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Sri Lanka Standard

SPECIFICATION FOR ALUMINIUM CONDUCTORS FOR OVERHEAD POWER TRANSMISSION PURPOSES

PART 2 - ALUMINIUM CONDUCTORS, STEEL - REINFORCED

SRI LANKA STANDARDS INSTITUTION

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SPECIFICATION FOR ALUMINIUM CONDUCTORS FOR OVERHEAD POWER TRANSMISSION PURPOSES

Part 2 - Aluminium Conductors, Steel-reinforced

FOREWORD

This Sri Lanka Standard was authorised for adoption and publication by the Council of the Sri Lanka Standards Institution on ....88-01-25.... after the draft, finalised by the Drafting Committee on Aluminium Conductors for Overhead Power Transmission, has been approved by the Electrical Engineering Divisional Committee.

This specification lays down requirements and test methods for aluminium conductors, steel-reinforced and it is in line with the IEC 209 and BS 215 : Part 2 Specification for Aluminium Conductors, Steel-Reinforced. A note on Modulus of Elasticity and coefficient of linear expansion and the Code names for Standard Aluminium Conductors, steel-reinforced are given in Appendices B and C respectively. They are given for information purposes only.

All values in this specification are given in SI units.

For the purpose of deciding whether a particular requirement of this specification is complied with, the final value observed or calculated expressing the result of a test or observation shall be rounded off in accordance with CS : 102. The number of significant figures to be retained in the rounded off values should be the same as that of the specified value in this specification.

The assistance derived from the publications of the International Electrotechnical Commission and British Standards Institution in the preparation of this specification is gratefully acknowledged.

1 SCOPE

This Sri Lanka Standard specification, applies to Aluminium Conductors, steel-Reinforced for Overhead Power Transmission.

2 REFERENCES

BS 2627 Wrought Alumimium for Electrical Purposes - wire

BS 4565 Galvanized steel wire for Aluminium Conductors, Steel-reinforced.

3 DEFINITIONS

For the purposes of this specification the following definitions shall apply :

3.1 aluminium conductor, steel-reinforced : A conductor consisting of seven or more aluminium and galvanized steel wires build up in concentric layers. The centre wire or wires are of galvanized steel and the outer layer or layers of aluminium.

3.2 diameter : The mean of two measurements at right angles taken at the same cross section.

3.3 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 direction of the central part of the letter S when the conductor is held vertically.

3.4 lay ratio : The ratio of the axial length of a complete turn of the helix formed by an individual wire in a strandard conductor to the external diameter of the helix.

4 REQUIREMENTS

4.1 Standards for hard-drawn aluminium wire

4.1.1 Resistivity

The resistivity of aluminium wire depends upon its purity its physical condition. For purposes of this standard the maximum value permitted is $0.028264 \times 10^{-6}\,\Omega\,m$ at 20 °C and this value shall also be used as the standard resistivity for the purpose of calculation.

4.1.2 Density

At a temperature of 20°C the density of hard drawn aluminium wire is to be taken as $2.703 \times 10^{3}\,kg/m^{3}$.

4.1.3 Coefficient of linear expansion

The coefficient of linear expansion of hard drawn aluminium wire is to be taken as 23×10^{-6} /C°.

4.1.4 Constant-mass temperature coefffcient (α)

At a temperature of 20°C the 'constant-mass' temperature coefficient of resistance, of hard drawn aluminium wire, measured between two potential points rigidly fixed to the wire, is taken as 4.03×10^{-3}/C°.

4.2 Standards for galvanized steel wire

4.2.1 Density

At a temperature of 20°C, the density of galvanized steel is to be taken as 7.80×10^{3} kg/m³.

4.2.2 Coefficient of linear expansion

In order to obtain uniformity in calculations, a value of 11.5×10^{-6}/C° may be taken as the value for the coefficient of linear expansion of galvanized steel wires used for the cores of aluminium conductors, steel-reinforced.

4.3 Material

The aluminium wires in the construction of the conductor shall be material 1350 in the H9 condition as specified in BS 2627.

The galvanized steel wires shall be of the standard tensile strength grade given in BS 4565 unless one of the higher tensile strength grades is specified by the purchaser.

By aggreement between the purchaser and the manufacturer a suitable grease may be applied to the centre wire, or additionally to wires in specific layers, evenly throughout the length of the conductor.

