IS 7098-1 (1988): Crosslinked polyethylene insulated PVC sheathed cables, Part 1: For working voltage upto and including 1 100 V [ETD 9: Power Cables]

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IS : 7098 (Part 1) - 1988
(Reaffirmed 2000)

Indian Standard

SPECIFICATION FOR CROSSLINKED POLYETHYLENE INSULATED PVC SHEATHED CABLES

PART 1 FOR WORKING VOLTAGES UP TO AND INCLUDING 1 100 VOLTS

(First Revision)

Fourth Reprint SEPTEMBER 2003

UDC 621·315·221·8-678·742·2

BUREAU OF INDIAN STANDARDS
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Gr 5

January 1990

AMENDMENT NO. 1 APRIL 1994
TO
IS 7098 (PART 1) : 1988 CROSSLINKED POLYETHYLENE INSULATED PVC SHEATHED CABLES

PART 1 FOR WORKING VOLTAGES UP TO AND INCLUDING 1 100 V

(Second Revision)

(*Title*) — To be changed as follows:

'Indian Standard

CROSS-LINKED POLYETHYLENE INSULATED THERMOPLASTIC SHEATHED CABLES — SPECIFICATION

Part 1 FOR WORKING VOLTAGES UP TO AND INCLUDING 1 100 V'

(*Page* 1, *clause* **0.4**) — Insert the following clause **0.5** after **0.4** and renumber subsequent clauses:

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

(*Page* 1, *clause* **1.4**) — Add new clause **1.5**:

'**1.5** This standard also covers cables with improved fire performance, categories C1 and C2, as given in Appendix A. For such cables additional requirements have been included wherever necessary (*see* **7.2, 15.1.1, 15.2.1** and **17.2.1**).'

NOTE — Normal cables to this standard can be classified as meeting the requirement of category 0.1.'

[*Page* 2, *clause* **6.1** (b)] — Substitute 'formed wire' *for* 'strip'.

(*Page* 3, *clause* **6.2**) — Substitute the following for the first sentence:

'The galvanised steel wires formed wires/tapes shall comply with the requirements of IS 3975 : 1988, except that **3.3.1** and **3.2.2**, shall not apply.'

(*Page* 3, *clause* **7.1**) — Add new clause **7.2:**

'**7.2** For cables with improved fire performance, the outer sheath shall, inaddition, meet the requirement of tests applicable for the required category (**15.1.1 and 15.2.1**).'

(*Page* 7, *clause* **14.3.2**) — Substitute the following for the existing:

'**14.3.2** *Armoured Cables* — The thickness of outer sheath shall be not less than the minimum values specified in col 5 of Table 8.'

(*Page* 7, *clause* **15.1**) — Add clause **15.1.1:**

'**15.1.1** The following shall constitute additional type tests for cables with improved fire performance as per the categories given in Appendix A:

Category	Test	For Requirements Refer	For Test Method Refer Part No. of IS 10810
01	No additional tests		
C1	a) Oxygen index test	16.9	58 (under preparation)
	b) Flame retardance test on single cable	16.10	61
	c) Flame retardance test on bunched cables	16.11	62
	d) Temperature index	16.14	Under consideration
C2	a) Oxygen index test	16.9	58 (Under preparation)
	b) Flame retardance test on single cable	16.10	61
	c) Flame retardance test on bunched cable	16.11	62
	d) Test for specific optical density of smoke	16.12	Under consideration
	e) Smoke density	16.15	63
	f) Test for halogen acid gas evolution	16.13	59
	g) Temperature index	16.14	Under consideration

NOTES:

1. For category C1, tests (a) and (d) are to be performed on samples taken from outer sheath, as applicable, and prepared in the manner given in the relevant test method.

2. For category C2, tests (a), (e), (f) and g) are to be performed on samples taken from outer sheath, as applicable, and prepared in the manner given in the relevant test method.'

