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IS : 1554 (Part 2) - 1988
(Reaffirmed 1994)

Indian Standard

SPECIFICATION FOR PVC INSULATED (HEAVY DUTY) ELECTRIC CABLES

PART 2 FOR WORKING VOLTAGES FROM 3·3 kV UP TO AND INCLUDING 11 kV

(Second Revision)

Second Reprint DECEMBER 1999

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

Gr 4

April 1989

Category		*Test*	*For Requirements Ref to*	*For Test Method Ref Part No. of IS 10810*
01	No	Additional tests	—	—
C1	a)	Oxygen index test	19.9	58 (Under preparation)
	b)	Flame retardance test on single cable	19.10	61
	c)	Flame retardance test on bunched cables	19.11	62
	d)	Temperature index	19.14	Under consideration
C2	a)	Oxygen index test	19.9	58 (Under preparation)
	b)	Flame retardance test on single cable	19.10	61
	c)	Flame retardance test on bunched cables	19.11	62
	d)	Test for specific optical density of smoke	19.12	Under consideration
	e)	Test for halogen acid gas evolution	19.13	59
	f)	Smoke densidty	19.15	63
	g)	Temperature index	19.14	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* 7, *clause* **18.2.1**) — Add clause **18.2.2**:

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

Category	Test
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
	e) Smoke density test

(*Page* 7, *clause* **19.8**) — Add the following clauses:

'**19.9 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.

19.10 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. Marks from mixing devices, soot or changing of the colour are not considered damages.

19.11 Flame Retardance Test on Bunched 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 for method B, method C shall be used for both the categories C1 and C2.

19.12 Test for Specific Optical Density of Smoke

Under consideration.

19.13 Test for Halogen Acid Gas Evolution

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

19.14 Test for Temperature Index

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

19.15 Smoke Density Test

Under consideration.

(*Page* 7, *clause* **20.2**) — Add new clause:

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

Type of Cable	*Legend*
Improved Fire performance for category C1	FR
Improved fire performance for category C2	FR-LSH

(*Appendix* A, *Page 8*) — Insert the following new 'Appendix A' and renumber the existing 'Appendix A' as 'Appendix B'.

APPENDIX A

(*Clauses* 0.7, 1.4 *and* 18.1.3)

CLASSIFICATION OF CABLES FOR IMPROVED FIRE PERFORMANCE

Category	Environment Description	Type	Cable Definition
01	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

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AMENDMENT NO. 1 MAY 1994
TO
IS 1554 (Part 2) : 1988 SPECIFICATION FOR PVC INSULATED (HEAVY DUTY) ELECTRIC CABLES

PART 2 FOR WORKING VOLTAGES FROM 3.3 kV UP TO AND INCLUDING 1 100 kV

(Second Revision)

(Pag« 1, clause 0.7) - Substitute the following for the existing clause:

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

(Page 2, *clause* 1.3) -Insert the following itC\\' clause 1.4 after 1.3:

'1.4 This standard also covers cables with improved fire performance, categories Cl and C2, as given in Appendix A. For such cables additional requirements have been included wherever necessary (*see* 8.2, 18.1.3, 18.2.2 and 20.2.1).

NOTE - Normal cables 10 this standard can be classified as meeting the requirements of category 0 I.·

[*Page* 3, *clause* 7.1 (b) J - Substitute 'formed wires' *for* 'strip'.

(Page 3, *clause* 7.2) - Substitute the following for the first sentence:

'The galvanized steel wire/formed wires/tapes shall comply with the requirements of IS 3975: 1988, except that the provisions of 3.3.1 and 3.3.2 shall not apply.'

i Page 3, *clause* 8.1) - Insert the following new clause 8.2 after 8.1:

'8.2 For cables with improved fire performance, the outer sheath shall, in addition, meet the requirement of tests applicable for the required category (18.1.3 and 18.2.2) .'

(Page 5, *clause* 17.3.2, *line* 3) - Substitute 'Table 4' *for* 'Table 5'.

