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मानक

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“The Right to Information, The Right to Live”

“पुराने को छोड़ नये के तरफ”

Jawaharlal Nehru

“Step Out From the Old to the New”

IS 694 (2010): POLYVINYL CHLORIDE INSULATED UNSHEATHED AND SHEATHED CABLES/CORDS WITH RIGID AND FLEXIBLE CONDUCTOR FOR RATED VOLTAGES UP TO AND INCLUDING 450/750 V [ETD 9: Power Cables]



“ज्ञान से एक नये भारत का निर्माण”

Satyanarayan Gangaram Pitroda

“Invent a New India Using Knowledge”



“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”

Bhartrhari—Nitiśatakam

“Knowledge is such a treasure which cannot be stolen”

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भारतीय मानक

450/750 वोल्ट की और तक की कार्यकारिता वोल्टता के लिए
दढ़ और लचीले चालक वाली पोलिविनाइल क्लोराइड से
विद्युत रोधित अनावरित और आवरित केबल/डोरी
(चौथा पुनरीक्षण)

Indian Standard

POLYVINYL CHLORIDE INSULATED UNSHEATHED
AND SHEATHED CABLES/CORDS WITH RIGID AND
FLEXIBLE CONDUCTOR FOR RATED VOLTAGES
UP TO AND INCLUDING 450/750 V

(*Fourth Revision*)

ICS 621.315.211 [621.315.616.96]

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

FOREWORD

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

This standard was originally published in 1955 and was subsequently revised in 1964 when it was split up in two parts, Part 1 dealing with copper conductors and Part 2 dealing with aluminium conductors. Second revision was brought out in 1977 when the two parts were merged, including the requirements of weatherproof cables previously covered in IS 3035 (Part 1) : 1965 'Thermoplastic insulated weatherproof cables: Part 1 PVC insulated and PVC sheathed'. The two voltage grades specified as 250/440 V and 650/1 100 V were also merged. The third revision of this standard was brought out to take into account the experience gained since then to align with the international practices, to the extent considered appropriate.

Major changes in this revision include the following:

- a) Modification of the rated voltage up to and including 450/750 V ac in line with International Electrotechnical Commission (IEC) Specification.
- b) Inclusion of heat resistant PVC insulated and sheathed cable upto 85°C and inclusion of Type D insulation and ST3 type sheath for flexible cords for 70°C general application.
- c) Inclusion of flame retardant (FR) and flame retardant low smoke and halogen (FR-LSH) PVC cable.
- d) Introduction of reference number for each type of cable allocated for easy identification.
- e) Expansion of the scope of core identification expanded.
- f) Expansion of range of single and multi core sheathed and unsheathed cables.
- g) This standard has been divided into 3 sections.
- h) Clarity provided for testing different types of cables covered in this standard including test requirements of FR and FR-LSH PVC Cables.
- j) The range for single and multi core PVC insulated and sheathed cords defined.
- k) Inclusion of limited use of tinned copper conductor for special purpose cable.

While formulating this standard, assistance has been drawn from the following IEC and British Standards:

IEC 60227-1 (2007-10) Ed. 3.0	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V — Part 1: General requirements
IEC 60227-2 (2003-04) Ed. 2.1	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V — Part 2: Test methods
IEC 60227-2-am1 (2003-03) Ed. 2.0	Amendment 1 — Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V — Part 2: Test methods
IEC 60227-3 (1997-11) Ed. 2.1	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V — Part 3: Non-sheathed cables for fixed wiring
IEC 60227-3-am1 (1997-07) Ed. 2.0	Amendment 1 — Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V — Part 3: Non-sheathed cables for fixed wiring
IEC 60227-4 (1997-12) Ed. 2.1	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V — Part 4: Sheathed cables for fixed wiring
IEC 60227-4-am1 (1997-07) Ed. 2.0	Amendment 1 — Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V — Part 4: Sheathed cables for fixed wiring
IEC 60227-5 (2003-07) Ed. 2.2	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V — Part 5: Flexible cables (cords)

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IEC 60227-5-am2 (2003-06) Ed. 2.0	Amendment 2 — Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V — Part 5: Flexible cables (cords)
IEC 60719 (1992-03) Ed. 2.0	Calculation of the lower and upper limits for the average outer dimensions of cables with circular copper conductors and of rated voltages up to and including 450/750 V
IEC 60228 (2004-11) Ed. 3.0	Conductors of insulated cables
BS 6500 : 1984	Insulated flexible cords and cables

The composition of the Committee, responsible for the formulation of this standard is given at Annex B.

