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Draft IS 7098 (Part 1)

क्रॉसलिंक्ड पॉलिएथिलीन इंसुलेटेड के लिए विशिष्टता थर्मोप्लास्टिक शीटेड केबल

भाग 1
1100 वोल्ट तक और इसमें शामिल कार्यशील वोल्टेज के लिए

(दूसरा पुनरीक्षण)

SPECIFICATION FOR CROSSLINKED POLYETHYLENE INSULATED THERMOPLASTIC SHEATHED CABLES

PART 1 FOR WORKING VOLTAGES UP TO AND INCLUDING 1100 VOLTS

(Second Revision)

ICS 29.060.20

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Draft Indian Standard

Specification for cross-linked polyethylene insulated thermoplastic sheathed cables
Part 1 for working voltages up to and including 1 100 volts
(*Second Revision*)

(ICS 29.060.20)

Power Cables Sectional Committee, ETD 09	Last Date for Comments- 06.01.2024

FOREWORD

This Indian Standard Part 1 (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Power Cables Sectional Committee had been approved by the Electrotechnical Division Council.

This standard was first published in 1977 and was subsequently revised in 1988. This revision has been undertaken to align it with the international practices and to take into account the experience gained during this period in the manufacture of these types of cable in the country.

IS 16269:2018 "Recommended Short Circuit Rating of Electric Cables from 1.1 kV to 220 kV-Specification" shall be referred for short circuit ratings of cables covered in this standards.

IS 3961 (Part 6):2016 "Recommended Current Rating of Cables-Crosslinked Polyethylene insulated & PVC sheathed cables" shall be referred for the continuous current ratings of cables covered in this standard.

A special category of cables with improved fire performance has been included in this standard. Classification of such cables is given in Appendix A.

In the preparation of this standard, assistance has been derived from IEC 60502-1:2021 'Power cables with extruded insulation and their accessories for rated voltages from 1 kV and 3 kV' issued by the International Electrotechnical Commission.

Attention is drawn to the fact that cables with Category C3 (*see* **Appendix A**), which are sheathed with low smoke & halogen free (LSHF) compound are mechanically not comparable with other categories of cables. Such cables should be handled and installed with sufficient protection against adverse environmental factors such as mechanical damage, exposure to excessive heat, exposure to corrosive substances or solvents, exposure to UV radiations and not intended for outdoor installation.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the results of a test, shall be rounded off in accordance with IS 2:2022 'Rules for rounding off numerical values (*Second Revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Draft Indian Standard

SPECIFICATION FOR CROSS-LINKED POLYETHYLENE INSULATED THERMOPLASTIC SHEATHED CABLES

PART 1 FOR WORKING VOLTAGES UP TO AND INCLUDING 1100 VOLTS

(*Second Revision*)

SECTION 1 GENERAL

1. SCOPE

1.1 This standard (Part 1) covers the requirements for both armoured and unarmoured single, twin, three, four and multi core cross-linked polyethylene (XLPE) insulated and thermoplastic sheathed cables for electric supply and control purposes.

1.2 The cables covered under this standard are suitable for use on ac single phase or three phase (earthed or unearthed) systems for rated voltages up to and including 1 100 V. Theses cables may be used on dc systems for rated voltages up to and including 1 500 V.

NOTE— The cables conforming to this standard may be operated continuously at a power frequency voltage 10 percent higher than rated voltage.

1.3 Armoured cables specified in this standard are suitable for use in mines also. However, for such cables, additional requirements have been included wherever necessary (**4.1.1, 14.5** and **18.2**).

1.4 These cables are suitable for use where the combination of ambient temperature and temperature rise due to load results in conductor temperature not exceeding 90°C under normal operation and 250°C under short-circuit condition.

1.5 This standard also covers cables with improved fire performance, categories C1, C2 and C3, as given in Appendix A. For such cables additional requirements have been included wherever necessary (**8.2, 8.4, 16.1, 16.2** and **18.2.1**).

NOTE— Cables with PVC outer sheath in this standard can be classified as meeting the requirement of Category 01.

2. REFERENCES

The standards listed below contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed.

