SRI LANKA STANDARD 750 : PART I : 1986

UDC 621.315.1 : 621.315.5 : 669.71

SPECIFICATION FOR

ALUMINIUM CONDUCTORS FOR OVER HEAD POWER TRANSMISSION PURPOSES

PART I - ALUMINIUM STRANDED CONDUCTORS

SRI LANKA STANDARDS INSTITUTION

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SRI LANKA STANDARD

SPECIFICATION FOR ALUMINIUM CONDUCTORS FOR OVERHEAD POWER TRANSMISSION PURPOSES

PART 1 : ALUMINIUM STRANDED CONDUCTORS

FOREWORD

This Sri Lanka Standard was authorized for adoption and publication by the Council of the Sri Lanka Standards Institution on 1986-07-18, after the draft, finalized by the Drafting Committee on Aluminium Stranded Conductors has been approved by the Electrical Engineering Divisional Committee.

This standard is the Part 1 in the series of Sri Lanka Standards on Aluminium Conductors for Overhead Power Transmission : Part 2 in this series is titled "Aluminium Conductors, Steel-reinforced".

In Sri Lanka the usage of electrical power increased considerably over the past few years. Aluminium conductors are mainly used for the purpose of transmission and distribution of electrical power to various parts of the country.

Detailed requirements for aluminium wires are not included in this standard but are referred from the BS 2627 "wrought aluminium for electrical purposes wire". In this standard all dimensions are included in metric units.

Code names used for stranded Al conductors in industry and representative values of co-efficient of linear expansion, modulus of elasticity are given in Appendices.

At the present time there is an increasing use of conductors of constructions other than those covered in this standard. To facilitate standardization of these constructions lay ratio limits and the appropriate stranding factors in an appendix.

In the preparation of this standard data have been drawn from the publication of British Standards Institution and the International Electrotechnical Commission for which Sri Lanka Standards Institution is indebted.

1 SCOPE

This specification applies to aluminium stranded conductors for overhead power transmission purposes.

2 REFERENCES

BS 215 Aluminium conductors and aluminium conductors steel-reinforced for overhead power transmission
Part 1 - Aluminium stranded conductors

BS 2627 Wrought aluminium for electrical purposes

BS 4545 Galvanized steel wire for aluminium conductors, steel-reinforced

3 DEFINITIONS

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

3.1 stranded conductor : A conductor consisting of seven or more aluminium wires of the same nominal diameter twisted together in concentric layers. When the conductor consists of more than one layer, successive layers are twisted in opposite directions.

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 stranded conductor to the external diameter of the helix.

4 REQUIREMENTS

4.1 Material

The aluminium wires used in the construction of the conductor shall be material 1350 in the H9 condition as specified in BS 2627 : 1970. By agreement 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.

4.2 Standards for hard-drawn aluminium wire

4.2.1 *Resistivity*

The resistivity of aluminium wire depends upon its purity and its physical condition. For the purposes of this recommendation the maximum value permitted is 0.028 264 ohm.mm^2 /m at 20°C and this value shall also be used as the standard resistivity for the purpose of calculation.

4.2.2 *Density*

At a temperature of 20°C, the density of hard-drawn aluminium wire is to be taken as 2.703 kg/dm^3.

4.2.3 *Co-efficient of linear expansion*

The co-efficient of linear expansion of hard-drawn aluminium wire is to be taken as 23×10^{-6} per Celsius degree.

4.2.4 *Constant-mass temperature co-efficient (α)*

At a temperature of 20°C the "constant-mass" temperature co-efficient of resistance, α , of hard-drawn aluminium wire, measured between two potential points rigidly fixed to the wire, is taken as 0.00 403 per Celsius degree.

5 DIMENSIONS AND CONSTRUCTION

5.1 Dimensions

5.1.2 *Standard sizes of wires*

The aluminium wires for the standard constructions covered by this specification shall have the diameters specified in Table 1.

5.1.3 *Standard sizes of aluminium stranded conductors*

5.1.3.1 The sizes of standard aluminium stranded conductors shall be as given in Table 2.

5.1.3.2 The masses (excluding the mass of grease for corrosion protection) and resistances may be taken as being in accordance with Table 2.

5.1.3.3 Lengths and variations in length

Unless otherwise agreed between the purchaser and the manufacturer, aluminium stranded conductors shall be supplied in the manufacturer usual production lengths and with a permitted variation of ± 5 per cent in the length of any one conductor length. Additionally, it shall be permissible to supply not more than 5 per cent of the lengths on any one order in random lengths, none of which shall be shorter than one-third of the nominal length.

