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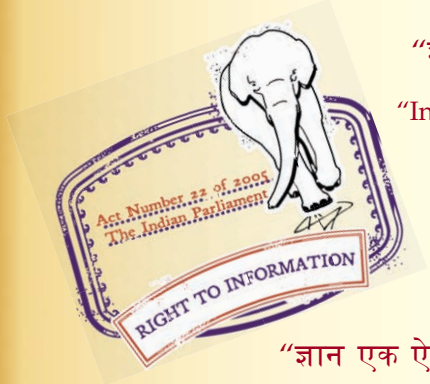

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SPECIFICATION FOR CONDUCTORS FOR INSULATED ELECTRIC CABLES AND FLEXIBLE CORDS

(First Revision)

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Indian Standard

SPECIFICATION FOR CONDUCTORS FOR INSULATED ELECTRIC CABLES AND FLEXIBLE CORDS

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 30 April 1984, after the draft finalized by the Power Cables Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard was first prepared in 1976 to cover the requirements for copper and aluminium conductors appearing in various Indian Standards for electric cables and cords. The present revision has been undertaken to align with international developments as far as practicable.

0.3 Opportunity has also been utilised to take account of experience and developments since the standard was initially published and to simplify the standard so far as is compatible with technical and economic considerations.

0.4 In addition to the quality of material used, the important features of a conductor are its maximum resistance and degree of flexibility and in this standard control is effected by specifying the minimum number of wires or maximum diameter of wires and the maximum resistance.

0.5 In this standard, the conductors are divided into different classes, the flexibility of the conductor increasing with the class number. The number of classes of conductor has been reduced to four. There are two classes of conductors for cables for fixed installations; class 1 is for solid conductors only and class 2 for stranded conductors. For flexible conductors also there are two classes; as these correspond closely with classes 5 and 6 of the previous edition, those class numbers have been retained to preserve continuity and avoid any confusion. Classes 3 and 4 have been omitted, since they have had relatively little use and classes 2 and 5 respectively are

considered suitable for most of the applications for which classes 3 and 4 had been employed.

0.6 In this revision, the number of different specified maximum resistance values for different types of conductor of the same nominal cross-sectional area have been reduced as follows:

a) For classes 1 and 2, conductors of the same material and same nominal cross-sectional area have the same specified maximum resistance for both classes and for both single and multicore cables and whether the conductors are circular or compacted circular or shaped. However, to avoid too large divergences from previous values, the differences in specified resistances between plain and tinned copper conductors have been retained.

b) Also in these two classes, the specified maximum resistance of each nominal cross-sectional area of aluminium conductor in the range up to and including 10 mm^2 is the same as for the next smaller standard size of copper conductor. The object of this is to provide equivalent of resistance between the small sizes of wiring cables with copper and aluminium conductors. For 16 mm^2 and above, separate resistances are retained between copper and aluminium conductors.

c) The resistance values chosen for classes 1 and 2 are those which were specified for class 2 in the previous edition for multicore cables for the nominal cross-sectional areas from 2·5 mm^2 up to and including 400 mm^2 and for the single core cables for the nominal cross-sectional areas above 400 mm^2. For the sizes up to 1·5 mm^2, for which the difference between the resistances of class 1 and class 2 conductors in the previous edition were larger than for the other sizes, the lower values specified for class 1 in the previous edition for multicore cables have been adopted, in order to avoid any large increase in resistance values.

d) For flexible copper conductors of classes 5 and 6, the resistance values are the same and correspond to the resistance values for multicore cables specified in the previous edition for class 5, the difference between plain and tinned conductors again being retained.

0.7 In this revision, flexible aluminium conductors for welding cables have also been included.

0.8 As a result of the simplification achieved by combining resistances of single-and multicore cables and different forms of conductor into common resistance values, the method of calculation of resistances included in the previous edition is no longer strictly applicable and is now omitted. Also the details about methods of various tests have been taken out from this standard and are now covered in a separate standard, to which reference has been made at appropriate places.

0.9 While preparing this standard, assistance has been derived from IEC Pub 228 (1978) 'Conductors of insulated cables' issued by the International Electrotechnical Commission (IEC).