IS No.	*Title*
IS 1885 (Part 32) : 2019	Electrotechnical Vocabulary Part 32 Electric Cables (*Second Revision*)
IS 5831:1984	Specification for PVC insulation and sheath of electric cables (*First Revision*)
IS 8130:2013	Conductors for insulated electric cables and flexible cords - Specification (*Second Revision*)
IS 3975:1999	Low carbon galvanized steel wires, formed wires and tapes for armouring of cables - Specification (*Third Revision*)
IS 10810-	Methods of test for cables
(Part 1):1984	Methods of test for cables: Part 1 annealing test for wires used as conductors
(Part 2):1984	Methods of test for cables: Part 2 tensile test for aluminium wires
(Part 3):1984	Methods of test for cables: Part 3 wrapping test - For aluminium wires
(Part 5):1984	Methods of test for cables: Part 5 conductor resistance test
(Part 6):1984	Methods of test for cables: Part 6 thickness of thermoplastic and elastomeric insulation and sheath
(Part 7):1984	Methods of test for cables: Part 7 tensile strength and elongation at break of thermoplastic and elastomeric insulation and sheath
(Part 10):1984	Methods of test for cables: Part 10 loss of mass test
(Part 11):1984	Methods of test for cables: Part 11 thermal ageing in air
(Part 12):1984	Methods of test for cables: Part 12 shrinkage test
(Part 14):1984	Methods of test for cables: Part 14 heat shock test
(Part 15):1984	Methods of test for cables: Part 15 hot deformation test
(Part 21):1984	Methods of test for cables: Part 21 cold impact test
(Part 30):1984	Methods of test for cables: Part 30 hot set test
(Part 32):1984	Methods of test for cables: Part 32 carbon content test for polyethylene
(Part 36):1984	Methods of test for cables: Part 36 dimensions of armouring material
(Part 37):1984	Methods of test for cables: Part 37 tensile strength and elongation at break of armouring materials
(Part 45):1984	Methods of test for cables:Part 45 high voltage test
(Part 58):1998	Method of tests for cables:Part 58 oxygen index test
(Part 53):1984	Methods of test for cables: Part 53 flammability test
(Part 59):1988	Part 59 determination of the amount of halogen acid gas evolved during combustion of polymeric materials taken from cables
(Part 60):1988	Methods of test for cables: Part 60 thermal stability of PVC insulation and sheath
(Part 62):1993	Method of tests for cables: Part 62 flame retardance test for bunched cables
(Part 63):1993	Method of tests for cables: Part 63 measurement of smoke density of electric cables under fire conditions
(Part 64):2003	Methods of test for cables: Part 64 measurement of temperature index
IS 13360 (Part 6/Sec 9): 2001	Plastics - Methods of testing: Part 6 thermal properties section 9 determination of density of smoke from the burning or decomposition of plastics
IS 16269:2018	Recommended Short Circuit Ratings of Electric Cables with Rated Voltage from 1.1 kV to 220 kV — Specification
IS 3961 (Part 6):2016	Recommended Current Ratings for Cables Part 6 Crosslinked Polyethylene Insulated PVC Sheathed Cables

IS 10462 (Part 1):1983	Fictitious calculation method for determination of dimensions of protective coverings of cables: Part 1 elastomeric and thermoplastic insulated cables

3. TERMINOLOGY

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

3.1 Routine Test -Tests made by manufacturer on all the finished cable lengths to demonstrate integrity of the cable.

3.2 Type Test -Tests required to be made before supply on a general commercial basis on a type of cable in order to demonstrate satisfactory performance characteristics to meet the intended application.

NOTES

1. These tests are of such a nature that after they have been made, they need not be repeated unless changes are made in the cable materials or design which might change the performance characteristics.

2. When type tests have been successfully performed on a type of cable covered by this standard with a specific conductor cross sectional area, type approval shall be accepted as valid for cables of the same type with other conductor cross sectional area provided following conditions are satisfied:

a) The same material of insulation (ie, XLPE) and manufacturing process are used,
b) The conductor cross-sectional area is not larger than that of the tested cable.

Approval shall be independent of the conductor material.

3.3 Acceptance Tests- Tests carried out on samples taken from a lot for the purpose of acceptance of the lot.

3.4 Optional Tests- Special tests to be carried out, when required, by agreement between purchaser and supplier.

3.5 Earthed System- An electric system which fulfils any of the following conditions:

a) The neutral-point or the mid-point connection is earthed in such a manner that, even under fault conditions the maximum voltage that can occur between any conductor and the earth does not exceed 80 percent of the nominal system voltage;

b) The neutral-point or the mid-point connection is not earthed but a protective device is installed which automatically cuts out any part of the system which accidently becomes earthed: or

c) In case of ac systems only, the neutral point is earthed through an arc suppression coil with arrangement for isolation within 1 h of occurrence of the fault for the non-radial field cables and within 8 h for radial cables provided that the total of such periods in a year does not exceed 125 h.

3.6 Unearthed system- An electric system which does not fulfill requirement of earthed system (*see* **3.5**)

SECTION 2 MATERIALS

4. CONDUCTOR

4.1 The conductors shall be composed of plain copper or aluminium wires complying with IS 8130.

4.1.1 Mining cables to be used in gassy mines shall be of copper conductor only.

NOTE—As agreed between purchaser and supplier, copper conductors can be tinned.

5. INSULATION

5.1 The insulation shall be of cross-linked polyethylene (XLPE) conforming to the requirements given in **Table 1**.

Table 1 Properties of XLPE Insulation

(Clause 5.1*)*

Sl No	Property	Requirement
(1)	(2)	(3)
i)	Tensile Strength	12.5 N/mm^2(Min)
ii)	Elongation at break	200 % (Min)
iii)	Ageing in air oven a) Treatment: -Temperature -Duration b) Tensile strength variation c) Elongation at break	 135 $\pm$ 3ºC 7 days $\pm$ 25 % (Max) $\pm$ 25 % (Max)
iv)	Hot set a) Treatment: -Temperature -Time under load -Mechanical Stress b) Elongation under load c) Permanent elongation after cooling	 200 $\pm$ 3ºC 15 Minutes 20 N/cm^2 175 % (Max) 15 % (Max)
v)	Shrinkage a) Treatment:	

	-Temperature -Duration b) Shrinkage	130 ± 3ºC 1 h 4.0 % (Max)
vi)	Water absorption (gravimetric) a) Treatment: -Temperature -Duration b) Water absorbed	 85 ± 2ºC 14 days 1 mg/cm^2 (Max)
vii)	Volume resistivity: a) at 27^{0}C b) at 90^{0}C	 1x10^{14} ohm-cm (Min) 1x10^{12} ohm-cm (Min)

6. FILLER AND INNER SHEATH

6.1 The fillers and inner sheath shall be of the following:

a) Vulcanized or unvulcanized rubber, or
b) Thermoplastic materials

6.2 The vulcanized or unvulcanized rubber or thermoplastic materials used for inner sheath shall not be harder than insulation and outer sheath respectively. Fillers and inner sheath materials shall be so chosen as to be compatible with the temperature ratings of the cable and shall have no deleterious effect on any other component of the cable.

