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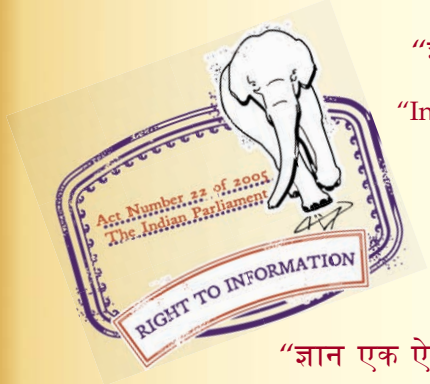

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भाग 1 एल्यूमिनियम लड़दार चालक

(तीसरा पुनरीक्षण)

Indian Standard

ALUMINIUM CONDUCTORS FOR OVERHEAD TRANSMISSION PURPOSES — SPECIFICATION

PART 1 ALUMINIUM STRANDED CONDUCTORS

(Third Revision)

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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AMENDMENT NO. 1 APRIL 1999
TO
IS 398 (PART 1) : 1996 ALUMINIUM CONDUCTORS FOR OVERHEAD TRANSMISSION PURPOSES — SPECIFICATION

PART 1 ALUMINIUM STRANDED CONDUCTORS

(Third Revision)

(*Page* 3, *clause* 12.4, *line* 3) — Substitute '12.1.1 or 12.1.2' *for* '11.1.1 or 11.1.2'.

(*Page* 4, *clause* 12.5, *formula*) — Substitute the following for the existing formula:

$$'R_{20} = R_T \frac{1}{1 + \alpha (T - 20)}$$

where α is constant mass temperature co-efficient of resistance, 0·004 03; and'

(ET 37)

Reprography Unit, BIS, New Delhi, India

FOREWORD

This Indian Standard (Third Revision) was adopted by the Bureau of Indian Standards after the draft finalized by the Conductors and Accessories for Overhead Lines Sectional Committee had been approved by the Electrotechnical Division Council.

This standard was originally published in 1953, the first revision was brought out in 1961. In this revision the specification has been modified in the light of the modern development in the techniques of conductor manufacture. The other salient point incorporated in this revision is the inclusion of wrapping test for the aluminium wires in place of the elongation test originally specified for aluminium wires.

The second revision was brought out in 1976. In that revision, it was decided to issue it in different parts covering different types of conductors. This part dealing with aluminium stranded conductors forms Part 1 of the series. The other parts in the series are given below:

Part 2 Aluminium conductors, galvanized steel-reinforced.

Part 3 Aluminium conductors, aluminized steel-reinforced.

Part 4 Aluminium alloy stranded conductors.

Part 5 Aluminium conductors, galvanized steel reinforced for extra high voltage (400 kV and above).

This third revision has been undertaken with a view to effecting the following considerations:

a) To line up with International Standards.

b) All amendments approved and circulated after 1976 have been considered while preparing this specification for third revision.

c) The most important consideration has been taken regarding improvement in conductivity of E.C. Grade Aluminium - the maximum resistivity of 0.028 264 ohm. mm^2/m at 20°C, as per IEC standard.

d) Measurement of wire diameter, lay ratio, test procedures and testing of routine tests and acceptance tests have been included.

e) Type tests have been included.

The values of modulus of elasticity and coefficient of linear expansion are given in Annex B for information.

In the preparation of this standard assistance has been derived from the following:

IEC Pub IEC 889 - - Hard drawn aluminium wire for overhead line conductors

IEC 1089 – Round wire concentric laid overhead electrical conductors

BS 215: Part 1 : 1970 Specification for aluminium conductors and aluminium conductors, steel-reinforced for overhead power transmission. Part 1 Aluminium stranded conductors. British Standards Institution.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values *(revised)*'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

ALUMINIUM CONDUCTORS FOR OVERHEAD TRANSMISSION PURPOSES — SPECIFICATION

PART 1 ALUMINIUM STRANDED CONDUCTORS

(Third Revision)

SECTION 1 GENERAL

1 SCOPE

1.1 This standard (Part 1) covers the requirements and tests for aluminium stranded conductors used for overhead transmission purposes.

2 REFERENCES

2.1 The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
1778 : 1980	Reels and drums for bare conductors (*first revision*)
1885 (Part 32) : 1993	Electrotechnical vocabulary : Part 32 Electric cables (*first revision*)
5484 : 1978	EC grade aluminium rods produced by continuous casting and rolling
7623 : 1993	Lithium base grease for industrial purposes (*second revision*)

3 TERMINOLOGY

3.0 For the purpose of this standard, the following definitions in addition to those given in IS 1885 (Part 32) : 1993 shall apply.