4.4 Dimensions and construction

4.4.1 Standard sizes of wires

The aluminium and steel wires for the standard constructions covered by this specification shall have the diameters specified in Table 1 and 2 respectively. The diameters of the steel wires shall be measured over the zinc coating.

4.4.2 Standard sizes of aluminium conductors, steel-reinforced

4.4.2.1 The sizes of standard aluminium conductors, steel-reinforced are given in Table 3.

4.4.2.2 The masses (excluding the mass of grease for corrosion protection) and resistances may be taken as being in accordance with Table 3.

4.5 Joints in wires

4.5.1 Aluminium wires

In aluminium conductors, steel reinforced, containing any number of aluminium wires, joints in individual aluminium wires are permitted, in addition to those made in the base rod or wire before final drawing, but not two such joints shall be less than 15 m apart in the complete stranded conductor. Such joints shall be made by resistance or cold-pressure butt-welding. They are not required to fulfil the mechanical requirements for unjointed wires. Joints made by resistance butt-welding shall, subsequent to welding, be annealed over a distance of at least 200 mm on each side of the joint.

4.5.2 Galvanized steel wires

There shall be no joints, except those made in the base rod or wire before final drawing, in steel wires forming the core of an aluminium conductor, steel-reinforced, unless the core consists of seven or more galvanized steel wires. In the latter case joints in individual wires are permitted, in addition to those made in the base rod or wire before final drawing, but no two such joints shall be less than 15 m apart in the complete steel core. Joints in galvanized steel wires shall be made by resistance butt-welding and shall be protected against corrosion.

4.6 Stranding

4.6.1 The wires used in the construction of an aluminium conductor, steel - reinforced shall, before stranding, satisfy all the relevant requirements of this standard.

4.6.2 The lay ratio of the different layers shall be within the limits given in Table 4.

4.6.3 In all constructions the successive layers shall have opposite directions of lay, the outermost layer being right-handed. The wires in each layer shall be evenly and closely stranded.

4.6.4. In conductors 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.

4.6.5 Steel wires shall be formed during stranding so that they remain inert when the conductor is cut.

4.7 Completed conductor

The completed conductor shall be free from dirt, grit excessive amounts of drawing oil and other foreign deposits.

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5 SELECTION OF TEST SAMPLES

5.1 Samples for the tests specified in 7 shall be taken by the manufacturer before stranding, from not less than 10% of the individual lengths of :

i) aluminium wire and ;

ii) galvanized steel wire,

Which will be included in any one consignment of stranded conductor. One sample, sufficient to provide one test specimen for each of the appropriate tests, shall be taken from each of the selected lengths of wire, for the tests specified in 7.

5.2 Alternatively, when the purchaser states at the time of ordering that he desires tests to be made in the presence of his representative, samples of wire shall be taken from lengths of stranded conductor selected from a approximately 10% of the lengths included in any one consignment. One sample, sufficient to provide one specimen for each of the appropriate tests shall be taken from each of an agreed number of wires of the conductor in each of the selected lengths, for the tests specified in 7 of this specification.

6 PACKING AND MARKING

6.1 The conductor shall be wound on reels or drums and each drum or reel shall bear a durable tag marked with the following :

a) Manufacturer's name or trade name ;

b) Size of conductor ;

c) Net and gross mass of conductor ; and

d) Length of conductor.

7 TESTS

7.1 Aluminium wires

The test samples of aluminium wires taken as in 5.1 shall be subjected to the following tests in accordance with this specification and shall meet the requirements herein.

a) Tensile test (7.4)

b) Wrapping test (7.7)

c) Resistivity test (7.9)

Test samples of aluminium wires taken as in 5.2 shall be subjected to the same tests but in the case of tensile test, the tensile strength of the specimen shall be not less than 95% of the appropriate minimum value specified in this speicification.

7.2 Steel wires

The test samples of galvanized steel wires taken as in 5.1 shall be subjected to the following tests in accordance with this specification and shall meet the requirements herein.

a) Determination of stress at 1% elongation (7.3)

b) Tensile test (7.4)

c) Torsion test or elongation test as appropriate (7.5),(7.6)

d) Wrapping test (7.7)

e) Galvanizing test (7.8)

The test samples of galvanized steel wires taken as in 5.2 shall be subjected to the following tests in accordance with this specification.

a) Determination of stress at 1% elongation

b) Tensile test

c) Torsion test or elongation test as appropriate

d) Wrapping test

e) Galvanizing test

In the case of the tensile test the tensile strength of the specimen shall be not less than 95% of the appropriate minimum value specified in 7.4.

