



BSI Standards Publication

Conductors for overhead lines — Round wire concentric lay stranded conductors

National foreword

This British Standard is the UK implementation of EN 50182:2001, incorporating corrigenda April 2004, June 2005 and July 2013. It supersedes BS 215-1:1970 and BS 215-2:1970, which are withdrawn.

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A list of organizations represented on this committee can be obtained on request to its committee manager.

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2 June 2004	See national foreword
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30 September 2013	Implementation of CENELEC corrigendum July 2013: Table F.3 replaced
31 December 2024	Correction to supersession details in national foreword

EUROPEAN STANDARD

EN 50182

NORME EUROPÉENNE

EUROPÄISCHE NORM

May 2001

ICS 29.060.10

Incorporating corrigendum July 2013

English version

Conductors for overhead lines - Round wire concentric lay stranded conductors

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

Leiter für Freileitungen -
Leiter aus konzentrisch verseilten
runden Drähten

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

This European Standard was prepared by the Technical Committee CENELEC TC 7, Overhead electrical conductors.

The text of the draft was submitted to the formal vote and was approved by CENELEC as EN 50182 on 2000-11-01.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2001-11-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2003-11-01

Annexes designated "normative" are part of the body of the standard. Annexes designated "informative" are given for information only. In this standard, annexes A, B, C and E are normative and annexes D and F are informative.

The contents of the corrigendum of April 2004 have been included in this copy.

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1 Scope

This European Standard specifies the electrical and mechanical characteristics of round wire concentric lay bare overhead electrical conductors stranded in alternate directions, with or without grease as per EN 50326, made of one or a combination of any of the following:

- a) Hard drawn Aluminium as per EN 60889 designated AL1
- b) Aluminium alloy as per EN 50183 designated AL2 to AL7
- c) Zinc coated steel wire as per EN 50189 with grade and class designated ST1A, ST2B, ST3D, ST4A, ST5E, and ST6C.
- d) Aluminium-clad steel wire as per EN 61232 with class designation 20SA (grades A and B), 27SA, 30SA and 40SA.

Conductors made of zinc coated steel wires only are not included.

2 Normative references

This European standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European standard only when incorporated in it by amendment or revision. For undated references the latest issue of the publication referred to applies.

EN 50183	Conductors for overhead lines — Aluminium-magnesium-silicon alloy wires
EN 50189	Conductors for overhead lines — Zinc coated steel wires
EN 50326 ¹⁾	Conductors for overhead lines — Characteristics of greases
EN 60889	Hard-drawn aluminium wire for overhead line conductors.
EN 61232	Aluminium-clad steel wires for electrical purposes.
IEC 60050-466	International Electrotechnical Vocabulary (IEV) - Chapter 466: Overhead Lines.

3 Definitions

In addition to the definitions given in IEC 60050-466, the following definitions apply:

3.1

aluminium

for the purposes of this standard, aluminium is used as a generic term to mean hard drawn aluminium and aluminium alloy

3.2

direction of lay

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 central part of the letter S when the conductor is held vertically

¹⁾ At draft stage

3.3

lay ratio

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

3.4

lot

a group of conductors manufactured by the same manufacturer under similar conditions of production

NOTE 1 A lot may consist of part of or all the purchased quantity.

NOTE 2 The constitution of a lot may be agreed between the purchaser and the manufacturer

3.5

nominal

the target value of a measurable property by which a conductor or component of a conductor is identified and to which tolerances are applied

3.6

wire

a filament of drawn metal having a constant circular cross-section

3.7

rated tensile strength

an estimate of the conductor breaking load calculated using the specified tensile properties of the component wires

4 Designation system

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

4.2 Homogeneous aluminium conductors are designated ALx, where x identifies the type of aluminium. Homogeneous aluminium clad steel conductors are designated yzSA where y represents the type of steel (Grade A or B, applicable to class 20SA only), and z represents the class of aluminium cladding (20, 27, 30 or 40).

4.3 Composite aluminium/zinc coated steel conductors are designated ALx/STyz, where ALx identifies the external aluminium wires (envelope), and STyz identifies the steel core. In the designation of zinc coated steel wires, y represents the type of steel (Grades 1 to 6) and z represents the class of zinc coating (A to E).

4.4 Composite aluminium/aluminium-clad steel conductors are designated ALx/yzSA, where ALx identifies the external aluminium wires (envelope), and yzSA identifies the steel core as in 4.2.

4.5 Conductors are identified as follows:

- (a) a code number giving the nominal area, rounded to an integer, of the aluminium or steel as appropriate;
- (b) a designation identifying the type of wires constituting the conductor. For composite conductors the first description applies to the envelope and the second to the core.

EXAMPLES:

16-AL1:	Conductor of AL1 aluminium with an area of 15,9 mm ² , rounded to 16 mm ² .
587-AL2:	Conductor of AL2 aluminium with an area of 586,9 mm ² , rounded to 587 mm ² .
401-AL1/28-ST1A:	Conductor made of AL1 aluminium wires around a core of ST1A zinc coated steel wires with a Class A zinc coating. The integer area of AL1 wires is 401 mm ² and that of the ST1A wires 28 mm ² .
401-AL1/28-A20SA:	Conductor made of AL1 aluminium wires around a core of grade A, class 20 aluminium-clad steel wires. The integer area of AL1 wires is 401 mm ² and that of the A20SA wires 28 mm ² .
65-A20SA:	Conductor made of grade A, class 20 aluminium clad steel wires with an area of 65 mm ² .