5.1.3.4 Tolerance on nominal diameters of wires

The aluminium wires shall not depart from the nominal diameter by more than the following amounts:

Nominal diameter	Tolerance
2.50 mm and greater	± 1%
Less than 2.50 mm	± 0.025 mm

5.2 Constructions

5.2.1 *Joints in wires*

5.2.1.1 Conductors containing seven wires

There shall be no joints in any wire of a stranded conductor containing seven wires, except those made in the base rod of wire before final drawing.

5.2.1.2 Conductors containing more than seven wires

In stranded conductors containing more than seven wires, 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 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.

5.2.2 *Stranding*

5.2.2.1 The wire used in the construction of a stranded conductor shall, before stranding, satisfy all the relevant requirements of this standard.

5.2.2.2 The lay ratio of the different layers shall be within the limits given in Table 3.

NOTE - It is important to note that lay ratio is now defined as the ratio of the axial length of a complete turn of the helix formed by an individual wire in a stranded conductor to the external diameter of the helix.

5.2.2.3 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.

5.2.2.4 In aluminium stranded conductors having multiple layers of wires, the lay ratio of any layer shall be not greater than the lay ratio of the layer immediately beneath it.

5.2.3 *Completed conductor*

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

6 TESTING

6.1 Selection of test samples

6.1.1 Samples for the tests specified in 6.3, 6.4 and 6.5 shall be taken by the manufacturer before stranding, from not less than 10 per cent of the individual lengths of aluminium 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.

6.1.2 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 approximately 10 per cent 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.

5.2.1.2 Conductors containing more than seven wires

In stranded conductors containing more than seven wires, 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 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.

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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.

6.1.2 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 approximately 10 per cent 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.

6.2 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.

6.3 Tensile test

The breaking load of one specimen cut from each of the samples taken under 6.1.1 or 6.1.2 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 or 3 of Table 4.

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 4.

6.4 Wrapping test

One specimen cut from each of the samples taken under sub-clause 6.1.1 or 6.1.2 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.

6.5 Resistivity test

The electrical resistance of the specimen cut from each of the samples taken under sub-clause 6.1.1 or 6.1.2 shall be measured at a temperature which shall be not less than 10°C and not 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 co-efficient of resistance (= 0.004 03)

The resistivity at 20°C shall then be calculated from the resistance at 20°C. The resistivity at 20°C shall not exceed 0.028 264 ohm.mm^2 m.

TABLE 1 - Aluminium wires used in the construction of standard aluminium stranded conductors

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
1	2	3	4	5	6
mm	mm^2	kg	Ω	N	mm
2.06	3.333	9.009	8.480	600	2.06
3.10	7.548	20.40	3.745	1250	3.10
3.25	8.296	22.42	3.407	1370	3.25
3.40	9.079	24.54	3.113	1490	3.40
3.78	11.22	30.33	2.519	1800	3.78
4.22	13.99	37.81	2.021	2240	4.22
4.39	15.14	40.91	1.867	2410	4.39
4.65	16.98	45.90	1.664	2700	4.65

NOTE - The values given in column 2 to 5 are given information only.

TABLE 2 - Standard aluminium stranded conductors

Nominal aluminium area	Stranding and wire diameter	Sectional area	Approximate overall diameter	Approximate mass per km	Calculated d.c. resistance at 20°C per km	Calculated breaking load	Nominal aluminium area
1	2	3	4	5	6	7	8
mm^2	mm	mm^2	mm	kg	Ω	kN	mm^2
22	7/2.06	23.33	6.18	64	1.227	3.99	22
50	7/3.10	52.83	9.30	145	0.541 9	8.28	50
60	7/3.40	63.55	10.20	174	0.450 5	9.90	60
100	7/4.39	106.0	13.17	290	0.270 2	16.00	100
150	19/3.25	157.6	16.25	434	0.182 5	25.70	150
200	19/3.78	213.2	18.90	587	0.134 9	32.40	200
250	19/4.22	265.7	21.10	731	0.108 3	40.40	250
300	19/4.65	322.7	23.25	888	0.08916	48.75	300
400	37/3.78	415.2	26.46	1145	0.06944	63.10	400

NOTES

1 For the basis of calculation of this table, see Appendix A.

2 The sectional area of stranded conductor is the sum of the cross-sectional areas of the individual wires.

3 Attention is drawn to the fact that the sectional areas of stranded 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.