6.3 Materials used for fillers and inner sheath in case of LSHF cables shall be halogen free and comply with v) of **Table 1B**.

7. ARMOURING

7.1 Armouring shall be of the following:

a) Galvanised round steel wire, or
b) Galvanised formed steel wire (strip), or
c) Any metallic non-magnetic wire / strip

7.2 The galvanised round steel wires / formed steel wires shall comply with requirements of IS 3975 and clause 14.6.

The requirement of non-magnetic materials shall be as agreed between purchaser and supplier.

NOTE—Steel wires/strips in this document are galvanised round steel wires / galvanised formed steel wires, unless otherwise mentioned.

8. OUTER SHEATH

8.1 The outer sheath shall be of polyvinyl chloride (PVC) compound or thermoplastic polyethylene (PE) compound or thermoplastic Low Smoke & Halogen Free (LSHF) compound.

8.2 The PVC compound shall conform to Type ST2 of IS 5831.

NOTE—For Category C1 & C2, PVC type ST2, with suitable additives is to be used to meet requirements of **16.1** & **16.2**.

8.3 The PE compound shall conform to **Table 1A**.

8.4 The LSHF compound shall conform to **Table 1B**.

Table 1A Properties of PE sheathing compound
(Clause 8.3*)*

Sl No	**Properties**	**Requirement**
(1)	(2)	(3)
i)	Without aging a) Tensile Strength b) Elongation at break	 12.5 N/mm^2 (Min) 300 % (Min)
ii)	Ageing in air oven: a) Treatment -Temperature -Duration b) Elongation at break	 110$\pm$2^{0}C 7 days 300 % (Min)
iii)	Hot Deformation Test -Temperature -Duration -Depth of Indentation	 110 $\pm$2^{0}C 6 hours 50 % (Max)
iv)	Carbon black content (For Black sheath only)	2.5 $\pm$ 0.5%

Table 1B Properties of LSHF sheathing compound
(Clause 6.3, 8.4*)*

Sl No		**Type ST8** *	**Type ST12** *
	Properties	**Requirement**	**Requirement**
(1)	(2)	(3)	(4)
i)	Before aging - Tensile Strength - Elongation at break	 9.0 N /mm^2 (Min) 125 % (Min)	 12.5 N /mm^2 (Min) 300 % (Min)

ii)	After ageing in air oven - Temperature - Duration - Tensile Strength - Variation of Tensile Strength - Elongation at break - Variation of Elongation	 100 ± 2 ^{0}C 7 days 9.0 N /mm^2 (Min) ± 40 % (Max) 100 % (Min) ± 40 % (Max)	 110 ± 2 ^{0}C 10 days 10.0 N /mm^2 (Min) ± 30 % (Max) 300 % (Min) -
iii)	Hot Deformation Test - Temperature -Duration -Depth of Indentation	 80 ±2^{0}C 4 hours 50 % (Max)	 110 ±2^{0}C 4 hours 50 % (Max)
iv)	Water absorption (Gravimetric method) -Temperature -Duration - Increase in mass	 70±2^{0}C 24 hours 10 mg/cm^2 (Max)	 Not applicable
v)	- pH - Conductivity - HCL	4.3 (Min) 10 µS/mm (Max) 0.5% (Max)	4.3 (Min) 10 µS/mm (Max) 0.5% (Max)
vi)	- Cold bend Test -Temperature -Duration	No cracks -15 ±2^{0}C 3 hours	No cracks -15 ±2^{0}C 3 hours
	- Cold elongation -Temperature -Duration	20% (Min) -15 ±2^{0}C 3 hours	20% (Min) -15 ±2^{0}C 3 hours
	- Cold Impact test - Temperature - Duration	No cracks -15 ±2^{0}C 3 hours	No cracks -15 ±2^{0}C 3 hours
vii)	Shrinkage Test -Temperature -Duration -No. of cycles -Shrinkage	Not applicable	 80 ±2^{0}C 5 hours 5 cycles 3% (Max)

NOTE— Type ST12 is mechanically superior and also meets requirements of Type ST8.

SECTION 3 CONSTRUCTION

9. CONDUCTOR

9.1 The construction of the conductor shall be as follows:

Nominal Cross section		**Solid/ Stranded**	**Flexibility class (ref IS 8130)**
Copper mm^2	**Aluminium mm^2**		
(1)	(2)	(3)	(4)
-	1.5	Solid	1
1.5-6	2.5-10	Solid/ Stranded	1 for solid 2 for stranded
10 and above	16 and above	Stranded	2

9.2 A protective barrier may be applied between the conductor and insulation. Such barriers, when used shall be compatible with insulating material and suitable for the operating temperature of the cable.

9.3 Cables with reduced neutral conductor shall have sizes as given in **Table 2**.

TABLE 2 CROSS SECTIONAL AREA OF REDUCED NEUTRAL CONDUCTORS

Nominal Cross Sectional Area of main conductor	**Cross Sectional Area of Reduced Neutral Conductor**
mm^2	**mm^2**
(1)	(2)
25	16
35	16
50	25
70	35
95	50
120	70
150	70
185	95
240	120
300	150
400	185
500	240
630	300

10. INSULATION

10.1 The conductor (with protective barrier wherever applied) shall be provided with cross-linked Polyethylene (XLPE) applied by extrusion.