(*Page* 8, *clause* **15.2**) — Add clause **15.2.1**:

'**15.2.1** The following shall constitute additional acceptance tests for cable with improved fire performance as per the categories given in Appendix A:

Category	Test
01	No additional tests
C1	a) Oxygen index test
	b) Flame retardance test on single cable
C2	a) Oxygen index test
	b) Flame retardance test on single cable
	c) Test for specific optical density of smoke
	d) Test for halogen acid gas evolution'

(*Page* 8, *clause* **15.2.1**) — Renumber this clause as '**15.2.2**' — Substitute 'Appendix B' *for* 'Appendix A' in second line.

(*Page* 8, *clause* **16.2.1**, *line* 4) — Substitute 'a dc' *for* 'an ac'.

(*Page* 8, *clause* **16.3**) — Add the following clauses:

'**16.9** *Oxygen Index Test*

The test on samples of inner/outer sheath shall be done at 27 ± 2° C. The oxygen index shall not be less than 29.

16.10 *Flame Retardance Test on Single 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.

16.11 *Flame Retardance Test on Single 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 10810 (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 C1 and C2.

16.12 *Test for Specific Optical Density of Smoke*

Under consideration.

16.13 *Test for Halogen Acid Gas Evolution*

The level of HCl evolved shall not exceed 20 percent by weight.

16.14 *Test for Temperature Index*

The measured value of temperature index shall be 21 at a temperature of 250°C .

16.15 Smoke Density Test

Under consideration'.

(*Page* 9, *clause* **17.2.1**) — Substitute the following clause for the existing:

'**17.2.1** 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 performancefor category C2	FR-LSH

(*Page* 10, *Appendix* A) — Insert the following new 'Appendix A' and renumber the existing 'Appendix A' as 'Appendix B':

AMENDMENT NO. 2 FEBRUARY 2007
TO
IS 7098 (PART 1) : 1988 SPECIFICATION FOR CROSSLINKED POLYETHYLENE INSULATED PVC SHEATHED CABLES

PART 1 FOR WORKING VOLTAGES UP TO AND INCLUDING 1 100 V

(First Revision)

[*Page* 7, *clause* **15.1.1**, *col* 4 (*see also Amendment No.* 1)] — Delete 'under preparation' for category C1 and Test (a) under *For Test Method Refer Part No. of IS 10810.*

[*Page* 7, *clause* **15.1.1**, *col* 4 (*see also Amendment No.* 1)] — Substitute '64' *for* 'Under consideration' for category C1 and Test (d) under *For Test Method Refer Part No. of IS 10810.*

[*Page* 7, *clause* **15.1.1**, *col* 4 (*see also Amendment No.* 1)] — Delete 'Under preparation' for category C2 and Test (a) under *For Test Method Refer Part No. of IS 10810.*

[*Page* 7, *clause* **15.1.1**, *col* 4 (*see also Amendment No.* 1)] — Substitute '64' *for* 'Under consideration' for category C2 and Test (g) under *For Test Method Refer Part No. of IS 10810.*

Reprography Unit, BIS, New Delhi, India

AMENDMENT NO. 3 NOVEMBER 2007
TO
IS 7098 (PART 1) : 1988 SPECIFICATION FOR CROSSLINKED POLYETHYLENE INSULATED PVC SHEATHED CABLES

PART 1 FOR WORKING VOLTAGE UP TO AND INCLUDING 1 100 VOLTS

(First Revision)

[*Page* 2, *clause* 6.1(b)] — Substitute 'Galvanized steel formed wire (strip), or' *for* 'Galvanized steel strip, or'.

(*Page* 3, *clause* 6.2, *line* 1) — Substitute the following for the existing matter:

'The galvanized round steel wires/formed steel wires (strips) used for armouring shall conform to IS 3975 : 1999*.'

(*Page* 3, *footnote marked* *) — Substitute the following for the existing:

'*Low carbon galvanized steel wires, formed wires and tapes for armouring of cables – Specification.'

(*Page* 5, *clause* 13.3, *line* 2) — Insert the following at the end:

"The tolerance on nominal dimensions shall be as per IS 3975 : 1999. However, for formed steel wires compliance shall be ensured only for dimensions 'A' & 'C'."