3.1 Stranded Conductor

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

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 PHYSICAL CONSTANTS FOR HARD-DRAWN ALUMINIUM

4.1 Resistivity

The resistivity of aluminium depends upon its purity and its physical condition. For the purpose of this standard, the maximum value permitted is 0.028 264 ohm.mm^2/m at 20°C and this value has been used for calculation of the maximum permissible values of resistance.

NOTE — It is not intended to check the resistivity from the measured values of resistance

4.2 Density

At a temperature of 20°C, the density of hard drawn aluminium has been taken as 2.703 g/cm^3.

4.3 Constant-Mass Temperature Coefficient of Resistance

At a temperature of 20°C the constant-mass temperature coefficient of resistance of hard-drawn aluminium, measured between two potential points rigidly fixed to the wire, the metal being allowed to expand freely, has been taken as 0.004 03 per degree Celsius.

4.4 Coefficient of Linear Expansion

The coefficient of linear expansion of hard-drawn aluminium at 0°C has been taken as 23.0 × 10^{-6} per degree Celsius. This value holds good for all practical purposes over the range of temperature from 0°C to the highest safe operating temperature

SECTION 2 MATERIALS

5 MATERIAL

5.1 The conductor shall be constructed of hard-drawn aluminium wires having mechanical and electrical properties specified in Table 1. When specified by the purchaser, neutral grease may be applied between the layers of wires. The aluminium content shall be not less than 99.5 percent and copper conductor shall not be more than 0.04 percent.

5.1.1 The EC grade aluminium rods for use in the manufacture of aluminium wires shall confirm to IS 5484 : 1978.

5.2 When specified by the purchasers, neutral grease is to applied as per one of the following cases:

a) All conductor except outer layer.
b) All conductor including outer layer; and
c) All conductor except outer surface of the wires in the outer layer.

NOTE — Lithium soap grease corresponding to Grade II of IS 7623 : 1993 having minimum drop point not less than 180°C is suitable for such application.

6 FREEDOM FROM DEFECTS

6.1 The wires shall be smooth and free from all imperfections, not consistent with good commercial practice.

SECTION 3 DIMENSIONS AND CONSTRUCTION

7 STANDARD SIZES

7.1 Wires

7.1.1 *Nominal Sizes*

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

7.2 Stranded Conductors

7.2.1 *Sizes*

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

7.2.2 The resistances shall be in accordance with Table 2. The masses (excluding the mass of grease, if applied) are given in Table 2 for information.

8 JOINT IN WIRES, EXCEPT DURING STRANDING

8.1 The wires shall be drawn in continuous length, without joints, except those made in wire rod or before drawing.

8.2 Joints in Stranded Conductors

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

8.2.2 *Conductor Containing Seven Wires*

Joints in wires other than those permitted under 8.1 shall not be permitted in any wire of stranded conductor containing seven wires.

8.2.3 *Conductors Containing More than Seven Wires*

In case of stranded conductor containing more than seven wires, joints are permitted in wire broken during stranding provided such breaks are not associated with either inherently defective wire or with those of short lengths of aluminium wires. Joints shall be dressed smoothly with a diameter equal to that of parent wires and shall not be kinked. No two joints other than those in wires before stranding permitted under 8.1 occur at points in the stranded conductors nearer than 15 m.

8.2.4 Joints shall be made by electric butt welding, electric butt cold upset welding or cold pressure welding. These joints shall be made in accordance with good commercial practice. Electric butt welding shall be annealed for approximately 250 mm on both sides of the welds.

8.2.5 While the joints specified are not required to meet the requirements of unjointed wires, they shall be withstanding a stress of not less than 75 MPa for annealed electric butt welded joints and not less than 130 MPa for cold pressure and electric butt cold upset welded joints. The manufacturer shall demonstrate that the proposed welding method is capable of meeting the specified strength requirements.

9 STRANDING

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

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

9.3 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.

9.4 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.

10 LENGTHS AND VARIATIONS IN LENGTHS

10.1 Unless otherwise agreed between the purchaser and the manufacturer, stranded aluminium conductors shall be supplied in the manufacturer's usual production lengths and with a permitted variation of ± 5 percent in the length of any one conductor length.