10.2 The average thickness of insulation shall be not less than the nominal value (t_i) specified in **Table 3**.

TABLE 3 THICKNESS OF INSULATION
(Clauses 10.2 & 10.3*)*

Nominal Area of conductor	Nominal thickness of Insulation (t_i)	
	Single core armoured cables	Single core armoured and Multi-core cables
mm^2	mm	mm
(1)	(2)	(3)
1.5	1.0	0.7
2.5	1.0	0.7
4	1.0	0.7
6	1.0	0.7
10	1.0	0.7
16	1.0	0.7
25	1.2	0.9
35	1.2	0.9
50	1.3	1.0
70	1.4	1.1
95	1.4	1.1
120	1.5	1.2
150	1.7	1.4
185	1.9	1.6
240	2.0	1.7
300	2.1	1.8
400	2.4	2.0
500	2.6	2.2
630	2.8	2.4
800	3.1	2.6
1000	3.3	2.8

10.3 Tolerance on Thickness of Insulation-The smallest of the measured values of thickness of insulation shall not fall below the nominal value (t_i) specified in **Table 3** by more than 0.1+0.1 t_i.

10.4 Application of Insulation: The insulation shall also be applied that it fits closely on the conductor (or barrier if any) and it shall be possible to remove it without damaging the conductor.

11. CORE IDENTIFICATION

11.1 Cores shall be identified as specified below:

a) Coloured strip applied on the core (*see* NOTE 1), or
b) Colouring of XLPE Insulation as follows:

1 Core : Red, black, yellow, blue or natural;
2 Core : Red & black;
3 Core : Red, yellow & blue;
4 Core : Red, yellow, blue & black;
5 Core : Red, yellow, blue, black & grey;
6 Core and above : Two adjacent cores (counting and direction core) in each layer, blue and yellow, remaining cores, grey; or

c) By numerals either by applying numbered strips or by printing on the cores as follows *(see* NOTE 2):
2 Core : 0 & 1
3 Core : 0,1 & 2
4 Core core : 0,1,2 & 3

NOTES
1. For identification by using coloured strips red, yellow and blue colours shall be used to identify the phase conductors, and black to identify reduced neutral conductor.

2. Identification by numerals is applicable up to 4 core cables. For control cables, numerals 0 & 1 shall be adopted for counting core and direction core respectively; remaining cores shall not be numbered.

11.2 For reduced neutral conductors, the core shall be black.

11.3 For cables having more than 4 cores, as an alternative to the provision of **11.1** the core identification may be done by numbers. In that case, the insulation of cores shall be of the same colour and numbered sequentially, starting by number 1 in the inner layer. The numbers shall be printed in Hindu-Arabic numerals on the outer surface of the cores. All the numbers shall be of same colour, which shall be contrast with the colour of the insulation. The numerals shall be legible.

11.4 For reduced neutral conductors, the core shall have '0' number.

NOTE— Specific core identification if any, shall be as agreed between purchaser and supplier.

12. LAYING UP OF CORES

12.1 In twin, three and multicore cables, the cores shall be laid up together with a suitable lay, the outermost layer shall have right-hand lay and the successive layers shall be laid with opposite lay. Where necessary, the interstices shall be filled with non-hygroscopic material.

12.2 The recommended plan for lay-up of multi-cores up to 100 shall be in accordance with **Table 4**.

TABLE 4 LAY UP OF CORES FOR CABLES
(*Clause* 12.2)

No of cores	Lay-up	No of cores	Lay-up	No of cores	Lay-up

(1)	(2)	(3)	(4)	(5)	(6)
2	2	35	5-12-18	67	2-8-13-19-25
3	3	36	0-6-12-18	68	2-8-14-19-25
4	4	37	0-6-12-18	69	2-8-14-20-25
5	5	38	1-6-12-19	70	2-8-14-20-26
6	6	39	1-6-13-19	71	2-8-14-20-27
7	1-6	40	1-7-13-19	72	2-8-14-21-27
8	1-7	41	1-7-13-20	73	3-9-15-20-26
9	1-8	42	2-8-13-19	74	3-9-15-21-26
10	2-8	43	2-8-14-19	75	3-9-15-21-27
11	3-8	44	2-8-14-20	76	3-9-15-21-28
12	3-9	45	2-8-14-21	77	3-9-15-22-28
13	3-10	46	3-9-14-20	78	4-10-15-21-28
14	4-10	47	3-9-15-20	79	4-10-16-22-27
15	5-10	48	3-9-15-21	81	4-10-16-22-29
16	5-11	49	3-9-15-22	82	4-10-16-23-29
17	5-12	50	3-9-16-22	83	4-10-17-23-29
18	0-6-12	51	4-10-16-21	84	5-11-17-23-28
19	1-6-12	52	4-10-16-22	85	5-11-17-23-29
20	1-7-12	53	4-10-16-23	86	5-11-17-23-30
21	1-7-13	54	4-10-17-23	87	5-11-17-24-30
22	2-7-13	55	4-11-17-23	88	5-11-18-24-30
23	2-7-13	56	5-11-17-23	89	0-6-11-18-24-30
24	2-8-14	57	5-11-17-24	90	0-6-12-18-24-30
25	2-8-15	58	5-11-18-24	91	1-6-12-18-24-30
26	3-9-14	59	5-12-18-24	92	1-6-12-18-24-31
27	3-9-15	60	0-6-12-18-24	93	1-6-12-18-25-31
28	3-9-16	61	1-6-12-18-24	94	1-6-12-19-25-31
29	4-10-15	62	1-6-12-18-24	95	1-6-13-19-25-31
30	4-10-16	63	1-7-12-18-25	96	1-7-13-19-25-31
31	4-10-17	64	1-7-13-18-25	97	1-7-13-19-26-31
32	5-11-16	65	1-7-13-19-25	98	2-8-13-19-25-31
33	5-11-17	66	1-7-13-19-26	99	2-8-14-19-25-31
34	5-11-18			100	2-8-14-20-25-31

NOTES

1. Figures indicate the number of cores in each successive layer; for example, 5-11-18 means, 5 cores in first, 11 cores in second and 18 cores in the third layer etc.
2. This table is for guidance only.
3. Assembly co-efficient are as per IS 10462 (Part 1). In case of number of cores above 48, the assembly co-efficient (not available in IS 10462 (Part 1) shall be as agreed between purchaser and supplier.