(*Page* 5, *clause* 13.5.2) — Insert the following new clauses after 13.5.2:

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

a) The tensile strength of round 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 : 1999.

d) The zinc coating shall not show any cracks and shall not flake off on rubbing 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 : 1999 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 : 1999.

g) The resistivity of the round steel wire/formed steel wire shall meet the requirements of IS 3975 : 1999.

[*Page* 7, *clause* **15.1**, *Sl No.* (b)] — Substitute the following for the existing matter:

b)	Tests for round steel wire/formed steel wire (strip) armour:		
1)	Dimensions	**13.3** of IS 7098 (Part 1)	Part 36 of IS 10810
2)	Physical tests on round/formed wire:		
	i) Tensile strength	**13.6**(a) of IS 7098 (Part 1)	Part 37 of IS 10810
	ii) Elongation at break	**13.6**(b) of IS 7098 (Part 1)	Part 37 of IS 10810
	iii) Torsion test for round wires	**13.6**(c) of IS 7098 (Part 1)	Part 38 of IS 10810
	iv) Winding test for formed wires	**13.6**(d) of IS 7098 (Part 1)	Part 39 of IS 10810

v) Uniformity of zinc coating	13.6(e) of IS 7098 (Part 1)	Part 40 of IS 10810
vi) Mass of zinc coating	13.6(f) of IS 7098 (Part 1)	Part 41 of IS 10810
vii) Resistivity	13.6(g) of IS 7098 (Part 1)	Part 42 of IS 10810

(*Page* 7, *footnote marked* ‡) — Substitute the following for the existing:

'‡Low carbon galvanized steel wires, formed wires and tapes for armouring of cables — Specification.'

(ET 09)

Reprography Unit, BIS, New Delhi, India

APPENDIX A

(*Clauses* 0.4, 0.5, 1.5, 15.1.1 *and* 15.2.1)

CLASSIFICATION OF CABLES FOR IMPROVED FIRE PERFORMANCE

Category	Environment Description	Type	Cable Definition
0 1	Cables in open areas		Flame retardent. Single cable self-extinguishing does not propagate flame
C1	Cables in constrained areas	FR	Flame retardent. Does not propagate fire even when installed in groups in vertical ducts
C2	Cables in constrained areas with limited human activity and/or presence of sophisticated systems	FR-LSH	Flame retardent cables with reduced halogen evolution and smoke

Indian Standard

SPECIFICATION FOR CROSSLINKED POLYETHYLENE INSULATED PVC SHEATHED CABLES

PART 1 FOR WORKING VOLTAGES UP TO AND INCLUDING 1 100 VOLTS

(*First Revision*)

0. FOREWORD

0.1 This Indian Standard (Part 1) (First Revision) was adopted by the Bureau of Indian Standards on 22 December 1988, after the draft finalized by the Power Cables Sectional Committee had been approved by the Electrotechnical Division Council.

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

0.3 Particular attention is drawn to the limitations of the short circuit ratings of the types of cable covered by this standard owing to the absence of the metallic sheath and the possible loss of the electrical contact between the strands of the armour wire as a result of corrosion or the presence of compound between them. A separate standard about recommended short circuit ratings of these types of cable is under preparation.

0.4 Attention is also drawn to the fact that the current rating of the types of cable covered by this standard are different from those of paper insulated metal sheathed cables. This standard does not include any data on the current ratings but information on this aspect will be covered in a separate Indian Standard later. In the meanwhile, users are advised to consult the manufacturers for information on this aspect.

0.5 In the preparation of this standard, assistarce has been derived from IEC Publication 502 (1983) 'Extruded solid dielectric insulated power cables for rated voltage from 1 kV to 30 kV', issued by the International Electrotechnical Commission.

0.6 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.

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

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 crosslinked polyethylene (XLPE) insulated and PVC sheathed cables for electric supply and control purposes.

1.2 The cables covered in 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. These cables may be used on dc systems for rated voltages up to and including 1 500 V to earth.

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 (**3.1.1**, **13.5** and **17.2**).

1.4 These cables are suitable for use where 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.

2. TERMINOLOGY

2.0 For the purpose of this standard the following definitions, in addition to those given in IS : 1885 (Part 32) - 1971* shall apply.