5 Requirements for stranded conductor

5.1 Material

The stranded conductor shall be made from wires and with grease, whenever greased conductor is specified, as defined in clause 1.

5.2 Conductor sizes

Lists of conductor sizes in frequent use in some of the member countries are given as guidance in annex F. 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 condition

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 Conductor diameter

The conductor diameter shall not vary from the nominal value, specified by the purchaser, by more than:

± 1 % for diameters larger or equal to 10 mm.

± 0,1 mm for diameters smaller than 10 mm.

5.5 Stranding

5.5.1 All wires of the conductor shall be concentrically stranded.

5.5.2 Adjacent wire layers shall be stranded with reverse lay directions. The direction of lay of the external layer shall be right hand except when otherwise specified by the purchaser.

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

5.5.4 The lay ratios for the zinc coated or aluminium-clad steel wire layers shall be as given in Table 1.

Table 1 - Lay ratios for zinc coated or aluminium-clad steel layers

Number of steel wires	Lay ratio							
	3 wire layer		6 wire layer		12 wire layer		18 wire layer	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
3	16	26	-	-	-	-	-	-
7	-	-	16	26	-	-	-	-
19	-	-	16	26	14	22	-	-
37	-	-	17	25	16	22	14	18
For zinc coated or aluminium-clad steel core constructions exceeding 37 wires, the lay ratio of the outer layer shall lie between 14 and 18, and the lay ratio of the inner layers shall lie between 16 and 26.								

5.5.5 The lay ratios for the aluminium layers of all types of conductor shall be as given in Table 2.

Table 2 - Lay ratios for aluminium layers

All inner layers		Outer layer	
Min.	Max.	Min.	Max.
10	16	10	14

5.5.6 In a multi-layer conductor, the lay ratio of any layer shall be equal to or less than the lay ratio of the layer immediately beneath it.

5.5.7 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 aluminium wires of a conductor.

5.5.8 Before stranding, aluminium and steel wires shall have approximately equal temperatures.

5.5.9 The conductor shall have the ability to be installed, using the purchaser's recommended installation method, without damage to the conductor. If required, this shall be demonstrated according to 6.4.9.

5.6 Joints

5.6.1 For conductors containing only one steel wire there shall be no joints made after heat treatment of the wire or rod. There shall be no joints of any kind made in the finished zinc coated or aluminium-clad steel core wire or wires during stranding.

5.6.2 No more than one jointed aluminium finished wire before stranding, as permitted in the relevant standard given in clause 2, shall be used per length of conductor.

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

5.6.4 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 the original wire, i.e. joints shall be dressed smoothly with a diameter equal to that of the parent wires and shall not be kinked.

The number of joints in aluminium wires shall not exceed those specified in Table 3. 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, cold pressure welding or other methods approved by the purchaser. The first type of joint shall be electrically annealed for approximately 250 mm on both sides of the weld.

5.6.5 While the joints specified in 5.6.4 are not required to meet the requirements of unjointed wires, they shall withstand a stress of not less than 75 N/mm² for annealed electric butt welded joints, and not less than 130 N/mm² for cold pressure joints.

Table 3 - Number of joints permitted in a given length

Conductor length L (m)				Number of joints permitted
Number of aluminium layers				
1	2	3	4	
$L \leq 1\,500$	-	-	-	2
$1\,500 < L \leq 2\,000$	$L \leq 1\,500$	-	-	3
$L > 2\,000$	$1\,500 < L \leq 2\,000$	$L \leq 1\,500$	-	4
-	$2\,000 < L \leq 2\,500$	$1\,500 < L \leq 2\,000$	$L \leq 1\,500$	5
-	$L > 2\,500$	$2\,000 < L \leq 2\,500$	$1\,500 < L \leq 2\,000$	6
-	-	$2\,500 < L \leq 3\,000$	$2\,000 < L \leq 2\,500$	7
-	-	$3\,000 < L \leq 3\,500$	$2\,500 < L \leq 3\,000$	8
-	-	$L > 3\,500$	$3\,000 < L \leq 3\,500$	9
-	-	-	$3\,500 < L \leq 4\,000$	10
-	-	-	$L > 4\,000$	11

5.7 Conductor mass per unit length

5.7.1 The conductor masses given in the Tables of annex F have been calculated for each size and stranding of conductor using densities for the aluminium, aluminium clad steel and zinc coated steel wires as given in the standards listed in clause 2. The masses do not include the mass of grease. The calculation of cross-sectional areas for aluminium, aluminium clad steel and zinc coated steel are based on the nominal diameter.

5.7.2 With the exception of the centre wire, all wires are longer than the stranded conductor and the increase in mass depends on the lay ratio used.

The increments, in per cent, for mass due to stranding, shall be as given in Table 4, which have been calculated using the commonly used lay ratios for each applicable layer of aluminium or steel wire given in annex D.