13. INNER SHEATH (COMMON COVERING)

13.1 The laid-up cores shall be provided with an inner sheath applied either by extrusion or by wrapping. It shall be ensured that it is as circular as possible.

13.2 The inner sheath shall be so applied that it fits closely on the laid-up cores and it shall be possible to remove it without damage to the insulation.

13.3 Thickness of Inner sheath-The thickness of inner sheath (common covering) shall be as given in **Table 5**. Single core cables shall have no inner sheath.

Table 5 Thickness of Inner Sheath

(*Clause* 13.3)

Calculated diameter over laid-up cores [Ref IS 10462 (Part 1)]		**Thickness of Inner sheath (Min)**
Over	Up to and including	
mm	mm	mm
(1)	(2)	(3)
-	25	0.3
25	35	0.4
35	45	0.5
45	55	0.6
55	-	0.7

13.3.1 When one or more layers of proofed or plastic tape are applied over the laid-up cores as a binder, the thickness of such tapes shall not be construed as part of extruded inner sheath.

14. ARMOURING

14.1 Application

14.1.1 Armouring shall be applied over the insulation in case of single core cables and over the inner sheath in case of twin, three and multi core cables.

14.1.2 The armour round wires/formed wires shall be applied as closely as practicable with a coverage of not less than 90%. The coverage of armour shall be done as per **Appendix C**.

14.1.3 The direction for lay of the armour shall be left hand. For double round wire / formed wire armoured cables, this requirement shall apply to the inner layer of round wires/formed wires. The outer layer shall, except in special cases, be applied in the reverse direction to the inner layer, and there shall be a separator of suitable non-hygroscopic material such as plastic tape, bituminised cotton tape, bituminized hessian tape, rubber tape or proofed tape between the inner and outer layers of armour wires.

14.1.4 A binder tape may be provided on the armour.

14.2 Type of armour- Where the calculated diameter below armouring does not exceed 13 mm, the armour shall consist of round wires.

Where the calculated diameter below armouring is greater than 13 mm, the armour shall consist of either round steel wires / formed wires.

NOTE— It may be desirable for single core cables intended for use on ac systems to be armoured with non-magnetic material. In such cases, special agreement shall be made between purchaser and supplier.

14.3 Dimensions- The dimensions of round wires or formed wires shall be as specified in **Table 6**. The tolerance on nominal dimensions shall be as per IS 3975. However, for formed wires compliance shall be ensured only for dimensions 'A' & 'C'.

Table 6 Diameter of armour wires
(Clause 14.3*)*

Calculated diameter under Armour [Ref IS 10462 (Part 1)]		**Nominal Thickness of formed wires**	**Nominal Diameter of round wires**
mm	mm	mm	mm
Over	Up to and including		
(1)	(2)	(3)	(4)
Method A:			
For all diameters in excess of 13		0.8	-
Method B:			
-	13	-	1.4
13	25	0.8	1.6
25	40	0.8	2.0
40	55	1.4	2.50
55	70	1.4	3.15
70	-	1.4	4.00

NOTE—Method A & Method B indicate two methods of practice in the application of armouring.

14.4 Joints- The joints in armour wires shall be made by brazing or welding and the surface irregularities shall be removed. A joint in any wire/strip shall be at least 300 mm from the nearest joint in any other armour wire/strip in the completed cable.

14.5 Resistance

14.5.1 If specified by the purchaser, the dc resistance of armour shall be measured. The result when corrected to 20°C shall comply with the value declared by the supplier.

14.5.2 In case of cables for use in mines, the resistance of armour shall not exceed that of the conductor as specified in IS 8130 by more than 33%. To satisfy this, substitution of round steel wires / formed steel wires in armouring by required number of tinned copper wires/strips is permissible.

14.6 The round steel wires / formed steel wires taken from the cable shall meet the following requirements.

a) The tensile strength of rounds steel wire / formed steel wire shall be not less than 250 N/mm^2 and not more 580 N/mm^2.
b) The elongation at break of round steel wire / formed steel wire shall be not less than 6 percent.
c) Round steel wire shall meet the requirements of torsion test. The gauge length between vices and the minimum number of turns without break shall be as per **Table 6** of IS 3975.
d) The zinc coating shall not show any cracks and shall not flake off on robbing by the bare finger when the formed steel wire is subjected to winding test.

e) The uniformity of zinc coating of round steel wire / formed steel wire shall comply with the requirements of IS 3975 subject to the following:
-The minimum number of dips shall be reduced by one half-minute dip.
-In case of formed wires dip test is applicable only for the face.

f) The mass of zinc coating of round steel wire shall be not less than 95 percent of the mass specified in **Table 2** of IS 4826:1979.
The mass of zinc coating of formed steel wire shall be not less than 95 percent of the mass specified in IS 3975.
g) The resistivity of the round steel wire / formed steel wire shall meet the requirements of IS 3975.

15. OUTER SHEATH

15.1 The outer sheath shall be applied by extrusion. It shall be applied:

a) over the insulation in case of unarmoured single core cables;
b) Over the inner sheath in case of unarmoured twin, three and multicore cables; and
c) Over armouring in case of armoured cables.