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

2.1 Routine Tests — Tests made by the manufacturer on all finished cable lengths to demonstrate the integrity of the cable.

2.2 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.

NOTE — 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.

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

2.4 Optional Tests — Special tests to be carried out, when required, by agreement between the purchaser and the supplier.

2.5 Earthed System — An electric system which fulfills 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.

2.6 Unearthed System — An electric system which does not fulfil the requirement of the earthed system (*see* **2.5**).

SECTION 2 MATERIALS

3. CONDUCTOR

3.1 The conductor shall be composed of plain copper or aluminium wires complying with IS : 8130-1984*.

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

4. INSULATION

4.1 The insulation shall be of crosslinked polyethylene conforming to the requirements given in Table 1.

TABLE 1 PROPERTIES OF XLPE INSULATION
(*Clause* 4.1)

Sl No.	Property	Requirement
(1)	(2)	(3)
i)	Tensile strength	12·5 N/mm², *Min*
ii)	Elongation at break	200 percent, *Min*
iii)	Ageing in air oven	
	a) Treatment : Temperature	135±3°C
	Duration	7 days
	b) Tensile strength variation	±25 percent, *Max*
	c) Elongation variation	±25 percent, *Max*
iv)	Hot set	
	a) Treatment : Temperature	200±3°C
	Time under load	15 minutes
	Mechanical stress	20 N/cm²
	b) Elongation under load	175 percent, *Max*
	c) Permanent elongation (set) after cooling	15 percent, *Max*
v)	Shrinkage	
	a) Treatment : Temperature	130±3°C
	Duration	1 hour
	b) Shrinkage	4 percent, *Max*
vi)	Water absorption (gravimetric)	
	a) Treatment : Temperature	85±2°C
	Duration	14 days
	b) Water absorbed	1 mg/cm², *Max*
vii)	Volume resistivity:	
	a) at 27°C	1×10^{14} ohm-cm, *Min*
	b) at 90°C	1×10^{13} ohm-cm, *Min*

5. FILLER AND INNER SHEATH

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

a) Vulcanized or unvulcanized rubber, or

b) Themroplastic materials.

5.2 Vulcanized or unvulcanized rubber or thermoplastic material used for inner sheath shall not be harder than XLPE and PVC used for 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. ARMOURING

6.1 Armouring shall be of the following:

a) Galvanized round steel wire, or

b) Galvanized steel strip, or

c) Any metallic non-magnetic wire/strip.

*Specification for conductors for insulated electric cables and flexible cords (*first revision*).

6.2 The galvanized steel wires/strips shall comply with the requirements of IS : 3975-1979*. The requirements of non-magnetic material shall be as agreed to between the purchaser and the supplier.

7. OUTER SHEATH

7.1 The outer sheath shall be of polyvinyl chloride (PVC) compound conforming to the requirements of type ST 2 compound of IS : 5831-1984†.

SECTION 3 CONSTRUCTION

8. CONDUCTOR

8.1 The construction of the conductor shall be as follows:

Nominal Cross-Section		*Solid Stranded*	*Flexibility Class (Ref IS : 8130 - 1984‡)*
Copper mm²	Aluminium mm²		
—	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

8.2 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.

8.3 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
(1)	(2)
mm²	mm²
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

*Specification for mild steel wires, strips and tapes for armouring of cables (*first revision*).

†Specification for PVC insulation and sheath of electric cables (*first revision*).

‡Specification for conductors for insulated electric cables and flexible cords (*first revision*).

9. INSULATION

9.1 The conductor (with protective barrier, wherever applied) shall be provided with cresslinked polyethylene insulation applied by extrusion.

9.2 **Thickness of Insulation** — 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* 9.2 *and* 9.3)

Nominal Area of Conductor	Nominal Thickness of Insulation (t_i)	
	Single Core Armoured Cables	Single Core Unarmoured and Multi-core Cables
(1)	(2)	(3)
mm²	mm	mm
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

9.3 **Tolerance on Thickness of Insulation** — The smallest of measured values of thickness of insulation shall not fall below the nominal value (t_i) specified in Table 3 by more than 0·1 mm + 0·1 (t_i).

