevant specification sheet.

20 Resistance to transformer oil

For requirements, see the relevant specification sheet.

21 Loss of mass

For requirements, see the relevant specification sheet.

23 Pin hole test

Requirements under consideration.

30 Packaging

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

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

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

a) manufacturer's name and/or trade mark;

b) type of wire and insulation, for instance trade name and/or IEC specification number;

c) net mass of wire;

d) nominal dimension(s) of wire and grade of insulation;

e) date of manufacture.

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Annex A
(informative)

Dimensions for intermediate nominal conductor diameters (R 40)

A.1 General

This Annex A covers those intermediate nominal conductor diameters from which the user may select intermediate sizes only for technical reasons.

Minimum overall diameter requirements may be used in lieu of the maximum overall diameters in Table A.1 or Table A.2 provided they are based on the minimum increases.

A.2 Enamelled wires without a bonding layer

Table A.1 – Dimensions of enamelled wires (R 40)

Nominal conductor diameter	Conductor tolerance	Minimum increase due to the insulation			Maximum overall diameter		
	±	mm			mm		
mm	mm	Grade 1	Grade 2	Grade 3	Grade 1	Grade 2	Grade 3
0,265	0,004	0,018	0,033	0,050	0,297	0,314	0,330
0,300	0,004	0,019	0,035	0,053	0,334	0,352	0,369
0,335	0,004	0,020	0,038	0,057	0,372	0,391	0,408
0,375	0,005	0,021	0,040	0,060	0,414	0,434	0,453
0,425	0,005	0,022	0,042	0,064	0,466	0,488	0,508
0,475	0,005	0,024	0,045	0,067	0,519	0,541	0,562
0,530	0,006	0,025	0,047	0,071	0,576	0,600	0,623
0,600	0,006	0,027	0,050	0,075	0,649	0,674	0,698
0,670	0,007	0,028	0,053	0,080	0,722	0,749	0,774
0,750	0,008	0,030	0,056	0,085	0,805	0,834	0,861
0,850	0,009	0,032	0,060	0,090	0,909	0,930	0,968
0.950	0,010	0,034	0,063	0,095	1,012	1,044	1,074
1.060	0,011	0,034	0,065	0,098	1,124	1,157	1,188
1.180	0,012	0,035	0,067	0,100	1,246	1,279	1,311
1.320	0,013	0,036	0,069	0,103	1,388	1,422	1,455
1.500	0,015	0,038	0,071	0,107	1,570	1,606	1,640
1.700	0,017	0,039	0,073	0,110	1,772	1,809	1,844
1.900	0,019	0,040	0,075	0,113	1,974	2,012	2,048
2.120	0,021	0,041	0,077	0,116	2,196	2,235	2,272
2.360	0,024	0,042	0,079	0,119	2,438	2,478	2,516
2.650	0,027	0,043	0,081	0,123	2,730	2,772	2,811
3.000	0,030	0,045	0,084	0,127	3,083	3,126	3,166
3.350	0,034	0,046	0,086	0,130	3,435	3,479	3,521
3.750	0,038	0,047	0,089	0,134	3,838	3,883	3,926
4.250	0,043	0,049	0,092	0,138	4,341	4,387	4,431
4.750	0,048	0,050	0,094	0,142	4,843	4,891	4,936

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A.3 Enamelled wires with a bonding layer

Table A.2 – Dimensions of enamelled wires with a bonding layer (R 40)

Nominal conductor diameter	Conductor tolerance	Minimum increase due to the insulation		Minimum increase due to bonding layer	Maximum overall diameter	
	±	mm			mm	
mm	mm	Grade 1B	Grade 2B	mm	Grade 1B	Grade 2B
0,265	0,004	0,018	0,033	0,013	0,316	0,333
0,300	0,004	0,019	0,035	0,014	0,354	0,372
0,335	0,004	0,020	0,038	0,015	0,393	0,412
0,375	0,005	0,021	0,040	0,016	0,436	0,456
0,425	0,005	0,022	0,042	0,016	0,489	0,511
0,475	0,005	0,024	0,045	0,017	0,543	0,565
0,530	0,006	0,025	0,047	0,017	0,600	0,624
0,600	0,006	0,027	0,050	0,018	0,674	0,699
0,670	0,007	0,028	0,053	0,019	0,748	0,775
0,750	0,008	0,030	0,056	0,020	0,832	0,861
0,850	0,009	0,032	0,060	0,020	0,937	0,967
0.950	0,010	0,034	0,063	0,021	1,041	1,073
1.060	0,011	0,034	0,065	0,022	1,154	1,187
1.180	0,012	0,035	0,067	0,022	1,276	1,309
1.320	0,013	0,036	0,069	0,023	1,419	1,453
1.500	0,015	0,038	0,071	0,023	1,602	1,638
1.700	0,017	0,039	0,073	0,024	1,805	1,842
1.900	0,019	0,040	0,075	0,025	2,008	2,046

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Annex B
(normative)

Method for the calculation of linear resistance

The limits of electrical resistance for nominal conductor diameters up to and including 1,000 mm are calculated on the following basis:

The minimum and the maximum values of resistance are calculated from the nominal value of the resistivity by accounting for each conductor diameter the relevant dimensional tolerance.

The linear resistance is calculated from

$$R_{min} = \rho_{min} \times q^{-1}{}_{max} \ (\Omega \cdot m^{-1})$$

$$R_{max} = \rho_{max} \times q^{-1}{}_{min} \ (\Omega \cdot m^{-1})$$

where:

ρ_{min} = 1/36,2 Ω mm^2·m^{-1};

ρ_{max} = 1/35,5 Ω mm^2·m^{-1};

q is the cross-section of the conductor, in square millimetres.

where

q_{max} is the maximum cross-section of the conductor in square millimetres, calculated from the nominal conductor diameter ~~minus~~ plus the dimensional tolerance;

q_{min} is the minimum cross-section of the conductor in square millimetres, calculated from the nominal conductor diameter ~~plus~~ minus the dimensional tolerance.

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