In the case of elongation test the elongation of the specimen shall be not less than the appropriate minimum value specified in 7.6 reduced in numerical value by 0.5.

In the case of stress at 1% elongation, torsion, wrapping and galvanizing tests the appropriate requirements of 7.3 shall be met.

NOTES -

1. Because of the difficulty in straightening samples taken from stranded cores, it is recommended that determination of stress at 1% elongation on samples taken as in 5.2 be carried out on the centre wire only.

2. The choice between a torsion test and an elongation test is to be at the discretion of the manufacturer and the choice of one test or the other in no way prejudices the quality of the steel used.

7.3 Determination of stress at 1% elongation

One specimen cut from each of the samples taken in accordance with 5 shall be gripped in the jaws of a tensile testing machine. A load corresponding to the appropriate tensile stress given in column 2 of Table 5 shall be applied and an extensometer applied on a 50 mm, 200 mm or 250 mm gauge length and adjusted to the appropriate initial setting given in column 3, 4 and 5 of Table 5.

The load shall then be increased uniformly until the extensometer indicates an extension of 0.50 mm in 50 mm, 2.00 mm in 200 mm or 1.50 mm in 250 mm. At this point, the load shall be read from which the value of the stress at 1% extension shall be calculated. The value obtained for the specimen shall be not less than the appropriate value given in column 2 of Table 6.

7.4 Tensile test

The breaking load of one specimen cut from each of the samples taken in accordance with 5 shall be determined by means of a suitable tensile testing machine.

The load shall be applied gradually and the rate of separation of the jaws of the testing machine shall be not less than 25 mm per minute and not greater than 100 mm per minute.

When tested before stranding, the ultimate tensile stress of the specimen shall be not less than the appropriate value given in column 2 of Table 6 or column 3 of Table 7. When tested after stranding, the ultimate tensile stress of the specimen shall be not less than the appropriate value given in column 3 of Table 6 or column 4 of Table 7.

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TABLE 1 - Aluminium wires used in the construction of standard aluminium conductors, steel-reinforced

1	2	3	4	5	6
Standard diameter	Cross sectional area of standard diameter wire	Mass per km	Standard resistance at 20 °C per km	Minimum breaking load for standard diameter wire	Standard diameter
mm	mm^2	kg	Ω	N	mm
2.36	4.374	11.82	6.461	770	2.36
2.59	5.269	14.24	5.365	906	2.59
2.79	6.114	16.53	4.623	1 030	2.79
3.00	7.069	19.11	3.999	1 190	3.00
3.18	7.942	21.47	3.559	1 310	3.18
3.35	8.814	23.82	3.207	1 450	3.35
3.61	10.24	27.67	2.761	1 660	3.61
3.86	11.70	31.63	2.415	1 870	3.86
4.72	17.50	47.30	1.615	2 780	4.72

TABLE 2 - Steel wires used in the construction of standard aluminium conductors, steel-reinforced

1	2	3	4
Standard diameter	Cross-sectional area of standard diameter wire	Mass per km	Minimum load at 1% elongation for standard diameter wire
mm	mm^2	kg	N
1.57	1.936	15.10	1 280
2.36	4.374	34.12	4 990
2.59	5.269	41.09	6 010
2.79	6.114	47.69	6 970
3.00	7.069	55.13	8 060
3.18	7.942	61.95	8 740
3.35	8.814	68.75	9 700
3.61	10.24	79.84	11 260
3.86	11.70	91.28	12 870

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[illegible] 3 - Standard aluminium conductors, steel-reinforced