0.10 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*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard specifies the properties and construction of copper and aluminium conductors for insulated electric cables and flexible cords.

1.2 This standard does not apply to:

a) conductors for use in coils of machines or apparatus;

b) conductors without insulation, for use in aerial lines;

c) conductors for telecommunication purposes; and

d) conductors of special design, for example, hollow-core conductors.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 1885 (Part 32)-1971† shall apply.

*Rules for rounding off numerical values (*revised*).

†Electrotechnical vocabulary : Part 32 Cables, conductors and accessories for electricity supply.

3. MATERIAL

3.1 Aluminium — The material for conductor shall consist of plain aluminium. It shall be of one of the following grades with the corresponding tensile strength limits :

Grade	*Tensile Strength* N/mm²
0	Up to and including 100
H2	Above 100 and up to and including 150
H4	Above 150

3.1.1 a) For shaped solid conductors and the welding cable conductors, only 0 grade aluminium shall be used;

b) For conductors of cross-sectional area up to and including 10 mm², H2 or H4 grade aluminium shall be used; and

c) For the remaining conductors, aluminium of 0, H2 or H4 grade may be used.

3.2 Copper — The conductors shall be made from high conductivity copper rods complying with IS : 613-1964*. The conductors shall consist of tinned or untinned annealed copper as may be specified.

3.3 Form of Conductor — The conductors shall be solid, circular, shaped, compacted, stranded or bunched as required by the appropriate cable specification. The conductor shall be clean, reasonably uniform in size and shape, smooth and free from harmful defects.

3.4 Joints in Conductor

3.4.1 *Stranded Conductors* — Joints shall be permitted in the individual wires of which the conductor is formed, but no joint shall be within 300 mm of any other joint within the same layer. The joints shall be made by resistance butt welding, fusion welding, cold pressure welding, electric welding, gas welding, brazing or silver soldering.

3.4.2 *Solid Conductors (Aluminium Conductors Only)* — No joints shall be made in the finished solid conductor.

*Specification for copper rods for electrical purposes (*revised*).

4. CLASSIFICATION

4.1 In this standard, the conductors have been divided into four classes as follows:

a) Cables for fixed installations	Classes 1 and 2
b) The flexibles	Classes 5 and 6
c) Copper welding cables	Class 6

4.2 Aluminium conductors for welding cables have not been assigned any class number.

5. CONSTRUCTION

5.1 Solid Conductor (Class 1)

5.1.1 The conductor shall consist of single wire of plain or tinned annealed copper or plain aluminium in accordance with Table 1.

5.1.2 Solid copper conductor shall be of circular cross-section.

5.1.3 Solid aluminium conductor of sizes from 1·5 mm^2, up to and including 16 mm^2 shall be of circular cross-section. Sizes 25 mm^2 and above may be of either circular or shaped cross-section.

5.2 Stranded Circular Non-Compacted Conductors (Class 2)

5.2.1 Conductor shall consist of plain or tinned annealed copper or plain aluminium.

5.2.2 The wires in the conductor shall have the same nominal diameter before stranding.

5.2.3 The number of wires in the conductor shall be not less than the appropriate minimum number given in Table 2.

5.3 Stranded Compacted Circular Conductors and Shaped Conductors (Class 2)

5.3.1 Conductor shall consist of plain or tinned annealed copper or plain aluminium.

5.3.2 The ratio of the diameters of two wires before stranding in the same conductor shall not exceed 2.

5.3.3 The number of wires in the conductor shall be not less than appropriate minimum number given in Table 2.

5.4 Flexible Conductors (Classes 5 and 6)

5.4.1 Conductor shall consist of plain or tinned annealed copper.

5.4.2 The wires in the conductor shall have same nominal diameter before bunching.

5.4.3 The diameter of the wires in any conductor shall not exceed the appropriate maximum value given in Table 3 for Class 5 and Table 4 for Class 6 conductors.