10.2 Random Lengths

Unless otherwise agreed between the purchaser and the manufacturer, it shall be permissible to supply not more than 10 percent of the lengths on any one order in random lengths; none of them shall be shorter than one-third of the nominal length.

SECTION 4 PACKING AND MARKING

11 PACKING AND MARKING

11.1 The conductor shall be wound on reels or drums (it is recommended that reels and drums conforming to IS 1778 : 1980 be used) and marked with the following :

a) Indication of the source of manufacture,
b) Size and type of conductor,
c) Net weight of conductor in kg,
d) Gross weight of conductor drum in kg, and
e) Length(s) of conductor in meters.

11.1.1 The conductor may also be marked with Standard Mark.

11.1.2 The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. Details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

SECTION 5 TESTS

12 TESTS

12.1 Selection of Test Samples for Acceptance and Routine Tests

12.1.1 Samples of individual wires for the tests specified in 12.2, 12.3, 12.4 and 12.5 shall normally be taken by the manufacturer before stranding, from the outer ends of not less than 10 percent of the spools.

12.1.2 Spools of individual wires offered for inspection shall be divided into equal lots, the number of lots being equal to the number of samples to be selected, a fraction of a lot being counted as a complete lot. One sample spool shall be selected at random from each lot. This may be done physically, or on the basis of identification numbers spools offered for supply.

12.1.3 Alternatively, if desired by the purchaser at the time of placing an order that the tests be made in the presence of his representative, samples of wire shall be taken from lengths of stranded conductors. Samples shall then be obtained by cutting 1.2 metres from outer end of the finished conductor from not more than 10 percent of the drums.

12.1.4 For the purpose of various tests, one specimen means sample of the wire or stranded conductor.

12.2 Measurement of Diameter of Individual Aluminium Wires

One specimen cut from each of the samples taken under 12.1.1 and 12.1.2 shall be measured by micrometer. The diameter of wire shall be measured using a micrometer having flat surface on both the anvil and the end of the spindle to be read with micrometer. The diameter in millimetre shall be the average of three diameter measurements each of which is the average of the maximum and minimum reading at a point taken near each end and in the centre of the sample. The diameter of the wire shall be within limit as specified in Table 1.

12.3 Breaking Load Test

The breaking load of one specimen cut from each of the samples taken under 12.1.1 or 12.1.3 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/min and not greater than 100 mm/min.

The ultimate breaking load of the specimen shall be not less than the appropriate value specified in Table 1.

12.4 Wrapping Testing

This test shall be made on aluminium wire.

One specimen cut from each of the samples taken under 11.1.1 or 11.1.2 shall be wrapped round the mandrel of diameter equal to wire diameter to form a close helix of eight turns. Six turns shall then be unwrapped and again closely wrapped in the same direction as before. The wire shall not break.

12.5 Resistance Test

The electrical resistance of one specimen cut from each of the samples taken under 12.1.1, 12.1.2 or 12.1.3 shall be measured at ambient temperature.

The measured resistance shall be corrected to the value at 20°C by means of the formula:

$$R_{20} = R_T \frac{1}{1 + x(T - 20)}$$

where

R_{20} = resistance corrected at 20°C;
R_T = resistance measured at T°C;
x = constant mass temperature coefficient of resistance, 0.004 03; and
T = ambient temperature during measurement.

The resistance corrected at 20°C shall be not more than the maximum value specified in Table 1.

12.6 Measurement of Lay Ratio/Direction of Lay

The lay ratio of each layer of the conductor shall be measured and checked as per requirements specified in Table 3, 9.2 and 9.4 and lay direction shall be as per requirements of 9.3.

13 CLASSIFICATION OF TESTS

13.1 Type Tests

a) Measurement of diameter of aluminium wire (*see* 12.2),
b) Breaking load test of individual aluminium wire (*see* 12.3),
c) Wrapping test of aluminium wire (*see* 12.4), and
d) Resistance test of aluminium wire (*see* 12.5), and
e) Measurement of lay ratio (*see* 12.6).

14 REJECTION AND RETESTS

14.1 Should any one of the test pieces first selected fail to pass the tests, three further specimens from the same batch shall be selected, one of which shall be from the length from which the original test specimen was taken, unless that length has been withdrawn by the supplier.

14.2 Should all of the three test pieces from these additional spacimens satisfy the requirements of the tests, the batch represented by these specimens shall be deemed to comply with the standard. Should the test pieces from any of the three additional specimens fail, the batch represented shall be deemed not to comply with the standard.