1	2	3	4	5	6	[illegible]	8	9	1
Nominal aluminium area	Stranding and wire diameter: Aluminium	Stranding and wire diameter: Steel	Sectional area of aluminium	Total sectional area	Approximate overall diameter	Approximate mass per km	Calculated d.c. resistance at 20°C per km	Claculated breaking load	Nominal aluminium area
mm^2	mm	mm	mm^2	mm^2	mm	kg	Ω	kN	mm^2
25	6/2.36	1/2.36	26.24	30.62	7.08	106	1.093	9.61	25
30	6/2.59	1/2.59	31.61	36.88	7.77	128	0.907 7	11.45	30
40	6/3.00	1/3.00	42.41	49.48	9.00	172	0.676 6	15.20	40
50	6/3.35	1/3.35	52.88	61.70	10.05	214	0.542 6	18.35	50
70	12/2.79	7/2.79	73.37	116.2	13.95	538	0.393 6	61.20	70
100	6/4.72	7/1.57	105.0	118.5	14.15	394	0.273 3	32.70	100
150	30/2.59	7/2.59	158.1	194.9	18.13	726	0.182 8	69.20	150
150	18/3.35	1/3.35	158.7	167.5	16.75	506	0.181 5	35.70	150
175	30/2.79	7/2.79	183.4	226.2	19.53	842	0.157 6	79.80	175
175	18/3.61	1/3.61	184.3	194.5	18.05	537	0.156 3	41.10	175
200	30/3.00	7/3.00	212.1	261.5	21.00	974	0.136 3	92.25	200
200	18/3.86	1/3.86	210.6	222.3	19.30	671	0.136 7	46.55	200
400	54/3.18	7/3.18	428.9	484.5	28.62	1 621	0.067 40	131.9	400

NOTES-

1. For the basis of calculation of this Table see Appendix A.
2. The sectional area is the sum of the cross-sectional areas of the relevant individual wires.
3. Attention is drawn to the fact that the aluminium sectional areas of standard conductors covered by this specification are larger than the nominal aluminium areas by which they are identified ; they should not be compared directly with conductors manufactured exactly to those nominal areas.

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TABLE 4 - Lay ratiosfor aluminium conductors, steel-reinforced

1	2	3	4	5	6	7	8	9	10	11	12	13
Number of wires		Ratios Aluminium wire diameter to steel wire diameter	Lay ratio for steel core		Lay ratios for aluminium layers							
					6 wire layer		12 - wire layer		18 - wire layer		24 - wire layer	
Aluminium	Steel		min.	max.	min.	max.	min.	max.	min.	max.	min.	max.
6	1	1.000	-	-	10	14	-	-	-	-	-	-
6	7	3.000	13	28	10	14	-	-	-	-	-	-
12	7	1.000	13	28	-	-	10	14	-	-	-	-
18	1	1.000	-	-	10	16	10	14	-	-	-	-
30	7	1.000	13	28	-	-	10	16	10	14	-	-
54	7	1.000	13	28	-	-	10	17	10	16	10	14

TABLE 5 - Initial stress and extensometer setting for determination of stress at 1% extension

1	2	3	4	5
Nominal diameter mm	Initial stress kg/mm^2	Initial setting of extensometer		
		in 50 mm	in 200 mm	in 250 mm
1.25	10	0.025	0.10	0.125
2.25	10	0.025	0.10	0.125
3.00	20	0.050	0.20	0.250
4.75	30	0.075	0.30	0.375

NOTE - For wire of intermediate diameter, the initial stress and the initial extensometer setting shall be the same as that for the next larger diameter listed.

TABLE 6 - Mechanical properties of hard-drawn aluminium wire

1	2	3
Nominal wire diameter mm	Minimum ultimate tensile stress	
	Before stranding kg/mm^2	After stranding kg/mm^2
1.25	20.4	19.4
1.50	19.7	18.7
1.75	19.2	18.2
2.00	18.8	17.9
2.25	18.4	17.5
2.50	18.0	17.1
2.75	17.6	16.7
3.00	17.2	16.3
3.25	16.9	16.0
3.50	16.7	15.9
3.75	16.5	15.7
4.00	16.3	15.5
4.25	16.3	15.5
4.50	16.2	15.4
4.75	16.2	15.4
5.00	16.2	15.4

NOTE - For wire of intermediate diameter, the minimum ultimate tensile stress shall be the same as that for the next larger diameter listed.

TABLE 7 - Mechanical properties and zinc coating requirements for steel wire

1	2	3	4	5	6
Nominal wire diameter mm	Minimum stress at 1% extension kg/mm^2	Minimum ultimate tensile stress		Minimum weight of zinc coating g/m^2	Minimum number of 1 - minutes dips
		Before Stranding kg/mm^2	After Stranding kg/mm^2		
1.25	119.5	133.6	126.9	183	2
1.50	119.5	133.6	126.9	183	2
1.75	119.5	133.6	126.9	198	2
2.25	119.5	133.6	126.9	214	2½
2.75	116.0	133.6	126.9	229	3
3.00	116.0	133.6	126.9	244	3½
3.50	112.5	133.6	126.9	244	3½
4.25	112.5	133.6	126.9	259	4
4.75	112.5	133.6	126.9	275	4

NOTE - For wire of intermediate diameter, the mechanical properties and zinc coating requirements shall be the same as those for the next larger diameter listed.

