

BUREAU OF INDIAN STANDARDS
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Draft Indian Standard

PVC insulated (Heavy Duty) electric cables - Specification
Part 2 for working voltages from 3.3 kV up to and including 11 kV

(Third Revision of IS 1554-II)

Power Cables Sectional
Committee, ETD 09

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FOREWORD

(Formal Clauses of the draft will be added later)

This draft Indian Standard (Part 2) (Third Revision) will be adopted by the Bureau of Indian Standards on the recommendation of the Power Cables Sectional Committee and approval of the Electrotechnical Division Council.

This standard was originally published in 1970 and subsequently revised in 1981 and 1988. This Third revision has been undertaken to align it with the international practices to the extent possible.

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 strands of adjacent wires/stripes of armouring as a result of corrosion or the presence of compound between them or both.

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.

The current ratings of cables with general purpose insulation covered in this standard are given in IS 3961 (Part 2) 'Recommended current ratings for cables: Part 2 PVC insulated and PVC sheathed heavy duty cables (First Revision)'.

IS 16269 '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.

All amendments to second revision has been incorporated in this third revision.

Another part of this series of Indian Standard cover PVC insulated (Heavy Duty) electric

cables:

Part 1 For working voltages up to and including 1100 V.

In the preparation of this standard, assistance has been derived from IEC 60502 series.

The composition of the Committee, responsible for the formulation of this standard is given in **Annex D**.

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: 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

**PVC INSULATED (HEAVY DUTY) ELECTRIC CABLES- SPECIFICATION
PART 2 FOR WORKING VOLTAGES FROM 3.3 kV
UP TO AND INCLUDING 11 kV**

(Third Revision)

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 (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_o/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 4.1.1, 17.5, 19 and 21.2*].

1.4 This standard also covers cables with improved fire performance, categories C1 and C2, as given in Annex A. For such cables additional requirements have been included wherever necessary (*see 9.2, 19 and 21.2.1*).

NOTE — Normal cables to this standard can be classified as meeting the requirements of category 01.

2 REFERENCES

The standards given 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 standard indicated below:

<i>IS No.</i>	<i>Title</i>
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IS 1885 (Part 32) : 2019	Electrotechnical Vocabulary Part 32 Electric Cables (Second Revision)
IS 3975 : 1999	Low carbon galvanized steel wires, formed wires and tapes for armoring of cables - Specification (Third Revision)
IS 4826 : 2023	Hot-Dip Galvanized Coatings on Round Steel Wires - Requirements
IS 4905 : 2015	Random sampling and randomization procedures (First 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 10418 : 2024	Drums for Electric Cables- Specification (First Revision)
IS 10462 (Part 1) : 1983	Fictitious calculation method for determination of dimensions of protective coverings of cables: Part 1 elastomeric and thermoplastic insulated cables
IS 10810 (Part 0) : 1984	Methods of test or cables
IS 10810 (Part 1) : 1984	Methods of test for cables: Part 1 annealing test for wires used as conductors
IS 10810 (Part 2) : 1984	Methods of test for cables: Part 2 tensile test for aluminium wires
IS 10810 (Part 3) : 1984	Methods of test for cables: Part 3 wrapping test - For aluminium wires
IS 10810 (Part 5) : 1984	Methods of test for cables: Part 5 conductor resistance test
IS 10810 (Part 6) : 1984	Methods of test for cables: Part 6 thickness of thermoplastic and elastomeric insulation and sheath
IS 10810 (Part 7) : 1984	Methods of test for cables: Part 7 tensile strength and elongation at break of thermoplastic and elastomeric insulation and sheath
IS 10810 (Part 10) : 1984	Methods of test for cables: Part 10 loss of mass test
IS 10810 (Part 11) : 1984	Methods of test for cables: Part 11 thermal ageing in air
IS 10810 (Part 12) : 1984	Methods of test for cables: Part 12 shrinkage test
IS 10810 (Part 14) : 1984	Methods of test for cables: Part 14 heat shock test
IS 10810 (Part 15) : 1984	Methods of test for cables: Part 15 hot deformation test
IS 10810 (Part 33) : 1984	Methods of test for cables: Part 33 water absorption test (Gravimetric)
IS 10810 (Part 36) : 1984	Methods of test for cables: Part 36 dimensions of armoring material
IS 10810 (Part 37) : 1984	Methods of test for cables: Part 37 tensile strength and elongation at break of armoring materials
IS 10810 (Part 38) : 1984	Methods of test for cables: Part 38 torsion test on galvanized steel wires for armoring
IS 10810 (Part 39) : 1984	Methods of test for cables: Part 39 winding test on galvanized steel strips for armoring
IS 10810 (Part 40) : 1984	Methods of test for cables: Part 40 uniformity of zinc coating on steel armour