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 or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

AMENDMENT NO. 1 SEPTEMBER 2012
TO
IS 694 : 2010 POLYVINYL CHLORIDE INSULATED
UNSHEATHED AND SHEATHED CABLES/CORDS WITH
RIGID AND FLEXIBLE CONDUCTOR FOR RATED
VOLTAGES UP TO AND INCLUDING 450/750 V

(Fourth Revision)

(Foreword, para 2, last sentence) — Delete.

(Foreword, para 2) — Insert the following after para 2:

‘The third revision was brought out in 1990 in which the terms used for the type of cables for use under special conditions had been rationalized, single core flexible cables and five core flexible cords had been added, overall dimensions had been stipulated and reference to the Indian Standards on conductor, insulation, sheath and methods of tests had been added. Also for single core sheathed cables, the process of single extrusion of insulation and sheath had been deleted. The fourth revision of this standard has been brought out to take into account the experience gained since then to align with the international practices, to the extent considered appropriate.’

[Foreword, para 3 (d)] — Substitute the following for existing:

‘d) Thermal stability test included for both insulation and sheath.’

[Foreword, para 3 (e)] — Delete the word ‘expanded’.

(Page 1, clause 1.1, line 11) — Delete the word ‘category’.

(Page 1, clause 1.1, Note 3, last line) — Substitute ‘1 125 V’ for ‘1 500 V’.

Amendment No. 1 to IS 694 : 2010

(Page 1, clause 1.1, Note 9, Section 2) — Insert ‘Non-sheathed’ before ‘Single core’.

(Page 2, clause 3.6, para 2) — Substitute ‘expressed’ for ‘expresses’.

(Page 2, clause 4.1) — Substitute the following for existing clause:

‘4.1 Material

The conductor shall be composed of annealed, bare or tinned high conductivity copper wires complying with IS 8130.

The conductor shall be composed of aluminum wires complying with IS 8130.

A separator tape made of suitable material may be applied over conductor at the discretion of the manufacturer.’

[Page 3, clause 5.1 (c)] — Substitute the following for the existing:

‘c) Type D – Flexible cords’

(Page 6, clause 13, Informal table) — Insert ‘Earth continuity conductor ECC and suitable for low temperature SZ’ after PVC sheath.

(Page 6, clause 15.2(d), line 2) — Insert ‘and halogen’ after smoke.

[Page 7, Table 1, Sl No. (ii), (e), col 2] — Insert ‘and sheath’ after insulation.

[Page 7, Table 1, Sl No. (ii), (f), col 2] — Insert ‘and sheath’ after insulation.

[Page 7, Table 1, Sl No. (ii), (f), col 4] — Substitute ‘IS 5831’ for ‘IS 8130’.

[Page 7, Table 1, Sl No. (ii), (g), col 4] — Substitute ‘IS 5831’ for ‘IS 8130’.

Amendment No. 1 to IS 694 : 2010

[Page 7, Table 1, Sl No. (iii), (c) (8), col 3] — Substitute ‘02’ for ‘01,02,FR and FR-LSH’.

[Page 7, Table 1, Sl No. (iii), (c) (9), col 3] — Substitute ‘02, FR and FR-LSH’ for ‘01,02,FR and FR-LSH’.

[Page 7, Table 1, Sl No. (iii), (d) (11), col 2] — Insert the following after 11)

‘12) Cold bend test	02	IS 5831	20
13) Cold impact test	02	IS 5831	21’

[Page 7, Table 1, Sl No. (iii), (e) (2), col 2] — Delete and renumber the subsequent numbers.

(Page 9, Section 2) — Insert ‘NON-SHEATHED’ before SINGLE CORE CABLES in the title.