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

10. CORE IDENTIFICATION

10.1 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 and black;

3 Core : Red, yellow and blue;

4 Core : Red, yellow, blue and black;

5 Core : Red, yellow, blue, black and 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, 3

4 Core : 0, 1, 2 and 3

NOTE 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.

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

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

10.3 For cables having more than 5 cores, as an alternate to the provisions of **10.1** 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 the same colour, which shall contrast with the colour of the insulation. The numerals shall be legible.

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

11. LAYING UP OF CORES

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

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

12. INNER SHEATH (COMMON COVERING)

12.1 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.

12.2 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.

TABLE 4 LAY-UP OF CORES FOR CABLES

(*Clause* 11.2)

(1) No. of Cores	(2) Lay-up
2	2
3	3
4	4
5	5
6	6
7	1-6
8	1-7
9	1-8
10	2-8
11	3-8
12	3-9
13	3-10
14	4-10
15	5-10
16	5-11
17	5-12
18	0-6-12
19	1-6-12
20	1-7-12
21	1-7-13
22	2-7-13
23	2-7-13
24	2-8-14
25	2-8-15
26	3-9-14
27	3-9-15
28	3-9-16
29	4-10-15
30	4-10-16
31	4-10-17
32	5-11-16
33	5-11-17
34	5-11-18
35	5-12-18
36	0-6-12-18
37	0-6-12-18
38	1-6-12-19
39	1-6-13-19
40	1-7-13-19
41	1-7-13-20
42	2-8-13-19
43	2-8-14-19
44	2-8-14-20
45	2-8-14-21
46	3-9-14-20
47	3-9-15-20
48	3-9-15-21
49	3-9-15-22
50	3-9-16-22
51	4-10-16-21
52	4-10-16-22
53	4-10-16-23
54	4-10-17-23
55	4-11-17-23
56	5-11-17-23
57	5-11-17-24
58	5-11-18-24
59	5-12-18-24
60	0-6-12-18-24
61	1-6-12-18-24
62	1-6-12-18-24
63	1-7-12-18-25
64	1-7-13-18-25
65	1-7-13-19-25

(*Continued*)

TABLE 4 LAY-UP OF CORES FOR CABLES—*Contd*

No. of Cores	Lay-up
66	1-7-13-19-26
67	2-8-13-19-25
68	2-8-14-19-25
69	2-8-14-20-25
70	2-8-14-20-26
71	2-8-14-20-27
72	2-8-14-21-27
73	3-9-15-20-26
74	3-9-15-21-26
75	3-9-15-21-27
76	3-9-15-21-28
77	3-9-15-22-28
78	4-10-15-21-28
79	4-10-16-22-27
80	4-10-16-22-28
81	4-10-16-22-29
82	4-10-16-23-29
83	4-10-17-23-29
84	5-11-17-23-28
85	5-11-17-23-29
86	5-11-17-23-30
87	5-11-17-24-30
88	5-11-18-24-30
89	0-6-11-18-24-30
90	0-6-12-18-24-30
91	1-6-12-18-24-30
92	1-6-12-18-24-31
93	1-6-12-18-25-31
94	1-6-12-19-25-31
95	1-6-13-19-25-31
96	1-7-13-19-25-31
97	1-7-13-19-26-31
98	2-8-13-19-25-31
99	2-8-14-19-25-31
100	2-8-14-20-25-31

NOTE 1 — The figures indicate the number of cores in each successive layer; for example, 5-11-18 means, 5 core in first, 11 cores in the second and 18 in the third layer, etc.

NOTE 2 — This table is for guidance only.

12.3 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

Calculated Diameter Over Laid-up Cores [Ref IS : 10462 (Part 1) - 1983*]		Thickness of Inner Sheath (*Min*)
Over	Up to and Including	
(1)	(2)	(3)
mm	mm	mm
—	25	0·3
25	35	0·4
35	45	0·5
45	55	0·6
55	--	0·7

*Fictitious calculation method for determination of dimensions of protective coverings of cables : Part 1 Elastomeric and thermoplastic insulated cables.