(Page 6, *clause* 18.1.2.1) - Insert tbe foJJowing new clause 11.1.3 after 18.1.2.1:

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

AMENDMENT NO. 2 JANUARY 2007
TO
IS 1554 (PART 2) : 1988 SPECIFICATION FOR PVC INSULATED (HEAVY DUTY) ELECTRIC CABLES

PART 2 FOR WORKING VOLTAGES FROM 3.3 kV UP TO AND INCLUDING 1 100 kV

(Second Revision)

[*Page* 6, *clause* **18.1.3**, *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* 6, *clause* **18.1.3**, *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* 6, *clause* **18.1.3**, *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* 6, *clause* **18.1.3**, *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.*

(ET 9)

Reprography Unit, BIS, New Delhi, India

AMENDMENT NO. 3 NOVEMBER 2007
TO
IS 1554 (PART 2) : 1988 SPECIFICATION FOR PVC INSULATED (HEAVY DUTY) ELECTRIC CABLES

PART 2 FOR WORKING VOLTAGES FROM 3.3 kV UP TO AND INCLUDING 11 kV

(Second Revision)

[*Page* 3, *clause* **7.1**(b)] — Substitute 'Galvanized steel formed wire (strip), or' *for* 'Galvanized steel strip, or'.

(*Page* 3, *clause* **7.2**, *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* 4, *clause* **16.3**, *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* 4, *clause* **16.5**) — Insert the following new clause after **16.5**:

'**16.6** 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 not be 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* 5, *clause* **18.1**, *Sl No.* (b)] — Substitute the following for the existing matter:

b)	Tests for round steel wire/formed steel wire (strip) armour:		
	1) Dimensions	**16.3** of IS 1554 (Part 2)	Part 36 of IS 10810
	2) Physical tests on round/formed wire:		
	i) Tensile strength	**16.6**(a) of IS 1554 (Part 2)	Part 37 of IS 10810
	ii) Elongation at break	**16.6**(b) of IS 1554 (Part 2)	Part 37 of IS 10810
	iii) Torsion test for round wires	**16.6**(c) of IS 1554 (Part 2)	Part 38 of IS 10810
	iv) Winding test for formed wires	**16.6**(d) of IS 1554 (Part 2)	Part 39 of IS 10810

v) Uniformity of zinc coating	**16.6**(e) of IS 1554 (Part 2)	Part 40 of IS 10810
vi) Mass of zinc coating	**16.6**(f) of IS 1554 (Part 2)	Part 41 of IS 10810
vii) Resistivity	**16.6**(g) of IS 1554 (Part 2)	Part 42 of IS 10810

(*Page* 6, *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

Indian Standard

SPECIFICATION FOR PVC INSULATED (HEAVY DUTY) ELECTRIC CABLES

PART 2 FOR WORKING VOLTAGES FROM 3·3 kV UP TO AND INCLUDING 11 kV

(Second Revision)

0. FOREWORD

0.1 This Indian Standard (Second Rivision) was adopted by the Bureau of Indian Standards on 25 July 1988, after the draft finalized by the Power Cables Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 The experience has shown that it is possible to use PVC insulated cables for the voltage grades covered by this standard, in place of paper-insulated lead-sheathed cables.

0.3 This standard was first brought out in 1970 and revised in 1981. The second revision of the standard has been undertaken to take into account experience gained since last revision. Opportunity has also been utilized to align the format of this specification with other specifications on different types of cables.

0.4 Particular attention is drawn to the limitations of the short-circuit ratings of the type of cable covered by this standard owing to the absence of the metallic sheath and the possible loss of electrical contact between stands of adjacent wires/strips of armouring as a result of corrosion or the presence of compound between them or both.

A separate standard about recommended short-circuit ratings of these types of cables is under preparation.

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

0.6 The correct type of cables should be selected for the system keeping in view whether the system is earthed or unearthed.