SECTION 6 TABLES

Table 1 Aluminium Wires Used in the Construction of Aluminium Stranded Conductors
(*Clauses* 5.1, 7.1.1, 12.2, 12.3 *and* 12.5)

Diameter			Cross-Sectional Area of Nominal Diameter Wire	Mass	Resistance at 20°C	Breaking Load *Min*	
Nom	*Min*	*Max*			*Max*	Before Stranding	After Stranding
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
mm	mm	mm	mm^2	kg/km	ohms/km	kN	kN
2.21	2.18	2.24	3.836	10.37	7.503	0.68	0.65
3.10	3.07	3.13	7.548	20.40	3.818	1.24	1.18
3.18	3.15	3.21	7.942	21.47	3.626	1.29	1.23
3.99	3.95	4.03	12.50	33.80	2.306	1.98	1.88
4.39	4.35	4.43	15.14	40.91	1.902	2.40	2.28
4.65	4.60	4.70	16.98	45.90	1.700	2.70	2.56

NOTES

1 The resistance has been calculated from the maximum values of resistivity and the cross-sectional area based on the minimum diameter.

2 The resistance of individual wires shall be such that the completed stranded conductor meets the requirements of the maximum resistance specified in Table 2 calculated by applying the relevant stranding constants given in Table 4.

Table 2 Aluminium Stranded Conductors
[*Clauses* 7.2.1, 7.2.2; and *Table* 1 (*Note* 2); and *Annex* A]

Nominal Aluminium	Stranding and Wire Diameter	Sectional Area	Approximate Overall Dia	Approximate Mass	Calculated Resistance at 20°C *Max*	Approximate Calculated Breaking Load
(1) mm^2	(2) mm	(3) mm^2	(4) mm	(5) kg/km	(6) ohms/km	(7) kN
25	7/2.21	26.85	6.63	74	1.096	4.52
50	7/3.10	52.83	9.30	145	0.552 5	8.25
100	7/4.39	106.0	13.17	290	0.275 2	15.96
150	19/3.18	150.9	15.90	415	0.194 2	23.28
240	19/3.99	237.6	19.95	654	0.123 5	35.74
300	19/4.65	322.7	23.25	888	0.091 07	48.74

NOTES

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

2 The sectional area of a stranded conductor has been taken as the sum of the cross-sectional areas of the individual wires.

Table 3 Lay Ratios for Aluminium Stranded Conductors
(*Clauses* 9.2, 12.6 *and* A-2.3)

Number of Wires in Conductor	Lay Ratio			
	6 Wire Layer		12 Wire Layer	
	Min	*Max*	*Min*	*Max*
(1)	(2)	(3)	(4)	(5)
7	10	14	—	—
19	10	16	10	14

Table 4 Stranding Constants
[*Clauses* A- 2.1, A-2.2 *and* A-2.3; and *Table* 1 (*Note* 2)]

Number of Wires in Conductor	Stranding Constants	
	Mass	Electrical Resistance
(1)	(2)	(3)
7	7.091	0.144 7
19	19.34	0.053 57

SECTION 7 ANNEXURES

ANNEX A

[*Table* 2 (*Note* 1)]

NOTES ON THE CALCULATION OF TABLE 2

A-1 INCREASE IN LENGTH DUE TO STRANDING

A-1.1 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

A-2.1 The resistance of any length of a stranded conductor is the resistance of the same length of any one wire multiplied by a constant, as set out in Table 4.

A-2.2 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-1.1 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 4.

A-2.3 In calculating the stranding constants in Table 4, the mean lay ratio, that is, the arithmetic mean of the relevant minimum and maximum values in Table 3, has been assured for each layer.

A-3 CALCULATED BREAKING LOAD OF CONDUCTOR

A-3.1 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 percent of the sum of the strengths of the individual aluminium wires calculated from the specified minimum breaking load.

ANNEX B

(Foreword)

MODULUS OF ELASTICITY AND COEFFICIENT OF LINEAR EXPANSION

No. of Wires	Final Modulus of Elasticity (Practical) GN/m^2	Coefficient of Linear Expansion/Degree C
7	59	23.0×10^{-6}
19	60	23.0×10^{-6}

NOTES

1 These values are given for information only.

2 Moduli values quoted may be regarded as being accurate to within ± 3 GN/m^2.

3 Moduli values quoted may be taken as applying to conductors stressed between 15 and 50 percent of the ultimate breaking of the stranded conductor.

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