Where an oversize centre wire (king wire) is used, the appropriate increase in mass shall be applied.

5.7.3 The mass per unit length of the conductor without grease shall not vary from its nominal value by more than $\pm 2\%$.

Table 4 - Increments due to stranding

Stranding of conductor				Increment (increase) (%)			
Aluminium		Steel		Mass		Electrical resistance	
No. of wires	No. of layers *	No. of wires	No. of layers *	Aluminium	Zn coated or Al. clad steel	Aluminium	Aluminium-clad steel
7	1	-	-	1,11	-	1,11	-
19	2	-	-	1,68	-	1,68	-
37	3	-	-	2,03	-	2,03	-
61	4	-	-	2,36	-	2,36	-
91	5	-	-	2,78	-	2,78	-
127	6	-	-	2,75	-	2,75	-
6	1	1	-	1,39	-	1,39	-
8	1	1	-	1,66	-	1,66	-
18	2	1	-	1,82	-	1,82	-
9	1	3	1	1,91	0,34	1,91	0,34
6	1	7	1	1,51	0,52	1,51	0,52
10	1	7	1	2,01	0,52	2,01	0,52
12	1	7	1	2,17	0,52	2,17	0,52
14	1	7	1	2,30	0,52	2,30	0,52
18	2	7	1	1,94	0,52	1,94	0,52
22	2	7	1	2,07	0,52	2,07	0,52
24	2	7	1	2,13	0,52	2,13	0,52
26	2	7	1	2,18	0,52	2,18	0,52
28	2	7	1	2,22	0,52	2,22	0,52
30	2	7	1	2,26	0,52	2,26	0,52
32	2	7	1	2,30	0,52	2,30	0,52
36	2	7	1	2,37	0,52	2,37	0,52
42	3	7	1	2,20	0,52	2,20	0,52
45	3	7	1	2,23	0,52	2,23	0,52
48	3	7	1	2,26	0,52	2,26	0,52
54	3	7	1	2,31	0,52	2,31	0,52
72	4	7	1	2,40	0,52	2,40	0,52
84	4	7	1	2,46	0,52	2,46	0,52
14	1	19	2	2,50	0,82	2,50	0,82
15	1	19	2	2,56	0,82	2,56	0,82
16	1	19	2	2,61	0,82	2,61	0,82
18	1	19	2	2,70	0,82	2,70	0,82
30	2	19	2	2,36	0,86	2,36	0,86
32	2	19	2	2,41	0,86	2,41	0,86
36	2	19	2	2,48	0,86	2,48	0,86
42	2	19	2	2,57	0,86	2,57	0,86
54	3	19	2	2,26	0,79	2,26	0,79
38+22	3	19	2	2,22	0,79	2,22	0,79
42+20	3	19	2	2,18	0,79	2,18	0,79
66	3	19	2	2,34	0,79	2,34	0,79
78	3	19	2	2,40	0,79	2,40	0,79
96	4	19	2	2,46	0,79	2,46	0,79
100	4	19	2	2,47	0,79	2,47	0,79
18	1	37	3	2,70	1,09	2,70	1,09
24	1	37	3	2,91	1,09	2,91	1,09
72	3	37	3	2,43	0,96	2,43	0,96
54+66	4	37	3	2,32	0,86	2,32	0,86
150	5	37	3	2,38	0,86	2,38	0,86

* Number of layers of each type of wire, not including the centre wire.

5.8 Grease

5.8.1 Whenever a greased conductor is specified, the grease shall meet the requirements of EN 50326 and shall be applied before the closing die.

5.8.2 Greases with different designations or from different manufacturers shall not be mixed within a length of conductor.

5.8.3 The mass of grease shall not vary by more than ± 20 % from the calculated value obtained using the method described in annex B.

5.9 Conductor rated tensile strength

5.9.1 The rated tensile strength of a homogeneous aluminium or aluminium clad steel conductor shall be taken as the sum of the minimum tensile strength of all the wires as defined in 5.9.3.

5.9.2 The rated tensile strength of composite ALx/STyz or ALx/yzSA conductors shall be the sum of the minimum tensile strength of the aluminium portion plus the minimum tensile strength of steel (zinc coated or aluminium clad) corresponding to an elongation compatible with that of aluminium at rupture load. For purpose of specification and practicability, this strength is taken as the tensile stress corresponding to 1 % elongation in a 250 mm gauge length before stranding.

5.9.3 The minimum tensile strength of any single wire is the product of its nominal area and the appropriate minimum stress given in the standards referenced in clause 2.

5.10 Nominal d.c. resistance

The nominal d.c. resistance at 20 °C of a conductor, expressed in Ω/km to three significant figures, is based on the resistivity value for calculation purposes and on the nominal diameter of the aluminium and aluminium clad steel wires referenced in clause 2, increased by the increments in Table 4 of this standard. For ALx/yzSA and yzSA conductors the Tables in annex F give two resistance values, a value calculated using both the aluminium and steel portions of the aluminium clad steel wires, and a value calculated using the aluminium portion only.

6 Tests

6.1 Classification of tests

Type tests are intended to verify the main characteristics of a conductor which depend mainly on its design. These tests are normally performed only once for a given conductor construction.