NOTE — It should be realized that in an electric system where an earth fault is not automatically and promptly eliminated, the extra stresses on the insulation of the cables during the earth fault reduce the life of the cable to a certain extent. Therefore, if the system is expected to be operated quite often with a prolonged earth-fault, it is advisable to select the cables suitable for unearthed system.

0.7 Work is being taken up separately to identify requirements and tests for fire retardant low smoke (FRLS) cables. It is intended to bring out these requirements either as a separate standard or through an amendment to this standard at a later date.

0.8 In preparing this standard, assistance has been derived from IEC Publication 502 (1983) 'Extruded solid dielectric insulated power cables for rated voltages from 1 kV up to 30 kV', issued by the International Electrotechnical Commission.

0.9 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 values 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 2) covers the requirements of the following categories of PVC insulated and PVC sheathed power cables for electricity supply purposes:

a) *Types of Cables*

1) Single-core unscreened, unarmoured (but non-magnetic metallic tape covered);

2) Single-core screened, unarmoured;
3) Single-core armoured (non-magnetic), screened or unscreened; and
4) Three-core armoured, screened or unscreened.

b) *Voltage Grade* (U_0/U)

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

1.2 The cables covered in this standard are used where combination of ambient temperature and temperature rise due to load results in conductor temperature not exceeding 70°C under normal operation and 160°C under short-circuit conditions.

1.3 Heavy duty armoured cables specified in this standard are suitable for use in mines also. However, for such cables, additional requirements have been included, wherever necessary [*see* **3.1.1**, **16.5**, **18.3**(d) and **20.2**].

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.

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

2.2 Type Tests — Tests required to be made before supply on a general commercial basis 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 characteristic.

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 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 accidentally 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**).

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

SECTION 2 MATERIALS

3. CONDUCTOR

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

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

4. INSULATION

4.1 The insulation shall be of polyvinyl chloride (PVC) compound conforming to the requirements of Type A compound for cables with rated voltages up to and including 3·3/3·3 kV and Type B compound for cables with rated voltages above 3·3/3·3 kV of IS : 5831-1984†.

5. SCREENING

5.1 The screening shall consist of one or more of the following, as specified:

a) Non-metallic semi-conducting tape;
b) Non-metallic semi-conducting compound; and
c) Non-magnetic metallic tape wire, strip or sheath.

NOTE — The semi-conducting tape and semi-conducting compound shall be suitable for the operating temperature of the cable and compatible with the insulating material.

5.1.1 *Non-magnetic Metallic Tape for Single-Core Unscreened and Unarmoured Cables* — Requirements for this tape shall be as agreed to between the purchaser and the manufacturer.

6. FILLERS AND INNER SHEATH

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

a) Unvulcanized rubber, or
b) Thermoplastic material, or
c) Proofed tapes (for inner sheath only).

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

6.2 Unvulcanized rubber or thermoplastic material shall not be harder than PVC used for insulation (**4.1**) and for outer sheath (**8.1**). The materials shall be chosen to be compatible with the temperature rating of the cable and shall have no deleterious effect on any other component of the cable.

7. ARMOURING

7.1 Armouring shall be of the following types:

a) Galvanized round steel wire, or

b) Galvanized steel strip, or

c) Any metallic non-magnetic wire/strip.

7.2 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.

8. OUTER SHEATH

8.1 The outer sheath shall be of polyvinyl chloride (PVC) compound conforming to the requirements of Type ST1 compound of IS : 5831-1984†.

*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*).

SECTION 3 CONSTRUCTION

9. CONDUCTOR

9.1 The conductor shall be of stranded construction, size 25 mm² and above complying with Class 2 of IS : 8130-1984*.

9.2 In case of 3·3 and 6·6 kV cables, a protective barrier may be applied between the conductor and insulation. Such barrier, when used, shall be compatible with insulating material and suitable for the operating temperature of the cable.

