

INTERNATIONAL STANDARD



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

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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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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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.

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

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.

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.

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.

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 mm	Maximum overall diameter mm	
		Grade 1B	Grade 2B		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.

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·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.

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.

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.

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.

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.

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 mm	Conductor tolerance ± mm	Minimum increase due to the insulation mm			Maximum overall diameter 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

A.3 Enamelled wires with a bonding layer

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

Nominal conductor diameter mm	Conductor tolerance ± mm	Minimum increase due to the insulation mm		Minimum increase due to bonding layer mm	Maximum overall diameter mm	
		Grade 1B	Grade 2B		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

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

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

where:

$$\rho_{\min} = 1/36,2 \Omega \text{ mm}^2 \cdot \text{m}^{-1};$$

$$\rho_{\max} = 1/35,5 \Omega \text{ mm}^2 \cdot \text{m}^{-1};$$

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.

Annex C (informative)

Resistance

The figures for nominal resistance in Table C.1 are given for information only. They are calculated on the basis of the nominal conductor diameter and a nominal resistivity of $1/35,85 \Omega\text{mm}^2\cdot\text{m}^{-1}$.

The minimum and maximum resistance figures for nominal conductor diameter up to and including 1,000 mm are derived from calculations made according to Annex B.

Table C.1 – Electrical resistances

Nominal conductor diameter mm	Resistance at 20 °C/Ω/m		
	Minimum	Nominal	Maximum
0,250	0,545 2	0,568 3	0,592 7
0,280	0,436 1	0,453 0	0,470 8
0,315	0,345 6	0,357 9	0,370 8
0,355	0,272 9	0,281 8	0,291 1
0,400	0,214 4	0,222 0	0,229 9
0,450	0,169 9	0,175 4	0,181 1
0,500	0,137 9	0,142 1	0,146 4
0,560	0,109 8	0,113 3	0,116 9
0,630	0,086 95	0,089 48	0,092 11
0,710	0,068 42	0,089 48	0,092 11
0,800	0,053 87	0,070 45	0,072 57
0,900	0,042 57	0,043 85	0,045 18
1,000	0,034 48	0,035 52	0,036 59

Bibliography

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

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

**Spécifications pour types particuliers de fils de bobinage –
Partie 0-3: Exigences générales – Fil de section circulaire en aluminium émaillé**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SPECIFICATIONS FOR PARTICULAR TYPES OF WINDING WIRES –**Part 0-3: General requirements – Enamelled round aluminium wire**

FOREWORD

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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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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 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

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**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 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.

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.

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.

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

Nominal conductor diameter	Conductor tolerance ±	Minimum increase underlying coating		Minimum increase bonding layer	Maximum overall diameter	
		mm			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.

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.

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·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 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.

8.2 Stretching test (nominal conductor diameters over 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.

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.

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
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.

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 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.

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 mm	Conductor tolerance ± mm	Minimum increase due to the insulation mm			Maximum overall diameter 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

A.3 Enamelled wires with a bonding layer

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

Nominal conductor diameter mm	Conductor tolerance ± mm	Minimum increase due to the insulation mm		Minimum increase due to bonding layer mm	Maximum overall diameter mm	
		Grade 1B	Grade 2B		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

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

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

where:

$$\rho_{\min} = 1/36,2 \Omega \text{ mm}^2 \cdot \text{m}^{-1};$$

$$\rho_{\max} = 1/35,5 \Omega \text{ mm}^2 \cdot \text{m}^{-1};$$

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 plus the dimensional tolerance;

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

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Annex C
(informative)

Resistance

The figures for nominal resistance in Table C.1 are given for information only. They are calculated on the basis of the nominal conductor diameter and a nominal resistivity of $1/35,85 \Omega\text{mm}^2\cdot\text{m}^{-1}$.

The minimum and maximum resistance figures for nominal conductor diameter up to and including 1,000 mm are derived from calculations made according to Annex B.

Table C.1 – Electrical resistances

Nominal conductor diameter mm	Resistance at 20 °C/Ω/m		
	Minimum	Nominal	Maximum
0,250	0,545 2	0,568 3	0,592 7
0,280	0,436 1	0,453 0	0,470 8
0,315	0,345 6	0,357 9	0,370 8
0,355	0,272 9	0,281 8	0,291 1
0,400	0,214 4	0,222 0	0,229 9
0,450	0,169 9	0,175 4	0,181 1
0,500	0,137 9	0,142 1	0,146 4
0,560	0,109 8	0,113 3	0,116 9
0,630	0,086 95	0,089 48	0,092 11
0,710	0,068 42	0,089 48	0,092 11
0,800	0,053 87	0,070 45	0,072 57
0,900	0,042 57	0,043 85	0,045 18
1,000	0,034 48	0,035 52	0,036 59

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Bibliography

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

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

SPÉCIFICATIONS POUR TYPES PARTICULIERS DE FILS DE BOBINAGE –

Partie 0-3: Exigences générales – Fil de section circulaire en aluminium émaillé

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Cette quatrième édition annule et remplace la troisième édition parue en 2008, l'Amendement 1:2013 et l'Amendement 2:2019. 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 7, pour indiquer que l'essai ne s'applique pas;
- b) révision de l'Article 10, pour indiquer que l'essai ne s'applique pas.

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

Projet	Rapport de vote
55/2049/FDIS	55/2054/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2, il a été développé selon les Directives ISO/IEC, Partie 1 et les Directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/publications.