5.5 Flexible Aluminium Conductors for Welding Cables

5.5.1 Conductor shall consist of plain aluminium.

5.5.2 The wires in the conductor shall have same nominal diameter before stranding.

5.5.3 The diameter of wires in any conductor shall not exceed the appropriate maximum value given in Table 5.

6. TESTS

6.1 Tests for Copper Conductors

6.1.1 *Persulphate Test (For Tinned Copper Only)*— This test shall be carried out in accordance with Method B given in IS : 10810 (Part 4)-1984*. The mass of copper dissolved shall not exceed the appropriate value given below:

Wire Diameter mm	*Permissible Mass of Copper Dissolved, Max* g/m²
Up to and including 0·41	5
Above 0·41	3

*Methods of test for cables: Part 4 Persulphate test of conductor.

6.1.2 *Annealing Test*

6.1.2.1 *Before stranding* — This test shall be carried out in accordance with IS : 10810 (Part 1) - 1984*. The elongation shall be not less than the appropriate value given below:

Wire Diameter		*Elongation, Min*
Over	Up to and Including	
mm	mm	Percent
—	0·21	9·0
0·21	0·41	13·5
0·41	1·36	18·0
1·36	—	22·5

6.1.2.2 *After stranding* — (Under consideration).

6.2 Tests for Aluminium Conductors

6.2.1 *Tensile Test* — This test shall be carried out in accordance with IS : 10810 (Part 2)-1984†. The sample shall meet the following requirements:

a) *Before stranding* — The tensile strength of any of the wires shall comply with the values given in 3.1.

b) *After stranding* — The tensile strength of any of the wires shall be not less than 95 percent of the minimum values given in 3.1.

NOTE — This test for wires taken from stranded conductors is not applicable in the case of compacted circular conductors or shaped conductors.

6.2.2 *Wrapping Test* — This test shall be done in accordance with IS : 10810 (Part 3)-1984‡. The criteria for passing is that the wire shall not break.

NOTE — This test is not applicable to:

a) shaped solid conductors,

b) wires taken from stranded conductors in case of compacted circular or shaped conductors, and

c) wires used for welding cable conductors.

*Methods of test for cables: Part 1 Annealing test for wires.

†Methods of test for cables: Part 2 Tensile test for aluminium wires.

‡Methods of test for cables: Part 3 Wrapping test for aluminium wires.

6.2.3 *Annealing Test* — This test is applicable to shaped solid conductor and wires of conductor (before stranding) for welding cables only. The test shall be carried out in accordance with IS : 10810 (Part 1)-1984* Shaped solid conductors shall have a minimum of 25 percent and wires of conductor for welding cables shall have a minimum of 12 percent elongation.

6.3 **Resistance Test (For Both Copper and Aluminium)** — This test shall be done on the finished conductors in accordance with IS : 10810 (Part 5)-1984†. The dc resistance of the conductor shall be measured at room temperature and corrected to 20°C by means of the appropriate factors given in Table 6.

6.3.1 The corrected dc resistance shall not exceed the values give inn the appropriate tables.

7. PACKING AND MARKING

7.1 The conductor shall either be wound on reels or drums or supplied in coils packed and labelled. The label shall contain the name of the manufacturer; trade-name, if any ; size and length of the conductor.

7.2 BIS Certification Marking

The product may also be marked with Standard Mark.

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

NOTE — The requirements of packing and marking are not applicable when the processing of the conductor forms part of the manufacturing of complete cable.

*Methods of test for cables: Part 1 Annealing test wires.
†Methods of test for cables: Part 5 Conductor resistance test.

TABLE 1 SOLID CONDUCTORS FOR SINGLE-CORE AND MULTICORE CABLES, CLASS 1

(*Clauses* 5.1.1 *and* 6.3.1)

Nominal Cross-Sectional Area	Maximum Resistance of Conductor At 20°C		
	Circular Copper Conductors		Aluminium Conductors Circular or Shaped
	Plain	Tinned	
mm²	ohm/km	ohm/km	ohm/km
0·5	36·0	36·7	—
0·75	24·5	24·8	—
1	18·1	18·2	—
1·5	12·1	12·2	18·1 †
2·5	7·41	7·56	12·1 †
4	4·61	4·70	7·41 †
6	3·08	3·11	4·61 †
10	1·83	1·84	3·08 †
16	1·15	1·16	1·91 †
25	0·727*	—	1·20
35	0·524*	—	0·868
50	0·387*	—	0·641
70	0·268*	—	0·443
95	0·193*	—	0·320
120	0·153*	—	0·253
150	0·124*	—	0·206
185	—	—	0·164
240	—	—	0·125
300	—	—	0·100

*The solid copper conductors having nominal cross-sectional areas of 25 mm² and above are intended for particular types of cables only and not for general purpose.