10. CONDUCTOR SCREENING

10.1 Cables rated for 6·35/11 kV shall be provided with conductor screening. Conductor screening shall be provided over the conductor by applying non-metallic semi-conducting tape or by extrusion of semi-conducting compound or a combination of the two.

11. INSULATION

11.1 The conductor (with protective barrier or screen, where applied) shall be provided with PVC insulation applied by extrusion.

11.2 Thickness of Insulation — The average thickness of insulation shall not be less than the nominal value (t_1) specified in Table 1.

11.3 Tolerance on Thickness of Insulation — The smallest of the measured values of the thickness of insulation shall not fall below the nominal values (t_1) specified in Table 1 by more than $0{\cdot}1 \text{ mm} + 0{\cdot}1\ t_1$.

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

12. INSULATION SCREENING

12.1 Cables rated for 6·35/11 kV shall be provided with insulation screening.

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

TABLE 1 THICKNESS OF INSULATION

(*Clauses* 11.2 *and* 11.3)

Nominal Area of Conductor	Thickness of Insulation (t_1)				
	1·9/3·3 and 3·3/3·3 kV		3·8/6·6 kV		6·35/11 kV
	Single-core armoured cable	Single-core unarmoured and 3-core cables	Single-core armoured cables	Single-core unarmoured and 3-core cables	Single core and 3-core cables
(1)	(2)	(3)	(4)	(5)	(6)
mm²	mm	mm	mm	mm	mm
25	2·6	2·3	3·9	3·6	4·2
35	2·6	2·3	3·9	3·6	4·2
50	2·6	2·3	3·9	3·6	4·2
70	2·6	2·3	3·9	3·6	4·2
95	2·6	2·3	3·9	3·6	4·2
120	2·6	2·3	3·9	3·6	4·2
150	2·6	2·3	3·9	3·6	4·2
185	2·6	2·3	3·9	3·6	4·2
240	2·6	2·3	3·9	3·6	4·2
300	2·8	2·5	4·0	3·6	4·2
400	3·1	2·7	4·0	3·6	4·2
500	3·4	3·0	4·0	3·6	4·2
630	3·9	3·4	4·1	3·6	4·2
800	3·9	3·4	4·1	3·6	4·2
1 000	3·9	3·4	4·1	3·6	4·2

12.2 The insulation screening shall consist of two parts, namely, metallic and non-metallic.

12.3 Non-metallic part shall be applied directly over the insulation of each core and shall consist of either a semi-conducting tape or extruded semi-conducting compound or a combination of the two or either material with a semi-conducting coating.

12.4 Metallic part shall consist of either tape or braid or concentric serving of wires or a sheath, shall be non-magnetic and shall be applied over the non-metallic part. For single-core armoured cables, the armouring may constitute the metallic part of the screening.

13. CORE IDENTIFICATION

13.1 Core identification for three-core cables shall be as follows:

Voltage Grade kV	*Method of Identification*
1·9/3·3, 3·3/3·3, 3·8/6·6	a) Different colouring of the PVC insulation, or b) Coloured strips applied on the cores, or c) By numerals (1, 2, 3), either by applying numbered strips or by printing on the cores.
6·35/11	a) Coloured strips applied on the cores, or b) By numerals (1, 2, 3), either by applying numbered strips or by printing on the cores.

13.1.1 For identification by different colouring of the PVC insulation or by using coloured strips. Red, yellow and blue colours respectively shall be used to identify phase conductors.

14. LAYING UP OF CORES

14.1 In three-core cables, the cores (with or without barrier or screening as the case may be) shall be laid together with a suitable right hand lay. Where necessary, the interstices shall be filled with non-hygroscopic material.

15. INNER SHEATH (COMMON COVERING)

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

15.2 Inner sheath shall be so applied that it fits closely on the laid-up cores and it shall be possible to remove it without damaging the insulation.

15.3 In case of single core cables where there are both metallic screening and armouring, there shall be extruded inner sheath between them.

15.4 Thickness of Inner Sheath — The values of thickness of inner sheath shall be as given in Table 2. Single-core cables, except those specified in **15.3**, shall have no inner sheath.