12.3.1 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 the extruded inner sheath.

13. ARMOURING

13.1 Application

13.1.1 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.

13.1.2 The armour wires/strips shall be applied as closely as practicable.

13.1.3 The direction of lay of the armour shall be left hand. For double wire/strip amoured cables, this requirement shall apply to the inner layer of wires/strips. 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, bitumenized cotton tape, bitumenized hessian tape, rubber tape or proofed tape between the inner and other layers of armour wires/strips.

13.1.4 A binder tape may be provided on the armour.

13.2 Type of Armour — Where the calculated diameter below armouring does not exceed 13 mm, the armour shall consist of galvanized round steel wires.

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

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 the purchaser and the manufacturer.

13.3 Dimensions — The dimensions of galvanized steel wires or strips shall be as specified in Table 6.

13.4 Joints — The joints in armour wire or strip 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.

13.5 Resistance

13.5.1 If specified by the purchaser, the dc resistance of the galvanized steel wire strip armour shall be measured. The result, when corrected to 20°C, shall comply with the appropriate values given in Table 7.

13.5.2 In case of cable for the use in mines, the resistance of armour shall not exceed that of

TABLE 6 DIMENSIONS OF ARMOUR ROUND WIRES AND STRIPS
(*Clause* 13.3)

Calculated Diameter Under Armour [Ref IS : 10462 (Part 1) - 1983*]		Nominal Thickness of Steel Strip	Nominal Diameter of Round Wire
Over	Up to and Including		
(1) mm	(2) mm	(3) mm	(4) mm
(a) For all diameter in excess of 13		0·8	—
or			
(b) —	13	—	1·40
13	25	0·8	1·60
25	40	0·8	2·00
40	55	1·4	2·50
55	70	1·4	3·15
70	—	1·4	4·00

NOTE — (a) and (b) indicate two methods of practice in the application of armouring.

*Fictitious calculation method for determination of dimensions of protective coverings of cables : Part 1 Elastomeric and thermoplastic insulated cables.

the conductor as specified in IS : 8130-1984* by more than 33 percent. To satisfy this, substitution of galvanized wires/strips in armouring by required number of tinned copper wires/strips is permissible.

14. OUTER SHEATH

14.1 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 multi-core cables; and

c) Over the armouring in case of armoured cables.

14.2 Colour or outer sheath shall be black or any other colour as agreed to between the purshaser and the supplier.

*Specification for conductors for insulated electric cables and flexible cords (*first revision*).

TABLE 7 ARMOUR RESISTANCE OF CABLES
[*Clauses* 13.5.1 *and* 15.4 (c)]

Nominal Area of Conductor	Maximum DC Resistance of Armour of Cable at 20°C											
	Two Core			Three Core			Four Core			Four Core with Reduced Neutral		
	Round wire	Strip		Round wire	Strip		Round wire	Strip		Round wire	Strip	
		4·0× 0·8 mm	6·1× 1·4 mm		4·0× 0·8 mm	6·1× 1·4 mm		4·0× 0·8 mm	6·1× 1·4 mm		4·0× 0·8 mm	6·1× 1·4 mm
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
mm²	ohm/ km	ohm/ km	ohm/ km	ohm/ km	ohm/ km	ohm/ km	ohm/ km	ohm/ km	ohm/ km	ohm/ km	ohm/ km	ohm/ km
1·5	6·71	—	—	6·35	—	—	5·82	—	—	—	—	—
2·5	6·07	—	—	5·73	—	—	5·24	—	—	—	—	—
4	5 45	—	—	5·14	—	—	4·69	—	—	—	—	—
6	4·91	—	—	4·63	—	—	4·21	—	—	—	—	—
10	4·25	—	—	3·99	—	—	3·62	—	—	—	—	—
16	3·57	—	—	2·89	4·77	—	2·62	4·32	—	—	—	—
25	3·00	4·95	—	2·68	4·42	—	2·29	3·78	—	2·36	3·90	—
35	2·88	4·75	—	2·52	4·16	—	2·12	3·49	—	2·18	3·60	—
50	2·47	4·07	—	2·20	3·64	—	1·93	3·18	—	1·99	3·28	—
70	2·15	3·55	—	1·49	3·12	—	1·24	2·59	—	1·29	2·70	—
95	1·53	3·21	—	1·31	2·75	—	1·12	2·34	—	1·18	2·48	—
120	1·38	2·88	—	1·17	2·45	—	1·01	2·11	—	1·12	2·34	—
150	1·26	2·63	—	1·05	2·19	—	0·737	1·95	1·07	1·01	2·10	—
185	1·14	2·38	—	0·767	2·03	1·11	0·652	1·72	0·944	0·715	1·89	1·03
240	0·791	2·09	1·14	0·675	1·78	0·976	0·590	1·55	0·855	0·625	1·64	0·905
300	0·726	1·92	1·05	0·619	1·63	0·896	0·409	1·37	0·755	0·577	1·52	0·836
400	0·627	1·65	0·908	0·428	1·43	0·791	0·377	1·26	0·697	0·384	1·28	0·710
500	0·421	1·41	0·778	0·379	1·27	0·701	0·245	1·04	0·581	0·358	1·19	0·662
630	0·376	1·25	0·695	0·264	1·13	0·627	0·214	0·910	0·507	0·241	1·03	0·571