7.5 Torsion test

This test shall be made on galvanized steel wires only. One specimen cut from each of the samples taken in accordance with 5 shall be gripped at its ends in two vices, one of which shall be free to move longitudinally during the test. A small tensile load, not exceeding 2% of the breaking strength of the wire, shall be applied to the sample during testing. The specimen shall be twisted by causing one of the vices to revolve until fracture occurs and the number of twists shall be indicated by a counter or other suitable device. The rate of twisting shall not exceed 60 rev/min.

When tested before stranding, the number of complete twists before fracture occurs shall be equivalent to not less than 18 on a length equal to 100 times the diameter of the wire. The fracture shall show a smooth surface at right angles to the axis of the wire.

When tested after stranding, the number of complete twists before fracture occurs shall be equivalent to not less than 16 on a length equal to 100 times the diameter of the wire. The fracture shall show a smooth surface at right angles to the axis of the wire.

7.6 Elongation test

As an alternative to the torsion test, an elongation test may be made on galvanized steel wires. The elongation of one specimen cut from each of the samples taken in accordance with 5 shall be determined. The specimen shall be straightened by hand and an original gauge length of 200 mm shall be marked on the wire. A tensile load shall be applied as described in 7.4 above and the elongation shall be measured after the fractured ends have been fitted together. If the fracture occurs outside the gauge marks, or within 25 mm of either mark, and the required elongation is not obtained, the test shall be disregarded and another test be made.

When tested before stranding, the elongation shall be not less than 4%. When tested after stranding, the elongation shall be not less than 3.5%. 12/

7.7 Wrapping test

7.7.1 Aluminium wires

One specimen cut from each of the samples of aluminium wire taken in accordance with 5 shall be wrapped round a mandrel of diameter equal to the wire diameter to form a close helix of eight turns. Six turns shall then be unwrapped and again closely wrapped. The wire shall not break or show any cracks.

7.7.2 Galvanized steel wires

One specimen cut from each of the samples of galvanized steel wire taken in accordance with 5 shall be wrapped found a mandrel of diameter equal to the wire diameter to form a close helix of eight turns. The wire shall not break.

7.8 Galvanizing tests

7.8.1 Determination of weight of zinc coating

One specimen cut from each of the samples of galvanized steel wire taken in accordance with 5 shall be made reasonably straight by hand and shall then be cleaned by being dipped into a suitable solvent, such as benzene, and wiped dry with a clean, soft cloth. The specimen shall be not less than 300 mm long and the weight of the specimen in grammes shall be not less than its diameter in millimetres multiplied by 4. For convenience, the specimen may be bent into the shape of a U.

The following reggents are required :

a) Antimony chloride solution prepared by dissolving 20 g of antimony trioxide or 32 g of antimony chloride in 1,000 ml of hydrochloric acid (specific gravity 1.19).

b) **Hydrochloric acid (specific gravity).**

The specimen shall be weighed to the nearest 0.01 g.

The specimen shall then be stripped off the zinc coating by complete immersion in any convenient volume of solution made by adding 5 ml of the antimony chloride solution to each 100 ml of hydrochloric acid. The same solution may be repeatedly used without further additions of antimony chloride solution, until the time for stripping becomes inconveniently long. The temperature of the stripping solution shall at no time exceed 38°C.

For single determination, a convenient volume of solution is 100 ml in a glass cylinder 50 mm in diameter and 150 mm in depth. The number of specimens immersed at any one time in a single determination shall not exceed 3 per 100 ml of solution.

As soon as the violent chemical action on the wire has ceased, the wire shall be removed from the acid, washed throughly in running water and wiped dry. The diameter of the wire shall then be determined to the nearest 0.025 mm by taking the average of two measurements at right angles to each other. The stripped specimen shall then be weighed to the nearest 0.01g.

The weight of coating per unit area of stripped wire surface shall be calculated from the following formula :

i) Weight of coating in grammes per square metre of stripped wire surface $= 1950\ dr$

Where :

d = diameter in millimetres of stripped wire.

$$r = \frac{\text{orginal weight - stripped weight}}{\text{stripped weight}}$$

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The weight shall be not less than the appropriate value given in column 5 of Table 7.

Alternative methods may be used for the determination of the weight of zinc coating, but in case of dispute the method given above shall be used.