IS 10810 (Part 41) : 1984	Methods of test for cables: Part 41 mass of zinc coating on steel armour
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)
IS 10810 (Part 43) : 1984	Methods of test for cables: Part 43 insulation resistance
IS 10810 (Part 45) : 1984	Methods of test for cables: Part 45 high voltage test
IS 10810 (Part 46) : 1984	Methods of test for cables: Part 48 partial discharge test
IS 10810 (Part 47) : 1984	Methods of test for cables: Part 47 impulse test
IS 10810 (Part 48) : 1984	Methods of test for cables: Part 48 dielectric power factor test
IS 10810 (Part 49) : 1984	Methods of test for cables: Part 49 heating cycle test
IS 10810 (Part 50) : 1984	Methods of test for cables: Part 50 bending test
IS 10810 (Part 53) : 1984	Methods of test for cables: Part 53 flammability test
IS 10810 (Part 58) : 1998	Method of tests for cables: Part 58 oxygen index test
IS 10810 (Part 59) : 1988	Method of tests for cables: Part 59 determination of the amount of halogen acid gas evolved during combustion of polymeric materials taken from cables
IS 10810 (Part 60) : 1988	Methods of test for cables: Part 60 thermal stability of PVC insulation and sheath
IS 10810 (Part 61) : 1988	Methods of test for cables: Part 61 flame retardant test
IS 10810 (Part 62) : 1993	Method of tests for cables: Part 62 flame retardance test for bunched cables
IS 10810 (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

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 Tests - Tests carried out by the manufacturer on all the finished cable length to check the requirements which are likely to vary during manufacture.

3.2 Type Tests - Tests intended to prove that the quality and design of a given type of cable are in accordance with the specifications.

NOTES

- a) 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.

- b) When type tests have been successfully performed on a type of cable covered by this standard with a specific conductor cross-sectional area and rated voltage, type approval may be accepted as valid for cables of the same type with other conductor cross sectional areas and/or rated voltages provided the following three conditions are all satisfied:
- 1) The same material that is, insulation and semi-conducting screens, and manufacturing process are used.
 - 2) The conductor cross-sectional area is not larger than that of the tested cable.
 - 3) The rated voltage is not higher than that of the tested cable.

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 the purchaser and the 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 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.

3.6 Unearthed System - An electric system which does not fulfil the requirement of the earthed system (*see 3.5*).

SECTION 2 MATERIALS

4 CONDUCTOR

4.1 The conductor shall be of plain/tinned copper or aluminium wires complying with IS 8130.

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

5 INSULATION

5.1 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.

6 SCREENING

6.1 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.

6.1.1 *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.

7 FILLERS AND INNER SHEATH

7.1 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).

7.2 Unvulcanized rubber or thermoplastic material shall not be harder than PVC used for insulation (**5.1**) and for outer sheath (**9.1**). 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.

8 ARMOURING

8.1 Armouring shall be of the following types:

- a) Galvanized round steel wire, or
- b) Galvanized steel formed wires, or
- c) Any metallic non-magnetic wire/strip.

8.2 The galvanized round steel wires/formed steel wires (strips) used for armouring shall conform to IS 3975. The requirements of non-magnetic material shall be as agreed to between the purchaser and the supplier.

9 OUTER SHEATH

9.1 The outer sheath shall be of polyvinyl chloride (PVC) compound conforming to the requirements of Type STI compound of IS 5831.