†Aluminium conductors 1·5 mm² to 16 mm² circular only.

TABLE 2 STRANDED CONDUCTORS FOR SINGLE-CORE AND MULTI-CORE CABLES, CLASS 2

(Clauses 5.2.3, 5.3.3 and 6.3.1)

Nominal Cross-Sectional Area	Minimum Number of Wires in the Conductor				Maximum Resistance of Conductor at 20°C		
	Circular Conductor (Non-compacted)		Circular Compacted or Shaped Conductor		Copper Conductor		Aluminium Conductor
					Plain Wires	Tinned Wires	
mm²	Cu	Al	Cu	Al	ohm/km	ohm/km	ohm/km
1	3	—	—	—	18·1	18 2	—
1·5	3	3	—	—	12·1	12·2	18·1
2·5	3	3	—	—	7·41	7·56	12 1
4	7	3	—	—	4·61	4·70	7·41
6	7	3	—	—	3·08	3·11	4·61
10	7	7	6	—	1·83	1·84	3·08
16	7	7	6	6	1·15	1·16	1·91
25	7	7	6	6	0·727	0·734	1·20
35	7	7	6	6	0·524	0·529	0·868
50	19	19	6	6	0·387	0·391	0·641
70	19	19	12	12	0·268	0·270	0·443
95	19	19	15	15	0·193	0·195	0·320
120	37	37	18	15	0·153	0·154	0·253
150	37	37	18	15	0·124	0·126	0·206
185	37	37	30	30	0·099 1	0·100	0·164
240	61	37	34	30	0·075 4	0·076 2	0·125
300	61	61	34	30	0·060 1	0·060 7	0·100
400	61	61	53	53	0·047 0	0·047 5	0.077 8
500	61	61	53	53	0·036 6	0·036 9	0·060 5
630	91	91	53	53	0·028 3	0·028 6	0·046 9
800	91	91	53	53	0·022 1	0·022 4	0·036 7
1 000	91	91	53	53	0·017 6	0·017 7	0·0291

TABLE 3 FLEXIBLE COPPER CONDUCTORS FOR SINGLE-CORE AND MULTI-CORE CABLES, CLASS 5

(*Clauses 5.4.3 and 6.3.1*)

Nominal Cross-Sectional Area	Maximum Diameter of Wires in Conductor	Maximum Resistance of Conductor at 20°C	
		Plain Wires	Tinned Wires
mm²	mm	ohm/km	ohm/km
0·5	0·21	39·0	40·1
0·75	0·21	26·0	26·7
1	0·21	19·5	20·0
1·5	0·26	13·3	13·7
2·5	0·26	7·98	8·21
4	0·31	4·95	5·09
6	0·31	3·30	3·39
10	0·41	1·91	1·95
16	0·41	1·21	1·24
25	0·41	0·780	0·795
35	0·41	0·554	0·565
50	0·41	0·386	0·393
70	0·51	0·272	0·277
95	0·51	0·206	0·210
120	0·51	0·161	0·164
150	0·51	0·129	0·132
185	0·51	0·106	0·108
240	0·51	0·080 1	0·081 7
300	0·51	0·064 1	0·065 4
400	0·51	0·048 6	0·049 5
500	0·61	0·038 4	0·039 1
630	0·61	0·028 7	0·029 2

TABLE 4 FLEXIBLE COPPER CONDUCTORS FOR SINGLE-CORE AND MULTI-CORE CABLES, CLASS 6

(*Clauses* 5.4.3 *and* 6.3.1)

