SLOVENSKI STANDARD
SIST IEC 61089:1999

01-november-1999

Round wire concentric lay overhead electrical stranded conductors - Amendment A1

Round wire concentric lay overhead electrical stranded conductors

Ta slovenski standard je istoveten z: IEC 61089

ICS:

29.060.10	Žice	Wires
29.240.20	Daljnovodi	Power transmission and distribution lines

SIST IEC 61089:1999 **en**

NORME INTERNATIONALE
INTERNATIONAL STANDARD

CEI
IEC
1089

Première édition
First edition
1991-05

Conducteurs pour lignes aériennes à brins circulaires, câblés en couches concentriques

Round wire concentric lay overhead electrical stranded conductors

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Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

CODE PRIX
PRICE CODE V

Pour prix, voir catalogue en vigueur
For price, see current catalogue

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ROUND WIRE CONCENTRIC LAY OVERHEAD ELECTRICAL STRANDED CONDUCTORS

FOREWORD

1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.

3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

This standard has been prepared by IEC Technical Committee No. 7: Bare aluminium conductors.

The text of this standard is based on the following documents:

Six Months' Rule	Report on Voting	Two Months' Procedure	Report on Voting
7(CO)429	7(CO)430	7(CO)431	7(CO)433

Full information on the voting for the approval of this standard can be found in the Voting Reports indicated in the above table.

This standard replaces the following publications:

IEC 207: 1966, *Aluminium stranded conductors.*

IEC 208: 1966, *Aluminium alloy stranded conductors (aluminium-magnesium-silicon type).*

IEC 209: 1966, *Aluminium conductors, steel-reinforced.*

IEC 210: 1966, *Aluminium alloy conductors, steel-reinforced.*

Annexes A, B and C form an integral part of this International Standard.

Annex D is for information only.

ROUND WIRE CONCENTRIC LAY OVERHEAD ELECTRICAL STRANDED CONDUCTORS

1 Scope

1.1 This International Standard specifies the electrical and mechanical characteristics of round wire concentric lay overhead electrical stranded conductors made of combinations of any of the following metal wires:

a) hard-drawn aluminium as per IEC 889 designated A1*;

b) aluminium alloy type B as per IEC 104 designated A2*;

c) aluminium alloy type A as per IEC 104 designated A3* (and when applicable to the following cores, as per IEC 888);

d) regular strength steel, designated S1A or S1B, where A and B are zinc coating classes, corresponding respectively to classes 1 and 2;

e) high strength steel, designated S2A or S2B;

f) extra high strength steel, designated S3A.

1.2 The conductor designations included in this standard are:

A1, A2, A3,
A1/S1A, A1/S1B, A1/S2A, A1/S2B, A1/S3A, A2/S1A,
A2/S1B, A2/S3A, A3/S1A,
A3/S1B, A3/S3A, A1/A2, A1/A3.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication of this standard, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 104: 1987, *Aluminium-magnesium-silicon alloy wire for overhead line conductors.*

IEC 888: 1987, *Zinc-coated steel wires for stranded conductors.*

IEC 889: 1987, *Hard-drawn aluminium wire for overhead line conductors.*

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* The resistivity of these metals is as follows (in increasing order):
A1: 28,264 nΩm (corresponding to 61% IACS),
A2: 32,530 nΩm (corresponding to 53% IACS),
A3: 32,840 nΩm (corresponding to 52,5% IACS).

3 Designation system

3.1 A designation system is used to identify stranded conductors made of aluminium, with or without steel wires.

3.2 Homogeneous aluminium conductors are designated Ax, where x identifies the type of aluminium.

3.3 Composite aluminium conductors are designated Ax/Ay, where Ax identifies external wires (or the envelope) and Ay identifies internal wires (or the core).

3.4 Composite aluminium-steel conductors are designated Ax/Syz, where Ax identifies the external aluminium wires (envelope), and Syz identifies the steel core. In the designation of steel wires, y represents the type of steel (regular, high or extra high strength) and z represents the class of zinc coating (A or B).

3.5 Conductors are identified as follows:

a) a code number giving the equivalent conductive section of A1 aluminium expressed in mm²;

b) a designation identifying the type of wires constituting the conductor. For composite conductors the first designation applies to the envelope and the second to the core;

c) one or two numbers giving the stranding of the conductor. For composite conductors, the first number identifies the number of wires of the envelope and the second identifies the number of wires of the core.