9.2 For cables with improved fire performance, the outer sheath shall, in addition, meet the requirement of tests applicable for the required category (**19**)

SECTION 3 CONSTRUCTION

10 CONDUCTOR

10.1 The conductor shall be of stranded construction, size 25 mm² and above complying with Class 2 of IS 8130.

10.2 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.

11 CONDUCTOR SCREENING

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.

12 INSULATION

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

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

12.3 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 $0.1 \text{ mm} + 0.1 t_1$.

12.4 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.

*Low carbon galvanized steel wires, formed wires and tapes for armouring of cables - Specification

TABLE 1
THICKNESS OF INSULATION
(Clauses 12.2 and 12.3)

Sl.	Nominal Area Of Conductor	Thickness Of Insulation (T_1)				
		1.9/3.3 and 3.3/3.3 kV		3.8/6.6 kV		6.35/11kV
		Single core armoured cable	Single core unarmoured and 3 core cables	Single core armoured cables	Single core unarmoured and 3 core cable	Single core and 3-core cables
	mm ²	mm	mm	mm	mm	mm
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	25	2.6	2.3	3.9	3.6	4.2
2.	35	2.6	2.3	3.9	3.6	4.2
3.	50	2.6	2.3	3.9	3.6	4.2
4.	70	2.6	2.3	3.9	3.6	4.2
5.	95	2.6	2.3	3.9	3.6	4.2
6.	120	2.6	2.3	3.9	3.6	4.2
7.	150	2.6	2.3	3.9	3.6	4.2
8.	185	2.6	2.3	3.9	3.6	4.2
9.	240	2.6	2.3	3.9	3.6	4.2
10.	300	2.8	2.5	4.0	3.6	4.2
11.	400	3.1	2.7	4.0	3.6	4.2
12.	500	3.4	3.0	4.0	3.6	4.2
13.	630	3.9	3.4	4.1	3.6	4.2
14.	800	3.9	3.4	4.1	3.6	4.2
15.	1 000	3.9	3.4	4.1	3.6	4.2

13 INSULATION SCREENING

13.1 Cables rated for 6.35/11 kV shall be provided with insulation screening.

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

13.3 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.

13.4 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.

14 CORE IDENTIFICATION

14.1 Core identification for three-core shall be as follows:

Voltage Grade (kV)	Method of Identification
1.9/3.3	a) Different colour of the PVC insulation, or b) Colour strips applied on the cores, or c) By numerals (1, 2, 3), either by applying numbered strips or by printing on the cores.
3.3/3.3	
3.8/6.6	
6.35/11	a) Colour strips applied on the cores, or
	b) By numerals (1, 2, 3), either by applying numbered strips or by printing on the cores.

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

15 LAYING UP OF CORES

15.1 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.

16 INNER SHEATH (COMMON COVERING)

16.1 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.

16.2 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.

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

16.4 Thickness of Inner Sheath — The values of thickness of inner sheath shall be as given in **Table 2**.

16.4.1 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.

TABLE 2
THICKNESS OF INNER SHEATH
(Clause 16.4)

Sl.	Calculated Diameter over Stranded Cores [Refer IS 10462 (Part 1)]		Thickness of Inner Sheath (<i>Min</i>)
	Over	Up to and Including	
	mm	mm	
(1)	(2)	(3)	(4)
1.	—	25	0.3
2.	25	35	0.4
3.	35	45	0.5
4.	45	55	0.6
5.	55	—	0.7

17 ARMOURING

17.1 Application

17.1.1 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.

17.1.2 The armour wires/formed wires shall be applied as closely as possible with a coverage of not less than 90 percent. The determination of coverage of armour shall be done as per **Annex C**.

17.1.3 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, bituminized cotton tape, bituminized hessian tape, rubber tape or proofed tape between the inner and outer layers of armour wires.

17.1.4 A binder tape may be provided on the armour.

17.2 Type of Armour

17.2.1 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.

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

17.3 Dimensions - The dimensions of galvanized steel wires/strips shall be as specified in **Table 3**. "The tolerance on nominal dimensions shall be as per IS 3975. However, for formed steel wires compliance shall be ensured only for dimensions 'A' and 'C'(fig. 1 of IS 3975)."