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

Both type and sample tests are listed in Table 5.

Table 5 - Type and sample tests for conductors

		Type test	Sample test	Clause
Conductor	- surface condition	x	x	6.4.1
	- diameter	x	x	6.4.2
	- inertness	x	x	6.4.3
	- lay ratio and direction of lay	x	x	6.4.4
	- number and type of wires	x	x	6.4.5
	- mass per unit length	x	x	6.4.6
	- stress-strain curve	(1)	-	6.4.7
	- tensile breaking strength	(1)	-	6.4.8
	- stringing test	(1)	-	6.4.9
Aluminium wires	- diameter	x	x	6.5.2
	- tensile strength	x	x	6.5.2
	- elongation (2)	x	x	6.5.2
	- resistivity	x	x	6.5.2
	- wrapping test	x	x	6.5.2
	- welding	x	-	6.5.3
Zinc coated Steel wires	- diameter	x	x	6.5.2
	- tensile strength	x	x	6.5.2
	- stress at 1 % extension	x	x	6.5.2
	- elongation or torsion test	x	x	6.5.2
	- wrapping test	x	x	6.5.2
	- mass of zinc	x	x	6.5.2
	- zinc dip test	x	x	6.5.2
	- adhesion of zinc coating	x	x	6.5.2
Aluminium-clad Steel wires	- diameter	x	x	6.5.2
	- tensile strength	x	x	6.5.2
	- stress at 1 % extension	x	x	6.5.2
	- elongation	x	x	6.5.2
	- torsion	x	x	6.5.2
	- cladding thickness/uniformity	x	x	6.5.2
	- resistivity	x	x	6.5.2
Grease	- mass per unit length	x	x	6.6.1
	- drop point	x	x	6.6.2
(1) By agreement between the purchaser and manufacturer.				
(2) Elongation test for AL1 is not required.				

6.2 Sample size

When agreed by the manufacturer and the purchaser at the time of ordering, tests shall be carried out on a minimum of 10 % of the drums offered for inspection and, in such cases, each wire shall be tested. Where the manufacturer has a demonstrated capability of meeting or exceeding the requirements, the number of test samples may be reduced, with the agreement of the purchaser and manufacturer, to a level which ensures that each production lot of conductor is given adequate monitoring.

Drums to be sampled shall be selected at random, and samples taken from the outer end of the drums.

The length of the sample of conductor taken shall be sufficient to allow all tests to be performed on the same specimens of wire.

In order to check the grease, a sample of conductor shall be taken from one drum of each inspection lot.

6.3 Rounding rules

The following rounding rules shall be used for determination of compliance with this standard.

6.3.1 When the figure immediately after the last figure to be retained is less than 5, the last figure to be retained remains unchanged.

6.3.2 When the figure immediately after the last figure to be retained is greater than 5, or equal to 5 and followed by at least one figure other than zero, the last figure to be retained is increased by one.

6.3.3 When the figure immediately after the last figure to be retained is equal to 5 and followed by zeros only, the last figure to be retained remains unchanged if even and is increased by one if odd.

6.4 Properties of conductor

6.4.1 Surface condition

The surface of the conductor shall comply with the requirements of 5.3.

6.4.2 Conductor diameter

The conductor diameter shall be measured either:

- (a) midway between the closing die and the capstan on the stranding machine, or
- (b) at the middle of a portion of conductor, at least 3 m long and more than 5 m from either end of the conductor, under a tension of at least 2 % of the conductor rated tensile strength.

The diameter shall be the average of two readings, rounded to two decimals of a millimetre, taken at right angles to each other at the same location.

The value obtained shall comply with the requirement of 5.4.

6.4.3 Inertness

The requirement of 5.5.7 shall be met.

6.4.4 Lay ratio and direction of lay

The lay ratio of a given layer of the conductor shall be obtained by dividing the measured lay length by the diameter of the layer.

The values obtained shall comply with the requirements of 5.5. In addition the direction of each layer shall be noted and shall also comply with the requirements of 5.5.

6.4.5 Number and type of wires

The number and type of wires shall be confirmed as being in accordance with the conductor designation stated on the order.

6.4.6 Mass per unit length

The mass per unit length of a 1m sample of conductor shall be determined by using apparatus capable of achieving an accuracy of $\pm 0,1$ %. The value obtained shall comply with the requirement of 5.7.3.

6.4.7 Stress-strain curves

6.4.7.1 If the provision of stress-strain curves is agreed between the manufacturer and purchaser at the time of placing the order, the method described in annex C shall be used.

6.4.7.2 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 conductor under load.

6.4.8 Tensile breaking strength

6.4.8.1 The sample length, between end terminations, shall be at least 400 times the conductor diameter but not less than 10 m. A shorter length may be agreed between the manufacturer and purchaser.

6.4.8.2 The breaking strength of the conductor shall be determined by pulling a conductor in a suitable tensile testing machine having an accuracy of at least ± 1 %. The rate of increase of load shall be as in C.6.8 of annex C.

6.4.8.3 At the request of the purchaser, an intermediate load may be held for a period during the test in order to allow tension fittings to be tested at the same time as the conductor.