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

16. ARMOURING

16.1 Application

16.1.1 Armouring shall be applied over insulation or non-metallic part of insulation or inner sheath in case of single core cables and over the inner sheath in case of three core cables.

TABLE 2 THICKNESS OF INNER SHEATH
(*Clause* 15.4)
All dimensions in millimetres.

Calculated Diameter Over Stranded Cores [Refer IS : 10462 (Part 1)-1983*]		Thickness of Inner Sheath (*Min*)
Over	Up to and Including	
(1)	(2)	(3)
—	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.

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

16.1.3 The direction of lay of the armour shall be left hand. For double wires/strips armoured 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, bituminized cotton tape, bituminized hessian tape, rubber tape, and proofed tape between the inner and outer layers of armour wires strips.

16.1.4 A binder tape may be provided on the armour.

16.2 Type of Armour

16.2.1 Where the calculated diameter below armouring does not exceed 13 mm, the armour shall consist of galvanized round steel wires. The armour of cables having calculated diameter below armouring greater than 13 mm shall consist of either galvanized round steel wires or galvanized steel strips.

16.2.2 In the case single-core cables, the armouring shall be of non-magnetic material.

16.3 Dimensions — The dimensions of galvanized steel wires/strips shall be as specified in Table 3.

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

16.5 Resistance — In case of cables for use in mines, the resistance of armour shall not exceed that of conductor as specified in IS : 8130-1984* by more than 33 percent. To satisfy this, substitution of galvanized wires/strips in the armour by required number of thinner copper wires/strips is permissible.

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

TABLE 3 DIMENSIONS OF ARMOUR — ROUND WIRES AND STRIPS

(*Clause* 16.3)

All dimensions in millimetres.

Calculated Diameter of Cable Under Armour [Refer IS : 10462 (Part 1)-1983*]		Nominal Thickness of Steel Strip	Nominal Diameter of Round Armour Wire
Over	Up to and Including		
(1)	(2)	(3)	(4)
a) For all diameters in excess of 13 or		0·8	—
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 method 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.

17. OUTER SHEATH

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

a) Over the non-magnetic metallic tape covering the insulation or over the non-magnetic metallic part of insulation screening in case of unarmoured single core cables, and

b) Over the armouring in case of armoured cables.

17.2 The colour of outer sheath shall be black, unless any other colour is agreed to between the purchaser and the supplier.

17.3 Thickness of Outer Sheath

17.3.1 Unarmoured Cables — The thickness of outer sheath of unarmoured cables determined by taking the average of a number of measurements shall be not less than the nominal value specified in col 3 of Table 4 and the smallest of the measured values shall be not less the minimum value specified in col 4 of Table 4.

TABLE 4 THICKNESS OF OUTER SHEATH

(*Clauses* 17.3.1 *and* 17.3.2)

All dimensions in millimetres.

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 Cable
Over	Up to and Including	Nominal (t_a)	Minimum	
(1)	(2)	(3)	(4)	(5)
—	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 protective coverings of cables: Part 1 Elastomeric and thermoplastic insulated cables.

17.3.2 Armoured Cables — The thickness of outer sheath shall be not less than the minimum value specified in col 5 of Table 5.

SECTION 4 TESTS

18. CLASSIFICATION OF TESTS

18.1 Type Tests — The following shall constitute type tests:

Test	*For Requirements, Ref to*	*For Test Method, Ref Part No. of IS : 10810**
a) Tests on Conductor		
1) Annealing test (for copper)	IS : 8130-1984†	1
2) Tensile test (for aluminium)	IS : 8130-1984†	2
3) Wrapping test (for aluminium)	IS : 8130-1984†	3
4) Resistance test	IS : 8130-1984†	5
b) Tests for armouring wires or strips	7, Table 3 and IS : 3975-1979‡	36 to 42
c) Test for thickness of insulation and sheath	11, 15 and 17	6