17.4 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.

17.5 Resistance - In case of cables for use in mines, the resistance of armour shall not exceed that of conductor as specified in IS 8130 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.

17.6 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/mm² and not more 580 N/mm²,
- 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 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 subject to the following:
 - 1) The minimum number of dips shall be reduced by one half-minute dip
 - 2) 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.
- g) The mass of zinc coating of formed steel wire shall not be less than 95 percent of the mass specified in IS 3975.
- h) The resistivity of the round steel wire/formed steel wire shall meet the requirements of IS 3975.'

TABLE 3
DIMENSIONS OF ARMOUR – ROUND WIRES AND STRIPS
(Clause 17.3)

Sl.	Calculated Diameter of Cable Under Armour [Refer IS 10462 (Part 1)]		Nominal Thickness of Steel Strip	Nomnal Diameter of Round Armour Wire
	Over	Up to and Including		
	mm	mm		
(1)	(2)	(3)	(4)	(5)
1.	a)	For all diameter in excess of 13 or	0.8	—
2.	b)	—	13	1.40
3.		13	25	0.8
4.		25	40	0.8
5.		40	55	1.4
6.		55	70	1.4
7.		70	—	1.4

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

18 OUTER SHEATH

18.1 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 nonmagnetic metallic part of insulation screening in case of unarmoured single core cables, and
- b) Over the armouring in case of armoured cables,

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

18.3 Thickness of Outer Sheath

18.3.1 *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
(Clause 18.3.1 and 18.3.2)

Sl.	Calculated Diameter Under The outer Sheath [Refer IS 10462 (Part 1)]		Thickness of Outer Sheath for Unarmoured Cables	Minimum Thickness of Outer Sheath for Armoured Cable	
	Over	Up to and Including		Minimum	
	mm	mm	Nominal (t_s)	mm	mm

(1)	(2)	(3)	(4)	(5)	(6)
1.	—	15	1.8	1.24	1.24
2.	15	25	2.0	1.40	1.40
3.	25	35	2.2	1.56	1.56
4.	35	40	2.4	1.72	1.72
5.	40	45	2.6	1.88	1.88
6.	45	50	2.8	2.04	2.04
7.	50	55	3.0	2.20	2.20
8.	55	60	3.2	2.36	2.36
9.	60	65	3.4	2.52	2.52
10.	65	70	3.6	2.68	2.68
11.	70	75	3.8	2.84	2.84
12.	75	—	4.0	3.00	3.00

18.3.2 Armoured Cables - The thickness of outer sheath shall be not less than the minimum value specified in col 5 of **Table 4**.

SECTION 4 TESTS

19 CLASSIFICATION OF TESTS

19.1 The following shall constitute different tests as applicable.

<i>Sl. No.</i>	<i>Test</i>	<i>For Requirements, Refer to</i>	<i>Test Methods (Refer to Part No of IS 10810)</i>
(1)	(2)	(3)	(4)
a) Routine test			
1.	Conductor resistance test	IS 8130	5
2.	High voltage test	Cl. 20.7	45
3.	Partial discharge test (for 6.35/11 kV cables only), the partial discharge test shall be carried out on full drum length	Cl. 20.2	46
4.	Resistance test for armour (for mining cable)	Cl. 17.6 (g)	42
b) Acceptance test			
1.	Annealing test (for copper)	IS 8130	1
2.	Tensile Test ((for aluminium)	IS 8130	2
3.	Wrapping test (for aluminium)	IS 8130	3
4.	Conductor resistance test	IS 8130	5
5.	Test for thickness of insulation and sheath and overall diameter	Cl. 12, 16 and 18	6
6.	Tensile strength and elongation at break of insulation and outer sheath	IS 5831	7
7.	Partial discharge test (for 6.35/11 kV cables only), the partial discharge test shall be carried out on full drum length	Cl. 20.2	46
8.	High voltage test	Cl. 20.7	45
9.	Insulation resistance test	IS 5831	43
c) Type test			
1.	a) Tests on Conductor		