Examples:

500-A1-37: Conductor made of 37 wires of A1 aluminium. Its area is 500 mm².

500-A2-37: Conductor made of 37 wires of A2 aluminium with a total conductive area equivalent to 500 mm² of A1 aluminium. From the tables of annex D we find its actual area is equal to 575 mm².

500-A1/S1A-45/7: Conductor made of 45 wires of A1 aluminium and 7 wires of regular strength steel with class 1 zinc coating. The area of A1 aluminium is 500 mm² and, from the tables of annex D, the area of S1A steel is 34,6 mm².

500-A3/S3A-54/7: Conductor made of 54 wires of A3 aluminium and 7 wires of extra high strength steel with class 1 zinc coating. The A3 aluminium area is equivalent in conductivity to 500 mm² of A1 aluminium (the actual area of A3 aluminium is 581 mm² and of steel is 75,3 mm², which can be obtained from the tables of annex D).

4 Definitions

The following definitions apply in this International Standard:

aluminium: All types of aluminium and aluminium alloys listed.

conductor: A material intended to be used for carrying electric current consisting of a plurality of uninsulated wires twisted together.

concentric lay stranded conductor: A conductor composed of a central core surrounded by one or more adjacent layers of wires being laid helically in opposite directions.

direction of lay: The direction of twist of a layer of wires as it moves away from the viewer. A right-hand lay is a clockwise direction and a left-hand lay is an anti-clockwise direction.

Alternative definition: The direction of lay is defined as right-hand or left-hand. With right-hand lay, the wires conform to the direction of the central part of the letter Z when the conductor is held vertically. With left-hand lay, the wires conform to the direction of the central part of the letter S when the conductor is held vertically.

lay length: The axial length of one complete turn of the helix formed by an individual wire in a stranded conductor.

lay ratio: Means the ratio of the lay length to the external diameter of the corresponding layer of wires in the stranded conductor.

lot: A group of conductors manufactured by the same manufacturer under similar conditions of production. A lot may consist of part or all of the purchased quantity.

nominal: The name or identifying value of a measurable property by which a conductor or component of a conductor is identified and to which tolerances are applied. Nominal values should be target values.

steel ratio: The ratio of steel area to aluminium area as a percentage in Ax/Syz conductors.

wire: A filament of drawn metal having a constant circular cross-section.

5 Requirements for stranded conductors

5.1 *Material*

Stranded conductors shall be made up of round aluminium wires and, when applicable, of round zinc-coated steel wires. All wires shall have before stranding the properties specified in IEC 104, IEC 888 and IEC 889.

5.2 *Conductor sizes*

A list of conductor sizes is given as guidance in annex D and it is recommended that for new designs of conductor sizes should be selected from those listed. Conductors for existing or established designs of overhead lines as well as sizes and strandings not included in this standard may be designed and supplied as agreed upon by the manufacturer and purchaser and the relevant requirements of this standard shall apply.

5.3 *Surface*

The surface of the conductor shall be free from all imperfections visible to the unaided eye (normal corrective lenses accepted), such as nicks, indentations, etc., not consistent with good commercial practice.

5.4 *Stranding*

5.4.1 All wires of the conductor shall be concentrically stranded.

5.4.2 Adjacent wire layers shall be stranded with reverse lay directions. The direction of lay of the external layer shall be "right-hand" except when specifically indicated in the purchase order.

5.4.3 The wires in each layer shall be evenly and closely stranded around the underlying wire or wires.

5.4.4 The lay ratios for the zinc-coated steel wire layers shall be as follows:

a) the lay ratio for the six-wire layer of 7 and 19-wire steel cores shall be not less than 16 nor more than 26;

b) the lay ratio for the 12-wire layer of 19-wire steel core shall be not less than 14 nor more than 22.

5.4.5 The lay ratios for the aluminium layers of all types of conductor shall be as follows:

a) the lay ratio for the outside layer of aluminium wires shall be not less than 10 nor more than 14;

b) the lay ratios for the inner layers of aluminium wires shall be not less than 10 nor more than 16.