TABLE 3 - Lay ratios for aluminium stranded conductors

Number of wires in conductor	Lay ratio					
	6-wire layer		12-wire layer		18-wire layer	
	min.	max.	min.	max.	min.	max.
1	2	3	4	5	6	7
7	10	14	-	-	-	-
19	10	16	10	14	-	-
37	10	17	10	16	10	14

NOTE - For the purpose of calculation the mean lay ratio shall be taken as the arithmetic mean of the relevant minimum and maximum values given in this table.

TABLE 4 - Mechanical properties of hard-drawn aluminium wire

Nominal wire diameter	Minimum ultimate tensile stress	
	Before stranding	After stranding
1	2	3
mm	kg/mm^2	kg/mm^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, the minimum ultimate tensile stress shall be the same as that for the next larger diameter listed on this table.

APPENDIX A

NOTES ON THE CALCULATION OF TABLE 2

A.1 INCREASE IN LENGTH DUE TO STRANDING

When straightened out, each wire in any particular layer of a stranded conductor, 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

The resistance of any length of a stranded conductor is the resistance of the same length of any wire multiplied by a constant as set out in Table 5.

The mass of each wire in any particular layer 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 that layer (see A.1 above). The total mass of any length of an aluminium stranded conductor is, therefore, obtained by multiplying the mass of an equal length of straight wire by an appropriate constant, as set out in Table 5.

In calculating the stranding constants in Table 5, the mean lay ratio, e.e. the arithmetic mean of the relevant minimum and maximum values in Table 3, has been assumed for each layer.

A.3 CALCULATED BREAKING LOAD OF CONDUCTOR

The breaking load of an aluminium stranded conductor containing not more than 37 wires, in terms of the strengths of the individual component wires, may be taken to be 95% of the sum of the strengths of the individual aluminium wires calculated from the specified minimum tensile strength.

TABLE 5 - Stranding constants

Number of wires in conductor	Stranding constants	
	Mass	Electrical resistance
7	7.091	0.144 7
19	19.34	0.053 57
37	37.74	0.027 57

APPENDIX B

NOTE ON MODULUS OF ELASTICITY AND CO-EFFICIENT OF LINEAR EXPANSION

The practical 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 per cent and 50 per cent of the breaking load of the conductor. They may be regarded as being accurate to within ± 300 h bar.

Number of wires in conductor	Practical(final) modulus of elasticity	Co-efficient of linear expansion/^{o}C
	h bar*	
7	5900	23.0×10^{-6}
19	5600	23.0×10^{-6}
37	5600	23.0×10^{-6}

NOTE - These values are given for information only.

** 1 h bar = 10 MN/m^2 = 10/N mm^2*

APPENDIX C

CODE NAMES FOR STANDARD ALUMINIUM STRANDED CONDUCTORS

Nominal aluminium area	Stranding	Code name
mm^2	mm	
22	7/2.06	MIDGE
50	7/3.10	ANT
60	7/3.40	FLY
100	7/4.39	WASP
150	19/3.25	HORNET
200	19/3.78	CHAFER
250	19/4.22	COCKROACH
300	19/4.65	BUTTERFLY
400	37/3.78	CENTIPEDE

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

APPENDIX D

NON-STRANDED CONSTRUCTIONS

D.1 Lay ratios and stranding constants

Number of wires in conductors	Lay ratio										Stranding constants	
	6-wire layer		12-wire layer		18-wire layer		24-wire layer		30-wire layer		Mass	Electrical resistor
	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.		
1	2	3	4	5	6	7	8	9	10	11	12	13
61	10	17	10	16	10	15	10	14	-	-	62.35	0.01676
91	10	17	10	16	10	15	10	14	10	13	93.26	0.01126

D.2 Calculated breaking load. The breaking load of an aluminium stranded conductor containing more than 37 wires, in terms of the strengths of the individual component wires, may be taken to be 90 per cent of the sum of the strengths of the individual aluminium wires calculated from the specified minimum tensile strength.

AMD 210

AMENDMENT NO. 01 APPROVED ON 1996-05-23 TO SLS 750 : PART 1 : 1986

SRI LANKA STANDARD SPECIFICATION FOR ALUMINIUM CONDUCTORS FOR OVERHEAD POWER TRANSMISSION PURPOSES

1. Insert the following new Clause immediately after 5.2.3.

6 PACKAGING AND MARKING

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;
d) Length of conductor; and
e) Overall dimensions of drum.

2. Re-number the existing clause 6 TESTING as given below.

Title	Existing Clause Number	New Clause Number
TESTING	6	7
Selection of test Samples	6.1	7.1
Place of testing	6.2	7.2
Tensile test	6.3	7.3
Wrapping	6.4	7.4
Resistivity test	6.5	7.5

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Printed at SLSI (Printing Unit)

SRI LANKA STANDARDS INSTITUTION

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