Nominal Cross-Sectional Area	Maximum Diameter of Wires in Conductor	Maximum Resistance of Conductor at 20°C	
		Plain Wires	Tinned Wires
mm^2	mm	ohm/km	ohm/km
0·5	0·16	39·0	40·1
0·75	0·16	26·0	26·7
1	0·16	19·5	20·0
1·5	0·16	13·3	13·7
2·5	0·16	7·98	8·21
4	0·16	4·95	5·09
6	0·21	3·30	3·39
10	0·21	1·91	1·95
16	0·21	1·21	1·24
25	0·21	0·780	0·795
35	0·21	0·554	0·565
50	0·31	0·386	0·393
70	0·31	0·272	0·277
95	0·31	0·206	0·210
120	0·31	0·161	0 164
150	0·31	0·129	0·132
185	0·41	0·106	0·108
240	0·41	0·080 1	0·081 7
300	0 41	0 064 1	0·065 4

TABLE 5 FLEXIBLE ALUMINIUM CONDUCTORS FOR WELDING CABLES

(*Clauses* 5.5.3 *and* 6.3.1)

Nominal Cross-Sectional Area	Maximum Diameter of Wires in Conductor	Maximum Resistance of Conductor at 20°C
mm^2	mm	ohm/km
25	0·31	1·23
35	0·31	0·901
50	0·31	0·634
70	0·31	0·445
95	0·31	0·334
120	0·31	0·256

TABLE 6 TEMPERATURE CORRECTION FACTORS k_t FOR CONDUCTOR RESISTANCE TO CORRECT THE MEASURED RESISTANCE AT t°C TO 20°C

(*Clause* 6.3)

TEMPERATURE OF CONDUCTOR AT TIME OF MEASUREMENT t°C	CORRECTION FACTOR k_t	TEMPERATURE OF CONDUCTOR AT TIME OF MEASUREMENT t°C	CORRECTION FACTOR k_t
5	1·064	28	0·969
6	1·059	29	0·965
7	1·055	30	0·962
8	1·050	31	0·958
9	1·046	32	0·954
10	1·042	33	0·951
11	1·037	34	0·947
12	1·033	35	0·943
13	1·029	36	0·940
14	1·025	37	0·936
15	1·020	38	0·933
16	1·016	39	0·929
17	1·012	40	0·926
18	1·008	41	0.923
19	1·004	42	0·919
20	1·000	43	0·916
21	0·996	44	0·912
22	0·992	45	0·909
23	0·988	46	0·906
24	0·984	47	0·903
25	0·980	48	0·899
26	0·977	49	0·896
27	0·973	50	0·893

k_t is based on resistance-temperature co-efficient of 0·004 per °C at 20°C using following formula :

$$k_t = \frac{1}{1 + 0{\cdot}004\,(t - 20)} = \frac{250}{230 + t}$$

(*Continued from page* 2)

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Plot No. 62-63, Unit VI, Ganga Nagar, BHUBANESHWAR 751001	40 36 27
Kalaikathir Buildings, 670 Avinashi Road, COIMBATORE 641037	21 01 41
Plot No. 43, Sector 16 A, Mathura Road, FARIDABAD 121001	8-28 88 01
Savitri Complex, 116 G.T. Road, GHAZIABAD 201001	8-71 19 96
53/5 Ward No.29, R.G. Barua Road, 5th By-lane, GUWAHATI 781003	54 11 37
5-8-56C, L.N. Gupta Marg, Nampally Station Road, HYDERABAD 500001	20 10 83
E-52, Chitaranjan Marg, C-Scheme, JAIPUR 302001	37 29 25
117/418 B, Sarvodaya Nagar, KANPUR 208005	21 68 76
Seth Bhawan, 2nd Floor, Behind Leela Cinema, Naval Kishore Road, LUCKNOW 226001	23 89 23
NIT BUilding, Second Floor, Gokulpat Market, NAGPUR 440010	52 51 71
Patliputra Industrial Estate, PATNA 800013	26 23 05
Institution of Engineers (India) Building 1332 Shivaji Nagar, PUNE 411005	32 36 35
T.C. No. 14/1421, University P. O. Palayam, THIRUVANANTHAPURAM 695034	6 21 17

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