NOTE 1 — The resistance of armour for single core cables has not been covered, since such cables are generally armoured with non-magnetic materials (*see* 13.2).

NOTE 2 — The resistance of the armour may be measured at room temperature and corrected to 20°C by means of correction factors given in IS: 10810 (Part 42) - 1984 'Methods of test for cables: Part 42 Resistivity test of armour wires and strips and conductance test of armour (wires/strips)'.

14.3 Thickness of Outer Sheath

14.3.1 *Unarmoured Cables* — The average thickness of PVC outer sheath of unarmoured cables shall be not less than the nominal value specified under col 3 of Table 8 and the smallest of the measured values shall not be less than the minimum value specified in col 4 of Table 8.

NOTE — In case of multi-core unarmoured cables, it is permissible to supply the inner and outer sheaths in a single extrusion out of the material intended for outer sheath. The thickness of such extruded sheath shall not be less than the sum of the inner sheath thickness specified in Table 5 and the nominal outer sheath thickness specified in col 3 of Table 8 and the smallest of the measured values shall not be less than the sum of the inner-sheath thickness specified in Table 5 and the minimum value of outer-sheath thickness specified in col 4 of Table 8.

14.3.2 *Armoured Cables* — The minimum thickness of PVC outer sheath of armoured cables shall not fall below the nominal value (t_s) specified in Table 8 by more than 0·2 mm $\pm$ 0·2 t_s.

SECTION 4 TESTS

15. CLASSIFICATION OF TESTS

15.1 Type Tests — The following shall constitute type test:

Test	*For Requirement Ref*	*For Test Method Ref Part Number of IS : 10810**
a) Tests on conductor		
i) Annealing test (for copper)	IS :8130 - 1984†	1
ii) Tensile test (for aluminium)	IS : 8130 - 1984†	2
iii) Wrapping test (for aluminium)	IS : 8130 - 1984†	3
iv) Resistance test	IS : 8130 - 1984†	5
b) Test for armouring wires/strips	6, Table 5 and IS : 3975 - 1979‡	36 to 42
c) Test for thickness of insulation and sheath	9, 12 and 14 Tables 2, 4 and 6	6
d) Physical tests for insulation		
i) Tensile strength and 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		
i) Tensile strength and elongation at break	IS : 5831 - 1984§	7
ii) Ageing in air oven	IS : 5831 - 1984§	11
iii) Loss of mass in air oven	IS : 5831 - 1984§	10
iv) Shrinkage test	IS : 5831 - 1984§	12
v) Hot deformation	IS : 5831 - 1984§	15
vi) Heat shock test	IS : 5831 - 1984§	14
vii) Thermal stability	IS : 5831 - 1984§	7
f) Insulation resistance (volume resistivity test)	Table 1	43
g) High voltage test	16.2	45
h) Flammability test	16.3	53

*Method of test for cables.
†Specification for conductors for insulated electric cables and flexible cords (*first revision*).
‡Specification for mild steel wires, strips and tapes for armouring of cables (*first revision*).
§Specification for PVC insulation and sheath of electric cables (*first revision*).
||Under preparation. In the meantime, reference may be made to Appendix B of IS : 5831-1984.