7.8.2 <u>Test for adherence of zinc coating</u>

One specimen cut from each of the samples of galvanized steel wire taken in accordance with 5 shall be wrapped at a rate not exceeding 15 rev/min in a close helix of at least eight turns round a cylindrical mandrel having a diameter of four times the diameter of the wire for wires of diameter up to and including of five times the diameter of the wire for wires greater than 3.50 mm.

The zinc coating shall remain firmly adherent to the steel and shall not crack or flake to such an extent that any zinc can be removed by rubbing with bare fingers.

7.8.3 <u>Tests for uniformity of zinc coating</u>

One specimen cut from each of the samples of galvanized steel wire taken in accordance with 5 shall be subjected to this test, and shall withstand the appropriate number of dips given in column 6 of Table 7.

The copper sulphate test solution shall be made by dissolving approximately 36 parts by weight of commercial copper sulphate crystals in 100 parts by weight of distilled water. Heat may be used to complete the solution of the copper sulphate crystals. If heated, the solution shall be allowed to cool. The solution shall then be shaken with an excess of powdered cupric hydroxide (see Note). The presence of an excess of cupric hydroxide will be shown by the sediment of this reagent at the bottom of the vessel. The neutralized solution shall be allowed to stand at least 24 hours and then filtered or decanted.

The test solution shall have a specific gravity of 1.186 at 18°C. If the solution is high in specific gravity, distilled water shall be added to reduce the specific gravity to 1.186 at 18°C. If the solution is low in specific gravity, a solution of higher specific gravity shall be added until the correct specific gravity is obtained.

Before testing, the specimens may be hand straightened. The specimens shall be clenaned with a volatile organic solvent such as carbon tetrachloride or benezene, then rinsed with alcohol and finally throughly washed with clean water and wiped dry with a clean cloth. Test specimens shall be brought to a temperature of from 15 to 21°C prior to the begining of the test.

Wire specimen shall be tested in a glass container of at least 50 mm inside diameter for 2.75 mm and smaller diameter wire, and of at least 75 mm inside diameter for wire larger in diameter than 2.75 mm. The container shall be filled with a fresh test solution to a depth of at least 100 mm. This quantity of solution shall be used for the simultaneous testing of from one to seven test specimens. After completion of the test, the solution shall be discarded and a fresh solution used for any additional tests.

The specimens shall be immersed in the copper sulphate which shall be at a temperature of 18 ± 2°C. The specimens shall be allowed to remain in a fixed position in the solution for exactly 1 minute. There shall be no agitation of the solution during the immersion period and the specimens shall not be allowed to touch each other or the sides of the container. After each dip, the specimens shall immediately be washed in rinse water and wiped dry with a clean cloth.

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The rinse water may be ordinary clean tap water and shall have a temperature of from 15 to 21 °C. In conducting a series of tests, the rinse water shall be changed often enough to ensure that it is reasonably free from copper sulphate.

Running water should be used when available.

Successive dips of 1 minute each shall be continued, with rinsing and wiping of the test specimens after each dip, until the specimens have withstood the required number of dips, or until the appearance of adherent copper indicates that the steel beneath the coating has been exposed. The ½ minute dip, if specified, shall be carried out after the completion of all the 1 minute dips, should a small amount of copper be deposited on the zinc coating, it must not be mistaken for the end point in which the copper plates out on to the steel. The appearance of copper within 25 mm of the cut end of the specimen shall likewise not be considered to be the end point of the test.

The end point (disappearance of zinc coating) shall be recognized by the appearance of an adherent copper deposit on the steel or by the exposure of the bare steel if the deposit fails to form.

In counting number of dips a coating withstands, the final dip at which the end point occurs shall not be included.

1 NOTE - Cupric oxide may be substituted for cupric hydroxide, provided the solution is allowed to stand not less than 48 hours after this addition, before filtering or decanting.

7.9 Resistivity test

This test shall be made on aluminium wires only.

The electrical resistance of one specimen cut from each of the samples of aluminium wire taken in accordance with 5 shall be measured at a temperature which shall be not less than 10°C nor more than 30°C. The measured resistance shall be corrected to the value at 20°C by means of the formula :

$$R_{20} = R_T \left(\frac{1}{1 + \alpha (T - 20)} \right)$$

where :

T = temperature of measurement in °C

R_T = resistance at T °C

R_{20} = resistance at 20°C

and α = constant-mass temperature coefficient of resistance (=0.00403)

The resistivity at 20°C shall then be calculated from the resistance at 20°C. The resistivity at 20° shall not exceed 0.028264×10^{-6} m.