6.4.8.4 The breaking strength of the conductor shall be determined by the load attained at which one or more wires of the conductor are fractured. The test shall be considered satisfactory if 95 % of the rated tensile strength is reached without the fracture of any wires. If fracture occurs within 5 cm of the end terminations before 95 % of the rated tensile strength has been reached, the fracture shall be deemed to have been caused by the end termination and the test shall be repeated. In this case, a change in the end terminations shall be considered. If a single wire fractures more than 5 cm from the end terminations before 95 % of the rated tensile strength has been reached, two re-tests shall be carried out on samples taken adjacent to the original sample. Both re-tested samples shall withstand 95 % of the rated tensile strength without the fracture of any wire.

6.4.9 Stringing test

Where the purchaser requires evidence that the conductor is capable of being installed using the purchaser's recommended installation method, this may be satisfied by a stringing test, an example of which is given in annex E. Alternative tests or evidence of satisfactory service experience may also be agreed.

6.5 Properties of wires after stranding

6.5.1 The specimen of wire shall be taken from the conductor sample and shall be removed from its position and straightened, care being taken not to stretch it in so doing.

6.5.2 The properties of the individual wires after stranding, including tests on the coating of steel wires, shall meet the requirements of the wire as specified in the standard referenced in clause 2 with the exceptions:

- (a) permitted reductions in wire properties after stranding, given in Table 6, shall apply together with the following:

The reduction in tensile strength after stranding for ST6C wire, given in Table 6, shall apply to the mean value of a lot, which shall be interpreted as being the mean value of all the wires of a given material in the conductor.

- (b) for wires where the mean of a lot is specified (AL4 and ST6C), 5 % of individual wire values may be below the minimum value for an individual wire for tensile strength before stranding, and above the maximum value for an individual wire for electrical resistivity

Table 6 - Permitted reductions in wire properties after stranding

Material	Reduction after stranding
Aluminium (AL1)	Tensile strength 5 %
Zinc coated steel (ST1A to ST6C) and Aluminium-clad steel (20SA to 40SA)	Stress at 1 % extension (1) : 5 %
	Tensile strength : 5 %
	Torsion : subtract 2 turns
	Elongation (2) : subtract 0,5
	Thickness of AL. cladding (SA wire) : 25 % of minimum
Aluminium alloy (AL2 to AL7)	None
(1) Measurements of stress at 1 % extension on steel wires other than the centre wire are unreliable. If these measurements are required to be made on wires other than the centre wire, then the minimum value may be agreed between the purchaser and the manufacturer.	
(2) Example: A minimum elongation value of 3,0 % for wire before stranding is reduced to 2,5 % for wire after stranding.	

6.5.3 Welding of aluminium wires

The manufacturer shall, if required by the purchaser, demonstrate that the method used for joining aluminium wires meets the strength requirement of 5.6.5 by performing the tensile test in the relevant wire standard given in clause 2.

6.6 Properties of grease

6.6.1 Mass per unit length

Using apparatus capable of achieving an accuracy of $\pm 0,1$ %, the mass of grease in a 1 m sample of conductor shall be determined from the difference between the mass of the conductor with grease and its mass after removing the grease with the aid of a suitable solvent. The mass of grease shall comply with the requirement of 5.8.3.

6.6.2 Drop point

A sample of grease removed from the conductor shall meet the drop point requirement of EN 50326, without preconditioning, after allowing for a reduction of 5 °C due to the sampling process.

6.7 Inspection

6.7.1 All tests and inspection shall be made at the manufacturer's plant prior to shipment unless otherwise agreed between the manufacturer and the purchaser at the time of placing the order and shall be so conducted as not to interfere unnecessarily with the manufacturer's operations. The manufacturer shall afford the inspector, representing the purchaser, sufficient testing facilities in order to satisfy him that the material is being furnished in accordance with this standard.

6.7.2 When inspection is to be made by the purchaser before shipment, the tests shall all be made within 14 days after receipt of a notice by the purchaser that the material is ready to test, and the material shall be accepted or rejected at the manufacturer's plant. If the purchaser does not have a representative present at the manufacturer's plant to test the material at the expiry of the said 14 days, the manufacturer shall make the tests herein provided for and furnish to the purchaser, when requested, official copies of the results of such tests, and the purchaser shall accept or reject the material in accordance with the results of such tests. Alternatively, the manufacturer may provide relevant test results if these have already been carried out during production.

6.8 Acceptance or rejection

6.8.1 Failure of a test specimen to comply with any one of the requirements of this standard shall constitute grounds for rejection of the lot represented by the specimen.

6.8.2 If any lot is so rejected, the manufacturer shall have the right to test, only once, all individual drums of conductor in the lot and submit those which meet the requirements for acceptance. Only those tests which do not meet the requirements for acceptance on the original specimen, shall be carried out.

7 Packaging and marking

7.1 Packaging

The conductor shall be suitably protected against damage or deterioration which could occur in ordinary handling and shipping.

The following shall be agreed upon between the manufacturer and the purchaser at the time of placing the order or at the earliest possible time:

- (a) the type and size of package and method of packing;
- (b) the packaging size and drum bore requirements and also the availability of the inner end of the conductor for grounding purposes, where the conductor stringing practices require special consideration.