15.2 The colour of outer sheath shall be black or any other colour as agreed to between purchaser and supplier.

15.3 Thickness of Outer Sheath

15.3.1 *Unarmoured cables*—The average thickness of outer sheath of unarmoured cables shall not be less than the nominal value specified under col 3 of **Table 7** and the smallest of the measured values shall not be less than the minimum value specified in col 4 of **table 7**.

NOTE—In case of multi-core unarmoured cables, it is permissible to apply the inner and outer sheath in a single extrusion out of the material intended for the outer sheath. The thickness of such extruded sheath shall not be less than sum of the inner sheath thickness specified in **Table 5** and the nominal outer sheath thickness specified in col 3 of **Table 7** and the smallest of the measured values shall not be less than the sum of inner sheath thickness specified in **Table 5** and the minimum value of the outer sheath thickness specified in col 4 of **Table 7**.

15.3.2 *Armoured cables*—The thickness of outer sheath shall not be less than the minimum values specified in col 5 of **Table 7**.

Table 7 Thickness of Outer Sheath
(Clause 15.3.1 & 15.3.2*)*

Calculated diameter under outer sheath [Ref IS 10462 (Part 1)]		**Thickness of outer sheath for Un-armoured cables**		**Minimum thickness of Outer sheath for Armoured cables**
Over	Up to and including	Nominal	Minimum	
(1)	(2)	(3)	(4)	(5)
mm	mm	mm	mm	mm
-	15	1.8	1.24	1.24
15	25	2.0	1.40	1.40
25	35	2.2	1.56	1.56
35	40	2.4	1.72	1.72
40	45	2.6	1.88	1.88
45	50	2.8	2.04	2.04
50	55	3.0	2.20	2.20
55	60	3.2	2.36	2.36
60	65	3.4	2.52	2.52
65	70	3.6	2.68	2.68
70	75	3.8	2.84	2.84
75	85	4.0	3.00	3.00

SECTION 4 TESTS

16. Classification of Tests

16.1 Type Tests: The following shall constitute type test:

	Test	**Ref of Requirements**	**Ref of Test Method of IS 10810**
a	Test on conductor		
	i) Annealing test (for copper)	IS 8130	1
	ii) Tensile Test (for aluminium)	IS 8130	2

	iii) Wrapping Test (for aluminium)	IS 8130	3
	iv) Resistance Test	IS 8130	5
b	Test for round steel wire / formed steel wire armour		
	1) Dimensions	14.3	36
	2) Physical tests on round wires / formed wires		
	i) Tensile strength	14.6 (a)	37
	ii) Elongation at break	14.6 (b)	37
	iii) Torsion test for round wires	14.6 (c)	38
	iv) Winding test for formed wires	14.6 (d)	39
	v) Uniformity of zinc coating	14.6 (e)	40
	vi) Mass of zinc coating	14.6 (f)	41
	vii) Resistivity	14.6 (g)	42
c)	Test for thickness of insulation and sheath	10,13 and 15, Tables 3,5 and 7	6
d)	Physical tests for insulation		
	i) Tensile strength & Elongation at break	Table 1	7
	ii) Ageing in air oven	Table 1	11
	iii) Hot set test	Table 1	30
	iv) Shrinkage Test	Table 1	12
	v) Water absorption (gravimetric)	Table 1	33
e)	Physical tests for outer sheath		
	1) **PVC Sheath**		
	i) Tensile strength & Elongation at break	IS 5831	7
	ii) Ageing in air oven	IS 5831	11
	iii) Loss of mass in air oven	IS 5831	10
	iv) Shrinkage test	IS 5831	12
	v) Hot deformation test	IS 5831	15
	vi) Heat shock test	IS 5831	14
	vii) Thermal stability	IS 5831	60
	2) **PE Sheath**		
	i) Carbon black content	Table 1A	32
	ii) Tensile strength and elongation at break before and after ageing	Table 1A	7
	iii) Hot deformation	Table 1A	15
	iv) Shrinkage test	Table 1A	12
	3) **LSHF Sheath**		
	i) Tensile strength and elongation at break before and after ageing	Table 1B	7

	ii) Hot deformation	Table 1B	15
	iii) Water absorption test (for Type ST8)	Table 1B	33
	iv) Shrinkage test (for Type ST12)	Table 1B	12
f)	Insulation resistance (volume resistivity test)	Table 1	43
g)	High Voltage Test	17.2	45
h)	Flammability Test	17.3	53
i)	Additional tests for cables with improved fire performance, as per categories in Appendix A		
	Category C1		
	a) Oxygen index test	17.4	58
	b) Temperature index test	17.9	64
	c) Flame retardance test on single cable	17.5	61
	d) Flame retardance test on bunched cables	17.6	62
	Category C2		
	a) Oxygen index test	17.4	58
	b) Temperature index test	17.9	64
	c) Flame retardance test on single cable	17.5	61
	d) Flame retardance test on bunched cables	17.6	62
	e) Smoke density test	17.8	IS 13360 (part 6/sec 9)
	f) Test for halogen acid evolution	17.7	59
	Category C3		
	a) Oxygen index test	17.4	58
	b) Temperature index test	17.9	64
	c) Flame retardance test on single cable	17.5	61
	d) Flame retardance test on bunched cables	17.6	62
	e) Smoke density test	17.8	IS 13360 (part 6/sec 9)
	f) Test for halogen acid evolution	17.7	59
	g) Test for light transmission	17.11	63
	h) Test for pH & conductivity	17.10	17.10