5.4.6 In a 19-wire steel core, the lay ratio of the 12-wire layer shall be not greater than the lay ratio of the 6-wire layer. Similarly, in a conductor having multiple layers of aluminium wires, the lay ratio of any aluminium layer shall be not greater than the lay ratio of the aluminium layer immediately beneath it.

5.4.7 All steel wires shall lie naturally in their position in the stranded core, and where the core is cut, the wire ends shall remain in position or be readily replaced by hand and then remain approximately in position. This requirement also applies to the outer layer of aluminium wires of a conductor.

5.4.8 Before stranding, aluminium and steel wires shall have approximately uniform temperatures.

5.5 *Joints*

5.5.1 There shall be no joints of any kind made in the zinc-coated steel core wire or wires during stranding.

5.5.2 No more than one jointed aluminium finished wire as permitted in the references of 5.1 shall be used per length of conductor.

5.5.3 During stranding, no aluminium wire welds shall be made for the purpose of achieving the required conductor length.

5.5.4 Joints are permitted in aluminium wires unavoidably broken during stranding, provided such breaks are not associated with either inherently defective wire or with the use of short lengths of aluminium wires. Joints shall conform to the geometry of original wire, i.e. joints shall be dressed smoothly with a diameter equal to that of the parent wires and shall not be kinked.

Joints in aluminium wires shall not exceed those specified in table 1. These joints shall not be closer than 15 m from a joint in the same wire or in any other aluminium wire of the completed conductor.

Joints shall be made by electric butt welding, electric butt cold upset welding or cold pressure welding (note 1) and other approved methods. These joints shall be made in accordance with good commercial practice. The first type of joints shall be electrically annealed for approximately 250 mm on both sides of the weld.

Table 1 – Number of joints permitted in aluminium conductors

Number of aluminium layers	Joints permitted per conductor length
1	2
2	3
3	4
4	5

5.5.5 While the joints specified in 5.5.4 are not required to meet the requirements of unjointed wires (note 2), they shall withstand a stress of not less than 75 MPa for annealed electric buttwelded joints, and not less than 130 MPa for cold pressure and electric butt cold upset welded joints. The manufacturer shall demonstrate that the proposed welding method is capable of meeting the specified strength requirements.

NOTES

1 It is a practice in some countries to require the annealing of cold pressure joints made in A2 or A3 material.

2 The behaviour of properly spaced wire joints in stranded conductor is related to both tensile strength and elongation. Because of higher elongation properties, the lower strength annealed electric buttwelded joint gives a similar overall performance to that of a cold pressure or an electric butt cold upset welded joint.

5.6 *Linear density – Mass per unit length*

5.6.1 The masses given in the tables of annex D have been calculated for each size and stranding of conductor using densities for the aluminium and zinc-coated steel wires as given in the standards listed in 5.1, the stranding increments given in table 2, and the cross-sectional areas for aluminium and zinc-coated steel wires based on their theoretical unrounded diameters.

5.6.2 The increments (note 1) in per cent, for mass due to stranding, based on the mean lay ratios given in 5.4.4 and 5.4.5, shall be taken as given in table 2.

5.6.3 Whenever a conductor is to be greased (note 2), the nominal mass of grease shall be calculated according to the method given in annex C.

NOTES

1 The mass of a stranded conductor is affected by the lay factor. With the exception of the centre wire, all wires are longer than the stranded conductor and the increase in mass depends upon the lay ratio employed.

2 Grease requirements are under consideration.

Table 2 – Standard* increments due to stranding

Stranding of conductor				Increment (increase) %		
Aluminium		Steel		Mass		Electrical resistance
Number of wires	Number of layers**	Number of wires	Number of layers**	Aluminium	Steel	
6	1	1	–	1,52	–	1,52
18	2	1	–	1,90	–	1,90
7	1	–	–	1,31	–	1,31
18	2	1	–	1,90	–	1,90
22	2	7	1	2,04	0,43	2,04
26	2	7	1	2,16	0,43	2,16
19	2	–	–	1,80	–	1,80
37	3	–	–	2,04	–	2,04
61	4	–	–	2,19	–	2,19
45	3	7	1	2,23	0,43	2,23
54	3	7	1	2,33	0,43	2,33
72	4	7	1	2,32	0,43	2,32
84	4	7	1	2,40	0,43	2,40
91	5	–	–	2,30	–	2,30
54	3	19	2	2,33	0,77	2,33
72	4	19	2	2,32	0,77	2,32
84	4	19	2	2,40	0,77	2,40

* These increments have been calculated using average lay ratios for each applicable layer of aluminium or steel.