7.2 Marking and tare

The gross, net and tare weight, length (or length and number of conductors, if more than one length is agreed upon to be supplied on the same drum), designation, and any other necessary identification shall be suitably marked inside the package. This same information, together with the purchase order number, the manufacturer's serial number (if any) and all shipping marks and other information shall appear on the outside of each package.

7.3 Random lengths

Unless otherwise agreed between the purchaser and manufacturer, random lengths of conductors unavoidably obtained during production should not exceed 5 % of the purchased quantity providing that no piece is less than 50 % of the contractual length.

7.4 Accuracy of lengths

The manufacturer shall use equipment to measure the length to an accuracy of $\pm 1\%$.

7.5 Drum barrel dimensions

The diameter of the drum barrel shall be sufficiently large not to cause problems during subsequent use of the conductor. The experience of some countries is that this value should be at least thirty times the conductor diameter or sixty times the steel core diameter, whichever is the greater.

8 Information to be clarified by the purchaser and manufacturer

When making an enquiry or placing an order the following information shall be clarified between the purchaser and manufacturer:

- a) quantity of conductor;
- b) conductor designation and number of wires of each type;
- c) length of conductor per drum, its tolerance, and where applicable, matching of conductor lengths;
- d) direction of lay. If this information is omitted, the direction of the external lay shall be right-hand;
- e) requirements for grease (designation according to EN 50326 and nominal mass according to annex B), if any;
- f) type and size of package and method of packing;
- g) special packaging requirements, if any;
- h) lagging requirements, if any;
- i) whether tests on wires after stranding are required;
- j) nominal conductor diameter and method of measurement;
- k) whether conductor breaking strength tests are required;
- l) whether conductor stress-strain tests are required;
- m) recommended or specified installation methods, or purchaser requirements for tests designed to demonstrate capability for satisfactory installation;
- n) if inspection is required and place of inspection;
- o) special requirements, for example any special national conditions (see annex A) which may apply.

NOTE This list is given for guidance only, and may not be complete.

Annex A
(normative)

Special national conditions

Special national condition: National characteristic or practice that cannot be changed even over a long period, e.g. climatic conditions, electrical earthing conditions. If it affects harmonization, it forms part of the European Standard or Harmonization Document.

For the countries in which the relevant special national apply these provisions are normative, for other countries they are informative.

<u>Clause</u>	<u>Special national condition</u>
1	Norway, Sweden Conductors outside the scope of this European Standard may be used. These conductors are specified in Svensk Standards SS 4240811, SS 4240812, SS 4240813 and SS 4240814.
5.5.7	Norway, Sweden This requirement shall not apply.
5.6.2 and 5.6.4	France Joints are not permitted in the outer layer of conductors of type AL4.
5.6.4	France Joints made by cold pressure welding should be annealed. The tensile strength of a joint in aluminium of type AL4 shall be not less than 130 N/mm ² and not more than 205 N/mm ² .

Annex B (normative)

Calculation of nominal mass of grease for stranded conductors

B.1 When it is required for bare conductors to be greased in order to reduce the risk of corrosion in some environments, the mass of grease shall be calculated using the methods given in this annex.

B.2 Four cases of grease application are:

- Case 1: Steel core only greased (**Figure B.1(a)**).
- Case 2: All the conductor is greased except the outer layer (**Figure B.1(b)**).
- Case 3: All the conductor is greased including the outer layer (**Figure B.1(c)**).
- Case 4: All the conductor is greased except the outer surface of the wires in the outer layer (**Figure B.1(d)**).

Other cases may be specified by the purchaser.