	1) Annealing test (for copper)	IS 8130	1
	2) Tensile test (for aluminium)	IS 8130	2
	3) Wrapping test (for aluminium)	IS 8130	3
	4) Resistance test	IS 8130	5
2.	b) Tests for round steel wire/formed steel wire (strip) armour:		
	1) Dimensions	Cl. 17.3	36
	2) Physical tests on round/formed wire:		
	i) Tensile strength	Cl. 17.6 (a)	37
	ii) Elongation at break	Cl. 17.6 (b)	37
	iii) Torsion test for round wires	Cl. 17.6 (c)	38
	iv) Winding test for formed wires	Cl. 17.6 (d)	39
	v) Uniformity of zinc coating	Cl. 17.6 (e)	40
	vi) Mass of zinc coating	Cl. 17.6 (f)	41
	vii) Resistivity	Cl. 17.6 (g)	42
3.	c) Test for thickness of insulation and sheath	Cl. 12, 16 and 18	6
4.	d) Physical tests for insulation and outer sheath (as applicable):		
	1) Tensile strength and elongation at break	IS 5831	7
	2) Ageing in air oven	IS 5831	11
	3) Shrinkage test	IS 5831	12
	4) Hot deformation test	IS 5831	15
	5) Loss of mass in air oven	IS 5831	10
	6) Heat shock test	IS 5831	14
	7) Thermal stability	IS 5831	60
	8) Water absorption (gravimetric for insulation, where applicable)	IS 5831	33
5.	e) Insulation resistance test	IS 5831	43
6.	f) Partial discharge test	Cl. 20.2	46
7.	g) Bending test	Cl. 20.3	50
8.	h) Dielectric power factor test	Cl. 20.4	48
	1) As a function of voltage		
	2) As a function of temperature		
9.	j) Heating cycle test	Cl. 20.5	49
10.	k) Impulse withstand test	Cl. 20.6	47
11.	m) High voltage test	Cl. 20.7	45
12.	n) Flammability test	Cl. 20.8	53
d) Optional test			
1.	Cold impact test	IS 5831	21
e) Additional type test for cables with improved fire performance as per Annex A			
	Category		
1.	01	No Additional tests	—
2.	C1	a) Oxygen Index test	20.9
		b) Flame retardance test on single cable	20.10
		c) Flame retardance test on bunched cable	20.11
		d) Temperature index	20.14

3.	C2	a) Oxygen index test	20.9	58
		b) Flame retardance test on single cable	20.10	61
		c) Flame retardance test on bunched cable	20.11	62
		d) Smoke density rating	20.12	IS 13360 (Part 6/Sec 9)
		e) Test for halogen acid gas evolution	20.13	59
		f) Temperature index	20.14	64
f) Additional acceptance test for cables with improved fire performance as per Annex A				
1.	C1	a) Oxygen Index test	20.9	58
		b) Flame retardance test on single cable	20.10	61
		c) Flame retardance test on bunched cable	20.11	62
2.	C2	a) Oxygen index test	20.9	58
		b) Flame retardance test on single cable	20.10	61
		c) Smoke density rating	20.12	IS 13360 (Part 6/Sec 9)
		d) Test for halogen acid gas evolution	20.13	59

19.1.1 Type test at (f), (g), (h), (j) and (k) are applicable to cables with screened cores, that is, 6-35/11 kV cables. It is permissible to carry out test (h) on different sample.

19.1.2 With the exception and provision of **19.1.1**, the following tests on screened cables shall be performed successively on the same test sample of completed cable not less than 10m 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.

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

19.2 A recommended sampling plan for acceptance tests is given in **Annex B**.

20 DETAILS OF TEST

20.1 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.

20.2 Partial Discharge Test - The partial discharge magnitude at test voltage equal to 1.5 U_o shall not exceed 40 percent.

20.3 Bending Test - The diameter of the test cylinder shall be 20 D ± 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 **20.2**.