** Number of layers of each type of wire not including the central wire.

5.7 *Conductor strength*

5.7.1 The rated tensile strength of a homogeneous aluminium conductor shall be taken as the sum of the minimum tensile strength of all wires as defined in 5.7.4.

5.7.2 The rated tensile strength of composite Ax/Syz conductors shall be the sum of the tensile strength of the aluminium portion plus the strength of steel corresponding to an elongation compatible with that of aluminium at rupture load. For the purpose of specification and practicability, this strength of steel is conservatively established as the stress corresponding at 1% elongation in a 250 mm gauge length.

5.7.3 The rated tensile strength of composite aluminium conductors (A1/A2 or A1/A3) shall be taken as the sum of the tensile strength of A1 portion plus 95% of the tensile strength of A2 or A3 portion.

5.7.4 The tensile strength of any single wire is the product of its nominal area and the appropriate minimum stress given in the standards listed in 5.1.

6 Tests

6.1 *Classification of tests*

6.1.1 *Type tests*

Type tests are intended to verify the main characteristics of a conductor which depend mainly on its design. They are carried out once for a new design or manufacturing process of conductor and then subsequently repeated only when the design or manufacturing process is changed.

Type tests shall be carried out only on a conductor which meets the requirements of all the relevant sample tests.

6.1.2 *Sample tests*

Sample tests are intended to guarantee the quality of conductors and compliance with the requirements of this standard.

6.2 *Test requirements*

Test requirements are as follows:

6.2.1 *Type tests*

a) joints in aluminium wires;

b) stress-strain curves;

c) breaking strength of conductor.

6.2.2 *Sample tests*

a) on wire before stranding:

- as per the applicable wire standards;

b) on the conductor:

- cross-sectional area;
- overall diameter;
- linear density;
- surface condition;
- lay ratio and direction of lay.

6.3 *Sample size*

Samples for the tests specified in 6.2.2 shall be taken at random from the outer end of 10% of the drums of conductor. However, the inspection of the surface condition of the conductor shall be carried out on every drum prior to lagging.

6.4 *Sample length*

6.4.1 Samples for tests on individual aluminium and zinc-coated steel core wires shall be taken before stranding and tested in accordance with the standards listed in 5.1.

6.4.2 Samples for tests of individual wires after stranding when requested, shall consist of a 1,5 m length or cut from the outer end of the coils or drums of conductors.

6.4.3 The sample length required for tensile and stress-strain tests shall be at least 400 times the diameter of the conductor but not less than 10 m.

The length of samples in this subclause is the minimum required for a good accuracy of stress-strain curves. In cases where the manufacturer can demonstrate to the satisfaction of the purchaser with significant comparative test results that a shorter length can give equally accurate results then a short length of samples may be used.

6.5 *Type tests*

6.5.1 Stress-strain curves shall be supplied as a type test when requested by the purchaser and shall represent the best knowledge of the behaviour of the purchased conductor under load.

6.5.2 If agreed between purchaser and supplier when placing an order, stress-strain tests shall be performed on the conductor and, when applicable, on the steel core, in accordance with the method given in annex B.

6.5.3 *Tensile test of the conductor*

When tests for breaking strength of conductors are required, these shall withstand, without the fracture of any wire not less than 95% of their rated tensile strength calculated according to 5.7.

The breaking strength of conductors shall be determined by pulling a conductor in a suitable tensile testing machine having an accuracy of at least ±1%. It is recommended that the rate of increase of load should be as in B.6.8 of annex B. For the purposes of this test, appropriate fittings shall be installed on the ends of the conductor samples. During this test, the breaking strength of the conductor shall be determined by the load attained at which one or more wires of the conductor are fractured. A retest, up to a total of three tests, may be made if wire fracture occurs within 1 cm of the end fittings and the tensile strength falls below the specified breaking strength requirements.