16.2 Acceptance Tests - The following tests shall constitute acceptance tests:

	Test	**Ref. of Requirements**	**Ref of Test Method of IS 10810**

a)	Annealing test (for copper)	IS 8130	1
b)	Tensile Test (for aluminium)	IS 8130	2
c)	Wrapping Test (for aluminium)	IS 8130	3
d)	Conductor Resistance Test	IS 8130	5
e)	Test for thickness of insulation and sheath	9,12 and 14, Tables 2,4 and 6	6
f)	Hot set test for insulation	Table 1	30
g)	Tensile strength and elongation at break test for insulation and sheath	Tables 1, 1A, 1B	7
h)	High voltage test	17.2	45
i)	Insulation resistance (volume resistivity test)	Table 1	43
j)	Additional tests for cables with improved fire performance, as per categories in Appendix A		
	Category C1		
	a) Oxygen index test	17.4	58
	b) Flame retardance test on single cable	17.5	61
	c) Flame retardance test on bunched cables	17.6	62
	Category C2		
	a) Oxygen index test	17.4	58
	b) Flame retardance test on single cable	17.5	61
	c) Flame retardance test on bunched cables	17.6	62
	d) Test for halogen acid evolution	17.7	59
	e) Smoke density test	17.8	IS 13360 (part 6/sec 9)
	Category C3		
	a) Oxygen index test	17.4	58
	b) Flame retardance test on single cable	17.5	61
	c) Flame retardance test on bunched cables	17.6	62
	d) Test for halogen acid evolution	17.7	59
	e) Test for light transmission	17.11	63
	f) Test for pH & conductivity	17.10	17.10

16.2.1 A recommended sampling plan for acceptance test is given in **Appendix B**. However, sampling for tests in sl no j) shall be one sample only.

16.3 Routine Tests - The following tests shall constitute Routine test:

	Test	**Ref of Requirements**	**Ref of Test Method of IS 10810**
a)	Conductor resistance test	IS 8130	5
b)	High voltage test	21.17	45
c)	Resistance test for armour (for mining	21.9	42

	cable only)		

16.4 Optional Tests - The following tests shall constitute optional test:

	Test	Ref of Requirements	Ref of Test Method of IS 10810
a)	Cold bend test for outer sheath (OD>12.5mm)	IS 5831 or Table 1B	20
b)	Cold impact test for outer sheath	IS 5831 or Table 1B	21
c)	Cold elongation test for LSHF sheath	Table 1B	7
c)	Resistance test for armour (other than mining cable)	14.5.1	42

17. DETAIL OF TESTS

17.1 General- Unless otherwise stated in this standard the tests shall be carried out in accordance with appropriate parts of IS 10810* taking into account additional information given in this standard.

17.2 High Voltage Test

17.2.1 *High Voltage Test at Room Temperature (Type, Acceptance, Routine Test)*—The cables shall withstand a voltage of 3 kV ac (rms) at a frequency of 40 to 60 Hz or dc voltage of 7.2 kV, between conductors and between conductors and ECC (if any) for a period of 5 minutes for each test connection.

17.3 Flammability Test Period of burning after removal of the flame shall not exceed 60 seconds and the unaffected (uncharred) portion from the lower edge of the top clamp shall be at least 50 mm.

17.4 Oxygen Index Test (FR, FR-LSH or LSHF sheath)- The test on samples of inner/outer sheath shall be done at 27 ± 2˚ C or room temperature. The oxygen index shall not be less than 29.

17.5 Flame Retardance Test on Single Cables (for overall diameter < 35 mm) (FR, FR-LSH or LSHF sheathed cables)- After the test, there should be no visible damages on the test specimen within 300 mm from its upper end. Mark from mixing devices, soot or changing of the colour are not considered damages.

17.6 Flame Retardance Test on Bunched Cables (FR, FR-LSH or LSHF sheathed cables) - After burning has ceased, the cables should be wiped clean and the charred or affected portion should not have reached a height exceeding 2.5 m above the bottom edge of the burner, measured at the front and rear of the cable assembly.

NOTE - Requirements for this test are split in 3 categories that is, A. B, and C as described in IS l0810 (Part 62). For the purpose of this standard, category B and C test methods shall be used. In the absence of any special requirements for method B, method C shall be used for both the categories Cl and C2.

17.7 Test for Halogen Acid Gas Evolution (FR-LSH or LSHF outer sheath)- The level of Hcl evolved shall not exceed 20 percent by weight for FR-LSH outer sheath and shall not exceed 0.5% for LSHF outer sheath.

17.8 Test for Smoke Density (FR-LSH or LSHF sheath)- The Smoke Density Rating shall be 60 maximum for FR-LSH outer sheath and 20 maximum for LSHF outer sheath.

17.9 Test for Temperature Index (FR, FR-LSH or LSHF sheath)- The extrapolated values of temperature at which Oxygen Index is 21 shall be minimum 250°C.

17.10 pH & conductivity of LSHF sheath- As per Annex F of IS 17505 (part 1)

17.11 Light transmission for LSHF sheathed cables- Completed cables shall be tested as per IS 10810 (Part 63). Light Transmittance shall be 70% (min)

SECTION 5 IDENTIFICATION, PACKING AND MARKING

18. IDENTIFICATION

18.1 Manufacturer's Identification- The manufacturer shall be identified throughout the length of the cable by means of a tape bearing, the manufacturer's name or trademark, or by manufacturer's name or trade mark being indented, printed or embossed on the cable. In case none of those methods can be employed, or if the purchaser so desires, colour identification threads in accordance with a scheme to be approved by the Bureau of Indian Standards (BIS) shall be employed. The indentation, printing, or embossing shall be done only on the outer sheath.