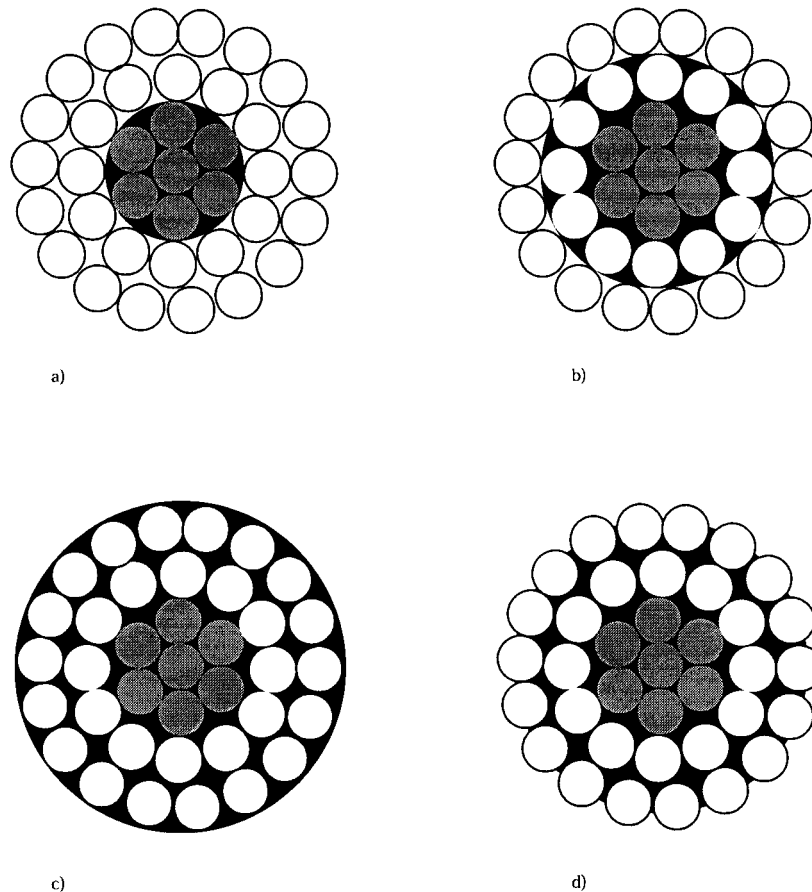


Figure B.1 - Application of grease to bare conductors

B.3 Assuming the grease completely fills the voids between the wires, the volume of grease in any given conductor shall be calculated from the following equations:

$$\text{Case 1: } V_g = 0,25 \pi (D_S^2 - n_S d_S^2)$$

$$\text{Case 2: } V_g = 0,25 \pi \{ (D_O - 2d_a)^2 - (n_a - n_O) d_a^2 - n_S d_S^2 \}$$

$$\text{Case 3: } V_g = 0,25 \pi (D_O^2 - n_a d_a^2 - n_S d_S^2)$$

$$\text{Case 4: } V_g = 0,125 n_O (D_O - d_a)^2 \sin(360/n_O) - 0,125 \pi (2n_a - n_O - 2) d_a^2 - 0,25 \pi n_S d_S^2$$

where:

V_g is the volume of grease, per unit length, in the conductor.

D_O is the external diameter of the conductor.

D_S is the diameter of the steel core.

d_a is the diameter of the aluminium wire in the outer layer.

d_S is the diameter of the steel wire.

n_a is the number of aluminium wires in the conductor.

n_O is the number of wires in the outer layer.

n_S is the number of steel wires in the conductor.

Since there is a geometric relationship between the parameters of these equations, it is possible to express the total mass of grease in a conductor with the following relation:

$$M_g = k d_a^2$$

where:

M_g is the mass of grease (kg/km).

k is a factor which depends on the conductor stranding and the grease density and the fill factor (ratio of theoretical volume).

Values of k are given in Table B.1 for the four cases of grease application, a grease density of $0,87\text{g/cm}^3$, and a fill factor of 0,8.

Table B.1 - Coefficients k for mass of grease

Stranding		k_1	k_2	k_3	k_4
Aluminium	Steel	Case 1	Case 2	Case 3	Case 4
7	-	-	-	1,09	0,17
19	-	-	1,09	3,28	1,79
37	-	-	3,28	6,56	4,52
61	-	-	6,56	10,93	8,35
91	-	-	10,93	16,40	13,27
127	-	-	16,40	22,96	19,28
6	1	-	-	1,09	0,17
8	1	-	-	1,46	0,34
18	1	-	1,09	3,28	1,79
9	3	0,90	-	2,88	1,46
6	7	0,12	-	1,21	0,29
10	7	0,66	-	2,48	1,18
12	7	1,09	-	3,28	1,79
14	7	1,63	-	4,18	2,51
18	7	0,12	1,21	3,40	1,91
22	7	0,34	1,80	4,35	2,67
24	7	0,49	2,13	4,86	3,10
26	7	0,66	2,48	5,40	3,54
28	7	0,86	2,87	5,97	4,02
30	7	1,09	3,28	6,56	4,52
32	7	1,35	3,72	7,18	5,05
36	7	1,94	4,68	8,50	6,19
42	7	0,34	4,35	7,99	5,77
45	7	0,49	4,86	8,69	6,37
48	7	0,66	5,40	9,41	7,01
54	7	1,09	6,56	10,93	8,35
72	7	0,49	8,69	13,61	10,75
84	7	1,09	10,93	16,40	13,27
14	19	1,76	-	4,31	2,64
15	19	2,10	-	4,83	3,07
16	19	2,46	-	5,38	3,52
18	19	3,28	-	6,56	4,52
30	19	1,18	3,37	6,65	4,61
32	19	1,46	3,83	7,29	5,16
36	19	2,10	4,83	8,66	6,35
42	19	3,28	6,56	10,93	8,35
54	19	1,18	6,65	11,02	8,44
38+22	19	1,42	5,42	9,43	7,03
42+20	19	1,30	4,33	7,98	5,76
66	19	2,46	9,39	14,49	11,54
78	19	4,21	12,59	18,43	15,11
96	19	2,10	13,58	19,59	16,19
100	19	2,46	14,49	20,68	17,19
18	37	3,35	-	6,63	4,59
24	37	6,56	-	10,93	8,35
72	37	3,35	11,00	16,47	13,33
54+66	37	4,39	16,44	23,00	19,33
150	37	3,35	23,03	30,68	26,45

Annex C (normative)

Stress - strain test method

(test to be performed if required by the purchaser)

C.1 Sample length

The sample length, between end terminations, shall be at least 400 times the conductor diameter but not less than 10 m. A shorter length may be agreed between the manufacturer and purchaser. The gauge length shall be a minimum of 100 times the conductor diameter.