Test	*For Requirements, Ref to*	*For Test Methods Ref Part No. of IS : 10810**
d) Physical tests for insulation and outer sheath (as applicable):		
1) Tensile strength and elongation at break	IS : 5831-1984§	7
2) Ageing in air oven	IS : 5831-1984§	11
3) Shrinkage test	IS : 5831-1984§	12
4) Hot deformation test	IS : 5831-1984§	15
5) Loss of mass in air oven	IS : 5831-1984§	10
6) Heat shock test	IS : 5831-1984§	14
7) Thermal stability	IS : 5831-1984§	60
8) Water absorption (gravimetric) (for insulation, where applicable)	IS : 5831-1984§	33
e) Insulation resistance test	IS : 5831-1984§	43
f) Partial discharge test	19.2	46
g) Bending test	19.3	50
h) Dielectric power factor test	19.4	48
1) As a function of voltage		
2) As a function of temperature		
j) Heating cycle test	19.5	49
k) Impulse withstand test	19.6	47
m) High voltage test	19.7	45
n) Flammability test	19.8	53

*Methods 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*).

18.1.1 Tests (f), (g), (h), (j) and (k) are applicable to cables with screened cores, that is, 6·35/11 kV cables. It shall be permissible to carry out test (h) on different samples.

18.1.2 With the exception and provision of **18.1.1**, the following tests on screened cables shall be performed successively on the same test sample of completed cable not less than 10 m in length between the test accessories:

a) Partial discharge test;
b) Bending test followed by partial discharge test;
c) Dielectric power factor as a function of the voltage and capacitance measurement;
d) Dielectric power factor as a function of temperature;
e) Heating cycle test followed by dielectric power factor as a function of voltage and partial discharge test;
f) Impulse withstand test; and
g) High voltage test.

18.1.2.1 If a sample fails in test (g), one more sample shall be taken for this test, preceded by test (b) and (e).

18.2 Acceptance Tests — The following tests shall be carried out as 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) Tensile strength and elongation at break of insulation and outer sheath,
g) Test for insulation resistance,

h) Partial discharge test (for 6·35/11 kV cables only), and

j) High voltage test.

NOTE — The partial discharge test shall be carried out on full drum length.

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

18.3 Routine Tests — The following shall be carried out as routine tests:

a) Conductor resistance test,

b) Partial discharge test (for 6·35/11 kV cables only),

c) High voltage test, and

d) Resistance test for armour (for mining cable).

NOTE — Partial discharge test shall be carried out on full drum length.

18.4 Optional Test — Cold impact test shall constitute the optional test.

19. DETAILS OF TEST

19.1 General — Unless otherwise stated in this standard, the tests shall be carried out in accordance with appropriate part of IS : 10810*, taking into account additional information given in this standard.

19.2 Partial Discharge Test — The partial discharge magnitude at test voltage equal to 1·5 U_0 shall not exceed 40 pC.

19.3 Bending Test — The diameter of the test cylinder shall be 20 $D \pm 5$ percent, where D is the overall diameter of completed cable. After completing the bending operations, the test sample shall be subjected to partial discharge measurement and shall comply with the requirements given in **19.2**.

19.4 Dielectric Power Factor Test — The measured values shall not exceed the following:

a) *As a Function of Voltage*

Tan δ at U_0	$1\,000 \times 10^{-4}$
Increment of tan δ between 0·5 U_0 and 2 U_0	65×10^{-4}

b) *As a Function of Temperature*

Tan δ at ambient temperature	$1\,000 \times 10^{-4}$
At maximum continuous operating temperature, product of permitivity and tan δ	0·75

19.5 Heating Cycle Test — The sample, which has been subjected to the previous tests, shall be subjected to heat cycles. After the third cycle, the sample shall be subjected to dielectric power factor as a function of voltage [**19.4**(a)] and partial discharge test (**19.2**).

19.6 Impulse Withstand Test — The cable shall withstand an impulse voltage of 75 kV. No breakdown of insulation shall occur during the test.