18.2 Cable identification - In order to distinguish these electric cables from telephone cables the word ‘ELECTRIC’ also shall be indented printed or embossed throughout the length of the cable. In case of cables intended for use in mines the word 'MINING’ also shall be indicated printed or embossed throughout the length of the cable. The indentation printing or embossing shall be done only on the outer sheath.

18.2.1 The following special cables shall be identified by indenting, embossing or printing the appropriate on the outer sheath throughout the cable length, in addition to the existing marking requirements:

Type of Cables	Legend
Improved fire performance for category C1	FR
Improved fire performance for category C2	FR-LSH
Improved fire performance for category C3	LSHF

18.2.2 Single core cables with magnetic armour for DC applications shall be additionally marked as ‘DC Cable’

18.3 Cable Code - The following code shall be used for designating the cable:

Sl No.	Constituent	Code Letter
i)	Aluminium conductor	A
ii)	XLPE insulation	2X
iii)	Steel round wire armour	W
iv)	Non-magnetic round wire armour	Wa
v)	Steel strip armour	F
vi)	Non-magnetic strip armour	Fa
vii)	Double steel strip armour	FF
viii)	Double steel round wire armour	WW
ix)	PVC outer sheath	Y
x)	PE outer sheath	2Y
xi)	LSHF outer sheath	Z

NOTE—No code letter for conductor is required when the conductor material is copper.

19. PACKING AND MARKING

19.1 The cable shall be wound on a drum (*see* IS 10418:1982) and packed. The ends of the cable shall be sealed by means of non-hygroscopic sealing material.

19.2 The cable shall carry the following information either stenciled on the drum or contained in a label attached to it:

a) Reference to this Indian Standard, IS 7098 Part 1;
b) Manufacturer's name or trade-mark;
c) Type of cable and voltage grade;
d) Number of cores;
e) Nominal cross-sectional area of conductor;
f) Cable code;
g) Length of cable on the drum;
h) Number of lengths on the drum (if more than one);
j) Direction of rotation of drum (by means of an arrow);
k) Gross mass:
m) Country of manufacture; and
n) Year of manufacture.

19.2.1 The cable (drum or label) may also be marked with the Standard Mark.

NOTE—The use of the Standard Mark is governed by the provisions of the Bureau of Indian Standards Act 2016 and the Rules and regulations made thereunder. The Standard Mark products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as further safeguard. Details of conditions under which a license for

the use of the Standard mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

APPENDIX A
(*Clause* 1.5)

CLASSIFICATION OF CABLES FOR IMPROVED FIRE PERFORMANCE

Category	Environment Description	Type	Cable Description
01	Cables in open areas	-	Flame Retardant, single self-extinguishing, does not propagate fire
C1	Cables in constrained area	FR	Flame Retardant, single self-extinguishing, does not propagate fire even when installed in groups in vertical ducts
C2	Cables in constrained area with limited human activities and/ or presence of sophisticated system	FR-LSH	Flame Retardant cables with reduced halogen evolution and smoke
C3	Cables in constrained area with limited human activities and/ or presence of sophisticated system, tunnels, airways etc	LSHF	Flame Retardant cables with Zero halogen evolution and low smoke also having adequate light transmission

APPENDIX B
(Clause 16.2.1)

SAMPLING OF CABLES

B-1 LOT

B-1.1 In any consignment the cables or the same size manufactured under essentially similar conditions of production shall be grouped together to constitute a lot.

B-2 SCALE OF SAMPLING

B-2.1 Samples shall be taken and tested from each lot for ascertaining the conformity of the lot to the requirement of the specification.

B-2.2 The number of drums (n) to be selected from the lot of drums (N) of consignment of cables shall be in accordance with col-2 and 1 of **Table 9** respectively. These samples shall be taken at random.

B-2.2.1 In order to ensure the randomness of selection, random number table, shall be used (*see* IS 4905:2015 Methods for random sampling)

B-3 NUMBER OF TESTS AND CRITERION FOR CONFORMITY

B-3.1 Suitable length of test sample shall be taken from each of the drums selected. These test samples shall be subjected to each of the acceptance tests (*see* **16.2**). A test sample is called defective if it fails in any of the acceptance tests. If the number of defectives is less than or equal to the corresponding permissible number (a) given in Col 3 of **Table 9** the lot shall be declared as conforming to the requirements of acceptance tests otherwise not.

TABLE 9 NUMBER OF DRUMS TO BE SELECTED FOR SAMPLING AND PERMISSIBLE NUMBER OF DEFECTIVES

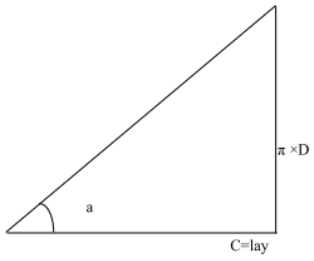
Sl No.	NUMBER OF DRUMS IN THE LOT	NUMBER OF DRUMS TO BE TAKEN AS SAMPLE	PERMISSIBLE NUMBER OF DEFECTIVES
(1)	(2)	(3)	(4)
	(N)	(n)	(a)
i)	Up to 25	3	0
ii)	26 to 50	5	0
iii)	51 to 100	8	0
iv)	101 to 300	13	1
v)	301 to above	20	1
vi)	501 and above	32	2

APPENDIX C
(*Clause* 14.1.2, 16.1)

ARMOUR COVERAGE PERCENTAGE

Percent Coverage = $\frac{N\ x\ d}{w}\ X\ 100$

Where,



N = number of parallel wires,
d = diameter of wire / width of formed wires.
W = π x D x Cos α
D = diameter under armour
α = angle between armouring wire / formed wires and axis of cable.
tan α = π x D/C, and
C = lay length of armouring wires / formed wires.