8 PLACE OF TESTING

Unless otherwise agreed between the purchaser and the manufacturer at the time of ordering, all tests shall be made at the manufacturer's works.

APPENDIX A

NOTES ON THE CALCULATION OF TABLE - 3

A.1 Increase in length due to stranding

When straightened, out, each wire in any particular layer of a stranded conductors, except the central wire, is longer than the stranded conductor by an amount depending on the lay ratio of that layer.

A.2 Resistance and mass of conductor

In aluminium conductors, steel-reinforced the conductivity of the steel core is neglected and the resistance of the conductor is calculated with reference to the resistance of the aluminium wires only. The resistance of any length of stranded conductor is the resistance of the same length of any one aluminium wire multiplied by a constant, as set out in Table 8.

The mass of each wire in a length of stranded conductor, except the central wire will be greater than that of an equal length of straight wire by an amount depending on the lay ratio of the layer (see A.1 above). The total mass of any length of conductor, is therefore, obtained by multiplying the mass of an equal length of straight wire by the appropriate constant set out in Table 8. The masses of the steel core and aluminium wires are calculated separately and added together.

In calculating the stranding constants in Table 8, the mean lay ratio, i.e. the arithmetic mean of the relevant minimum and maximum values in Table 4, has been assumed for each layer.

A.3 Calculated breaking load of conductor

The breaking load of a conductor, in terms of the strengths of the individual component wires, may be taken to be the sum of the strengths of the aluminium wires calculated from the specified minimum tensile strengths plus the sum of the strengths of the steel wires calculated from the specified minimum stress at 1% elongation.

TABLE 8 - Stranding constants

1	2	3	4	5
Number of wires in conductor		Stranding constants		
		Mass		Electrical
Aluminium	Steel	Aluminium	Steel	Resistance
6	1	6.091	1.000	0.169 2
6	7	6.091	7.032	0.169 2
12	7	12.26	7.032	0.085 14
18	1	18.34	1.000	0.056 60
30	7	30.67	7.032	0.034 08
54	7	55.23	7.032	0.018 94

APPENDIX B

NOTE ON MODULUS OF ELASTICITY AND COEFFICIENT OF LINEAR EXPANSION

The particular moduli of elasticity given below are based on an analysis of the final moduli determined from a large number of short-term stress/strain tests and may be taken as applying to conductors stressed between 15% and 50% of the breaking load of the conductor. They may be regarded as being accurate to within 30×10^6 kPa.

The coefficients of linear expansion given below have been calculated from the practical moduli for the aluminium and steel components of the conductors and coefficients of linear expansion of 23.0×10^{-6} and 11.5×10^{-6}/°C aluminium and steel respectively.

TABLE 9 - No. of stranded wires for aluminium conductors, steel-reinforced and corresponding values of modulus of elasticity and coefficient of linear expansion

Number of wires in conductor		Practical (final) modulus of elasticity	Coefficient of linear expansion/°C
Aluminium	Steel		
6	1	79×10^6	19.1×10^{-6}
6	7	75×10^6	19.8×10^{-6}
12	7	105×10^6	15.3×10^{-6}
18	1	66×10^6	21.2×10^{-6}
30	7	80×10^6	17.8×10^{-6}
54	7	69×10^6	19.3×10^{-6}

NOTE - These values are given for information purposes only.

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APPENDIX C

TABLE 10 - Code names for standard aluminium conductors, steel-reinforced

Nominal aluminium area	Stranding		Code name
	Aluminium	Steel	
mm^2	mm	mm	
25	6/2.36	1/2.36	GOPHER
30	6/2.59	1/2.59	WEASEL
40	6/3.00	1/3.00	FERRET
50	6/3.35	1/3.35	RABBIT
70	12/2.79	7/2.79	HORSE
100	6/4.72	7/1.57	DOG
150	30/2.59	7/2.59	WOLF
150	18/3.35	1/3.35	DINGO
175	30/2.79	7/2.79	LYNX
175	18/3.61	1/3.61	CARACAL
200	30/3.00	7/3.00	PANTHER
200	18/3.86	1/3.86	JAGUAR
400	54/3.18	7/3.18	ZEBRA

NOTE - These code names are not an essential part of the standard. They are given for convenience in ordering conductors.