C.2 Test temperature

Temperature readings shall be taken at the beginning and end of each hold period. If the temperature varies by more than 2 °C from that at the commencement of the test then allowance for the thermal expansion of the conductor shall be made.

C.3 Sample preparation

Great care shall be taken in the preparation of test samples. Relative displacements as small as 1 mm between the steel core and the aluminium layers of the conductor cause significant changes in the measured stress-strain curves. The sample preparation shall be as follows:

C.3.1 Before removing the sample from the drum, fit a bolted clamp 5 m $\pm$ 1 m from the end of the conductor length. The clamp shall apply sufficient pressure to prevent relative wire movements in the conductor.

C.3.2 Unwind the desired length of conductor from the drum and install another bolted clamp at the required distance from the first clamp. Apply adhesive tape and cut the conductor at a distance from the clamp just far enough to allow room for applying dead-end fittings.

C.3.3 During transportation to the test laboratory, the sample shall be properly protected from damage. The diameter of the coil or drum of conductor shall be at least 50 times the conductor diameter.

C.3.4 End fittings such as compression, epoxy type or solder type approved by the purchaser shall be used for stress-strain tests. The wires shall not be unwound, cleaned or greased prior to application of the end fittings.

C.3.5 Care shall be taken not to damage any wire during the end preparation of the sample.

C.3.6 The application of the end fitting shall not induce any slack in the wires which might alter the stress-strain curves of the conductor.

C.4 Requirements for compression fittings

When compression fittings are used for ALx/STyz conductors, the method indicated in C.4.1 to C.4.3 shall be followed.

C.4.1 Slide the aluminium sleeve on to the conductor. Cut back the aluminium wires to allow room for the steel terminal, the extrusion of the steel terminal and the extrusion of the aluminium wires by the aluminium compression sleeve. The space required between the aluminium wires and the steel terminal, before crimping, is typically 30 mm to 40 mm. Slide the compression steel dead-end terminal on to the steel core. Crimp the steel terminal, with a 2 % to 10 % maximum overlap, starting from the outer core end.

C.4.2 Pull the aluminium sleeve on to the steel terminal. Leave 40 mm of space if the conductor diameter is less than or equal to 30 mm and 50 mm of space if the conductor diameter is greater than 30 mm, between the end of the aluminium sleeve and the shoulder of the steel terminal for extrusion. Make the first crimp on the tapered mouth of the aluminium sleeve.

This locks the sleeve in place and inhibits extrusion of aluminium towards the test span. Proceed to crimp in the direction away from the span in small bites of 20 % on uncompressed metal.

Stop crimping before the filler hole in the sleeve is reached; the steel terminal and core are too small to support the crimped aluminium sleeve in this region. Continue towards the eye, on the other side of the terminal pad to lock the sleeve on to the expanded portion of the steel terminal.

C.4.3 The aluminium sleeve shall be oriented so that there is no interference with conductor movement during the test.

C.5 Test set-up

C.5.1 The test sample shall be supported in a trough over its full length, and the trough adjusted so that the conductor will not lift by more than 10 mm when under tension. This shall be ascertained by measurement rather than by tensioning the conductor.

C.5.2 The conductor strain shall be evaluated from the measured displacements at the two ends of the gauge length of the conductor. The gauge reference targets shall be attached to the bolted clamps which lock the conductor wires together. Target plates may be used with dial gauges or displacement transducers and care shall be taken to position the plates perpendicular to the conductor.

NOTE Twisting the conductor, lifting it and moving it from side to side by the maximum amounts expected during the test should introduce no more than 0,3 mm error in the reading.

C.6 Test loads for the conductor

The loading conditions for stress-strain tests for conductors shall be as follows:

C.6.1 Load initially to 5 % of RTS (rated tensile strength) to straighten the conductor and set the strain gauges to zero.

C.6.2 For non-continuous stress-strain data recordings, take the strain readings at intervals of 2,5 % RTS, rounded to the nearest kN, during both loading and unloading.

C.6.3 Load to 30 % RTS and hold for 0,5 h. Take readings after 5 min, 10 min, 15 min, and 30 min during the hold period. Release to the initial load.

C.6.4 Re-load to 50 % RTS and hold for 1 h. Take readings after 5 min, 10 min, 15 min, 30 min, 45 min and 60 min during the hold period. Release to the initial load.

C.6.5 Re-load to 70 % RTS and hold for 1 h. Take readings after 5 min, 10 min, 15 min, 30 min, 45 min and 60 min. Release to the initial load.

C.6.6 Re-load to 85 % RTS and hold for 1 h. Take readings after 5 min, 10 min, 15 min, 30 min, 45 min and 60 min. Release to the initial load.

C.6.7 After the fourth application of load, again apply tension, increasing uniformly, until the actual breaking strength is reached. Simultaneous readings of tension and elongation shall be taken up to 85 % RTS at least at the same time intervals as for the previous loading.

C.6.8 The rate of application of loads shall be uniform during testing. The time required to reach 30 % RTS shall not be less than one minute nor more than two minutes. The same rate of loading shall thereafter be maintained throughout the tests.