TABLE 8 THICKNESS OF OUTER SHEATH
(*Clauses* 14.3.1 *and* 14.3.2)

Calculated Diameter Under the Outer Sheath [Ref IS: 10462 (Part 1) - 1983*]		Thickness of Outer Sheath for Unarmoured 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	—	4·0	3·00	3·00

*Fictitious calculation method for determination of dimensions of protective coverings of cables: Part 1 Elastomeric and thermoplastic insulated cables.

15.2 Acceptance Tests — The following shall constitute acceptance tests:

a) Annealing test (for copper),
b) Tensile test (for aluminium),
c) Wrapping test (for aluminium),
d) Conductor resistance test,
e) Test for thickness of insulation and sheath,
f) Hot set test for insulation,
g) Tensile strength and elongation at break test for insulation and sheath,
h) High voltage test, and
j) Insulation resistance (volume resistivity) test.

15.2.1 A recommended sampling plan for acceptance tests is given in Appendix A.

15.3 Routine Tests — The following shall constitute routine tests:

a) Conductor resistance test,
b) High voltage test, and
c) Resistance test for armour (for mine cable only).

15.4 Optional Tests — The following shall constitute optional tests:

a) Cold bend test for outer sheath (IS : 5831-1984* and Part 20 of IS : 10810†);
b) Cold impact test for outer sheath (IS : 5831-1984* and Part 21 of IS : 10810†); and
c) Resistance test for armour (other than mining cable) (Table 7).

16. DETAIL OF TESTS

16.1 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.

16.2 High Voltage Test

16.2.1 *High Voltage Test at Room Temperature (Type, Acceptance and Routine Test)* — The cables shall withstand a voltage of 3 kV ac (rms) at a frequency of 40 to 60 Hz or an ac voltage of 7·2 kV, between conductors and between conductors and ECC (if any) for a period of 5 minutes for each test connection.

16.3 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.

SECTION 5 IDENTIFICATION, PACKING AND MARKING

17. IDENTIFICATION

17.1 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 trade-mark, or by manufacturer's name or trade-mark being indented, printed or embossed on the cable. In case none of these 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 identation, printing or embossing shall be done only on the outer sheath.

*Specification for PVC insulation and sheath of electric cables (*first revision*).

†Methods of test for cables.

*Methods of test for cables.

17.2 Cable Identification — In order to distinguish these electric cables from telephone cables, the word 'electric' 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 indented, printed or embossed throughout the length of the cable. The indentation, printing or embossing shall be done only on the outer sheath.

17.2.1 Cables with heat resisting insulation suitable for 85°C conductor temperature shall be identified by the letters 'HR 85' marked on it in any of the manners specified in 17.2.

17.3 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

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

18. PACKING AND MARKING

18.1 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-hygrosopic sealing material.

*Specification for drums for electric cables.

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

a) Reference to this Indian Standard, for example, Ref 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.

18.2.1 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 1986 and the Rules and Regulations made thereunder. The Standard Mark on 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 a further safeguard. 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.

APPENDIX A
(*Clause* 15.2.1)

SAMPLING OF CABLES

A-1. LOT

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

A-2. SCALE OF SAMPLING

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

A-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.

A-2.2.1 In order to ensure the randomness of selection, random number tables shall be used (*see* IS : 4905-1968*).

* Methods for random sampling.

A-3. NUMBER OF TESTS AND CRITERION FOR CONFORMITY

A-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* **15.2**). 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

Number of Drums in the Lot	Number of Drums to be Taken as Sample	Permissible Number of Defectives
(1)	(2)	(3)
(N)	(n)	(a)
Up to 50	2	0
51 to 100	5	0
101 to 300	13	0
301 to 500	20	1
501 and above	32	2

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This Indian Standard has been developed from Doc : No. ETD 59 (3087)

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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