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- 1) les fils de bobinage et les méthodes d'essai (IEC 60851);
- 2) les spécifications pour types particuliers de fils de bobinage (IEC 60317);
- 3) le conditionnement des fils de bobinage (IEC 60264).

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SPÉCIFICATIONS POUR TYPES PARTICULIERS DE FILS DE BOBINAGE –

Partie 0-3: Exigences générales – Fil de section circulaire en aluminium émaillé

1 Domaine d'application

La présente partie de l'IEC 60317 spécifie les exigences générales pour les fils de bobinage de section circulaire en aluminium émaillé, avec ou sans couche adhérente.

La plage des diamètres nominaux des conducteurs est donnée dans la feuille de spécification appropriée.

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 60317 (toutes les parties), *Spécifications pour types particuliers de fils de bobinage*

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

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

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

EN 1715-2, *Aluminium et alliages d'aluminium – Fil machine – Partie 2: Exigences spécifiques relatives aux applications électriques*

3 Termes, définitions, notes générales et aspect

3.1 Termes et définitions

Pour les besoins du présent document, les termes et définitions 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 <https://www.electropedia.org/>
- ISO Online browsing platform: disponible à l'adresse <https://www.iso.org/obp>

3.1.1

couche adhérente

matériau qui est déposé sur un fil émaillé, et qui a pour fonction particulière de coller les fils entre eux

3.1.2**classe**

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

3.1.3**revêtement**

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

3.1.4**conducteur**

métal nu après enlèvement de l'isolant

3.1.5**craquelure**

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

3.1.6**fil émaillé**

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

3.1.7**grade**

plage d'épaisseurs d'isolant d'un fil

3.1.8**isolant**

revêtement ou enveloppe sur le conducteur qui a pour fonction particulière de supporter la tension électrique

3.1.9**diamètre nominal 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 correctrices, 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

3.2 Notes générales**3.2.1 Méthodes d'essai**

Toutes les méthodes d'essai à utiliser dans la présente partie de l'IEC 60317, indépendamment de la classe du fil, sont données dans la série de normes IEC 60851.

Les numéros d'articles utilisés dans le présent document sont identiques aux numéros d'essais correspondants de la série de normes IEC 60851.

En cas de divergences entre la publication relative aux méthodes d'essai et le présent document, l'IEC 60317-0-3 doit prévaloir.

Dans le cas où aucune plage spécifique de diamètres nominaux des conducteurs n'est indiquée pour un essai, l'essai s'applique à tous les diamètres nominaux des conducteurs couverts par la feuille de spécification.

Sauf spécification contraire, tous les essais doivent être effectués à une température comprise entre 15 °C et 40 °C et à une humidité relative de 25 % à 75 %. Avant de procéder aux mesurages, les éprouvettes doivent être préconditionnées dans ces conditions atmosphériques pendant une durée suffisante pour leur permettre d'atteindre la stabilité.

Le fil à soumettre à l'essai doit être prélevé de son conditionnement de façon qu'il ne soit pas soumis à une traction ou à des pliages inutiles. Avant chaque essai, il convient d'éliminer une longueur de fil suffisante pour s'assurer que les éprouvettes ne comportent aucun fil endommagé.

3.2.2 Fil de bobinage

Voir la feuille de spécification appropriée.

En outre, lorsqu'il est fait référence à un fil de bobinage conforme à une norme de la série IEC 60317 indiquée à l'Article 2, les informations suivantes sont données dans la description:

- la référence de la spécification IEC;
- le diamètre nominal du conducteur en millimètres;
- le grade.

EXEMPLE IEC 60317-1 – 0,500 Grade 2.

3.3 Aspect

Le film de revêtement doit être essentiellement lisse et continu, exempt de rayures, de bulles et de corps étrangers lorsqu'il est examiné avec une vision normale, tandis qu'il est enroulé sur la bobine ou le touret d'origine.

En cas d'accord entre l'utilisateur et le fournisseur, un grossissement de 6× à 10× doit être utilisé pour examiner les fils dont le diamètre nominal est inférieur à 0,10 mm.

4 Dimensions

4.1 Diamètre du conducteur

La série des diamètres nominaux préférentiels des conducteurs doit correspondre à la série R 20 de l'ISO 3. Les valeurs réelles et leurs tolérances sont données dans le Tableau 1 et le Tableau 2.

L'utilisateur peut choisir des diamètres intermédiaires pour des raisons techniques. Ces diamètres nominaux intermédiaires des conducteurs doivent être choisis dans la série R 40 de l'ISO 3. Les valeurs réelles et leurs tolérances sont données à l'Annexe A.

Le diamètre du conducteur ne doit pas s'écarter du diamètre nominal d'une valeur supérieure à la tolérance donnée dans le Tableau 1 ou le Tableau 2.

Pour les diamètres nominaux intermédiaires des conducteurs, la valeur de l'accroissement minimal qui correspond à celui du diamètre nominal immédiatement supérieur s'applique.

Tableau 1 – Dimensions pour les fils émaillés (R 20)

Diamètre nominal du conducteur	Tolérance du conducteur ±	Accroissement minimal dû à l'isolant			Diamètre extérieur maximal		
		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 Les dimensions des diamètres nominaux intermédiaires des conducteurs pour la série R 40 sont données à l'Annexe A.