19.7 High Voltage Test

19.7.1 *Type/Acceptance Test* — The cable shall withstand without breakdown an ac voltage equal to 3 U_0 but not less than the value given in **19.7.2** when applied to the sample between conductor and screen/metallic tape/armour (and between conductors in case of unscreened cables). The voltage shall be gradually increased to specified value and maintained for a period of 4 hours. If, while testing, interruption occurs during 4 hours period, the test shall be prolonged to the same extent. If the interruption exceeds 30 minutes, the test shall be repeated.

19.7.2 *Routine Test* — The cable shall withstand without any failure the ac test voltages given below, when applied for a period of 5 minutes for each test connection:

Voltage Grade	*Test Voltage*	
	Between Conductor and Screen/ Armour	Between Conductor
kV	kV (rms)	kV (rms)
1·9/3·3	10	10
3·3/3·3		
3·8/6·6	12	20
6·35/11	17	—

19.8 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.

*Methods of test for cables.

SECTION 5 IDENTIFICATION, PACKING AND MARKING

20. IDENTIFICATION

20.1 Manufacturer's Identification — The manufacturer shall be identified throughout the length of cable by manufacturer's name or trade-mark, and the voltage grade and year of manufacture indented, printed or embossed or by means of a tape bearing this information. The indentation, printing or embossing shall be done only on the outer sheath. For manufacturer's name, if none of these methods is employed or if the purchaser so desires, colour identification threads in accordance with a scheme to be approved by the Bureau of Indian Standards shall be employed.

20.2 Cable Identification — In case of cables intended for use in mines, the word 'Mining' shall be printed, embossed or indented on the outer sheath throughout the length of the cable.

20.3 Cable Code — The following codes shall be used for designating the cables:

Constituent	*Code Letter*
Aluminium conductor	A
PVC insulation	Y
Steel round wire armour	W
Non-magnetic round wire armour	Wa
Steel strip armour	F
Non-magnetic strip armour	Fa
Double steel wire armour	WW
Double steel strip armour	FF
PVC outer sheath	Y

NOTE — In case of copper conductor, there is no need to use any code for designating conductor.

21. PACKING AND MARKING

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

21.2 The cable shall carry the following information stencilled on the drum:

a) Reference to this Indian Standard, for example, ref IS : 1554 (Part 2);

b) Manufacturer's name or trade-mark;

c) Type of cable and voltage grade;

d) Number of cores;

e) Nominal cross-sectional area of the conductor;

f) Cable code;

g) Length of the cable on the drum;

h) Number of lengths on drum (if more than one);

j) Direction of rotation of drum (by means of an arrow);

k) Approximate gross mass;

m) Country of manufacture; and

n) Year of manufacture.

21.2.1 The cable (drum) 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.

*Specification for drums for electric cables.

APPENDIX A

(*Clause* 18.2.1)

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 samples to be selected shall depend on col 1 and 2 as indicated below:

Number of Drums in the Lot	*Number of Drums to be Taken as Sample*	*Permissible Number of Defectives*
(*N*)	(*n*)	(*a*)
(1)	(2)	(3)
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

The 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*).

A-3. NUMBER OF TESTS AND CRITERION FOR CONFORMITY

A-3.1 Suitable lengths of test samples shall be taken from each of the drums selected. These test samples shall be subjected to each of the acceptance tests (**18.2**). A test sample is called defective if it fails in any one of the acceptance tests. If the number of defectives is less than or equal to the corresponding permissible number given in col 3 under **A-2.2**, the lot shall be declared as conforming to the requirements of acceptance tests, otherwise not.

*Methods for random sampling.

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Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones: 323 01 31, 323 33 75, 323 94 02

Telegrams: Manaksanstha
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Eastern	: 1/14 C.I.T. Scheme VII M, V.I.P. Road, Maniktola CALCUTTA 700054	337 84 99, 337 85 61 337 86 26, 337 91 20
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