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

a) As a Function of Voltage	
Tan δ at U _o	1000 × 10 ⁻⁴
Increment of tan δ between 0.5 U _o and 2 U _o	65 × 10 ⁻⁴
b) As a Function of Temperature	
Tan δ at ambient temperature	1000 × 10 ⁻⁴
At maximum continuous operating temperature, product of permittivity and tan δ	0.75

20.5 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 [**20.4(a)**] and partial discharge test (**20.2**).

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

20.7 High Voltage Test

20.7.1 Type/Acceptance Test — The cable shall withstand without breakdown an ac voltage equal to 3 U_o but not less than the value given in **20.7.2** 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 for maximum 30 minutes during 4 hour of period the test shall be extended for the interrupted period. If the interruption exceeds 30 minutes, the test shall be repeated.

20.7.2 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	10	10
3.8/6.6	12	20
6.35/11	17	—

20.8 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.

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

20.10 Flame Retardance Test on Single Cables - After the test, there should be no visible damages on the test specimen within 300 mm from upper end. Marks from fixing devices, soot or changing of the colour are not considered damages.

20.11 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 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.

20.12 Test for Smoke Density -Smoke density rating shall be 60 percent maximum.

20.13 Test for Halogen Acid Gas Evolution -The level of HCL evolved shall not exceed 20 percent by weight.

20.14 Test for Temperature Index- The temperature index shall be minimum 250°C at 21 percent of Oxygen Index.

SECTION 5 IDENTIFICATION, PACKING AND MARKING

21 IDENTIFICATION

21.1 Manufacturer's Identification — The manufacturer shall be identified throughout the length or 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.

21.2 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.

21.2.1 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

21.3 Cable Code - The following codes shall be used for designating the cables:

Sl.	Constituent	Code Letter
1.	Aluminium conductor	A
2.	Tinned Copper conductor	ATC
3.	PVC insulation	Y
4.	Steel round wire armour	W
5.	Non-magnetic round wire armour	Wa
6.	Steel strip armour	F
7.	Non-magnetic strip armour	Fa
8.	Double steel wire armour	WW
9.	Double steel strip armour	FF
10.	PVC outer sheath	Y

NOTE — When plain copper conductor material is used, no code letter is required for conductor.

22 PACKING AND MARKING

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

22.2 The cable shall carry the following information stenciled 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.

22.2.1 The cable (drum) may also be marked with the Standard Mark.

21.3 BIS Certification Marking - The use of the Standard Mark is covered by the provisions of the *Bureau of Indian Standards Act, 2016* and the Rules and Regulations made thereunder. The details of conditions under which the license for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

ANNEX A
CLASSIFICATION OF CABLES FOR IMPROVED FIRE PERFORMANCE
(Clauses Forward, 1.4, 19)

Category	Environment Description	Type	Cable Description
(1)	(2)	(3)	(4)
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

ANNEX B
SAMPLING OF CABLES
(Clause 19.2)

B-1. LOT

B-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.

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 requirements of the specification.

B-2.2 The number of samples to be selected shall be as given below:

Sl.	Number of drums in the lot	Number of drums to be Taken as sample	Permissible Number of Defectives
	(N)	(n)	(a)
(1)	(2)	(3)	(4)
	Up to 25	3	0
	26 to 50	5	0
	51 to 100	8	0
	101 to 300	13	1
	301 to 500	20	1
	501 and above	32	2

The samples shall be taken at random.

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

B-3. NUMBER OF TESTS AND CRITERION FOR CONFORMITY

B-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 (**19.2**). A test sample is called defective if it fails in anyone of the acceptance tests. If the number of defectives is less than or equal to the corresponding permissible number given in col 3 under **B-2.2**, the lot shall be declared as conforming to the requirements of acceptance tests, otherwise not.

ANNEX C **ARMOUR COVERAGE PERCENTAGE** (*Clause 17.1.2*)

$$\text{Percent Coverage} = \frac{N \times d}{w} \times 100$$

where

N = number of parallel wires,

d = diameter of wire / width of formed wires.

$$W = \pi \times D \times \cos a$$

D = diameter under armour

a = angle between armouring wire/formed wires and axis of cable.

$$\tan a = \pi \times D/C, \text{ and}$$

C = lay length of armouring wires/formed wires.