(Page 9, clause 16) — Substitute the following for the existing title:

‘SINGLE CORE NON-SHEATHED CABLES WITH RIGID CONDUCTOR (CLASS 1 OR CLASS 2) FOR GENERAL PURPOSE (70°C) OR HEAT RESISTANT (85°C)’

(Page 9, clause 17) — Substitute the following for the existing title:

‘SINGLE CORE NON-SHEATHED CABLES WITH FLEXIBLE CONDUCTOR FOR GENERAL PURPOSE (70°C) OR HEAT RESISTANT (85°C)’

(Page 10, clause 18) — Substitute the following for the existing title:

‘SINGLE AND MULTICORE CIRCULAR PVC INSULATED AND SHEATHED CABLES WITH RIGID CONDUCTOR (CLASS 1 OR CLASS 2) FOR GENERAL PURPOSE (70°C) OR HEAT RESISTANT (85°C)’

Amendment No. 1 to IS 694 : 2010

(Page 11, clause **18.2**) — Substitute the following for the existing clause:

‘18.2 Tests

The compliance with the requirement of **18.1** shall be checked by inspection and by tests given in Table 1.’

(Page 11, clause **19**) — Substitute the following for the existing title:

‘SINGLE AND MULTICORE CIRCULAR PVC INSULATED AND SHEATHED CABLES/CORDS WITH FLEXIBLE CONDUCTOR (CLASS 5) FOR GENERAL PURPOSE (70°C) OR HEAT RESISTANT (85°C)’.

(Page 12, clause **19.1.5**, para 1, line 1) — Substitute the following for the existing line

‘The sheath shall be PVC compound type ST3 in’.

(Page 12, clause **19.1.5**, para 4) — Substitute the following for the existing para:

‘The thickness of PVC sheath determined by taking average of number of measurements shall not be less than nominal value (t_s) specified in Table 5 for fixed installation and Table 6 for flexible PVC insulated and sheathed cables and Table 7 for flexible insulated and sheathed cords and flexible twin twisted and twin parallel cable by more than $0.1 \text{ mm} + 0.15 t_s$.’

(Page 12, clause **20**) — Substitute the following for the existing title:

‘MULTICORE CIRCULAR PVC INSULATED AND SHEATHED CABLES WITH FLEXIBLE CONDUCTOR (CLASS 5) FOR GENERAL PURPOSE (70°C) OR HEAT RESISTANT (85°C)’.

(Page 12, clause **20.1.3**, para 1, line 3) — Substitute ‘Lay-up of cores’ for ‘lay of cores’.

Amendment No. 1 to IS 694 : 2010

(Page 12, clause **20.1.4**, line 1) — Delete ‘For sheathed cable’.

(Page 13, Table 6, col 4 to col 8) — Substitute the following for the existing heading:
‘Nominal Thickness of sheath, t_s ’.

(Page 13, Table 7) — Substitute the following for the existing table heading:

‘Flexible PVC Insulated and Sheathed Cords (Circular) and Flexible Twisted Twin and Parallel Twin Cable’

(Page 13, Table 7, col 4 to col 8) — Substitute the following for the existing heading:

‘Nominal Thickness of Sheath, t_s ’.

(Page 14, clause **21**) — Substitute the following for the existing clause:

‘PARALLEL TWIN AND TWISTED TWIN FLEXIBLE PVC INSULATED NON-SHEATHED CORDS WITH FLEXIBLE CONDUCTOR (CLASS 5) FOR GENERAL PURPOSE (70°C) OR HEAT RESISTANT (85°C)’

(Page 12, clause **21.1.2**, line 5) — Substitute ‘Table 7’ for ‘Table 10’.

(Page 12, clause **21.1.3**, last sentence) — Substitute the following for the last line:

‘The dimension shall be as per Table 7 and the lay up of cores shall be as per Table 8.’

(Page 12, clause **20.1.4**, last para) — Delete ‘The sheath shall be absent in case of unsheathed cable’.

(Page 14, clause **22**) — Substitute the following for the existing clause:

Amendment No. 1 to IS 694 : 2010

‘TWO AND THREE CORE FLAT CABLES WITH PVC INSULATION AND SHEATH HAVING STRANDED OR FLEXIBLE CONDUCTOR (CLASS 2 OR CLASS 5) FOR GENERAL PURPOSE (70°C) OR HEAT RESISTANT (85°C)’

(ETD 09)

Reprography Unit, BIS, New Delhi, India

Indian Standard

POLYVINYL CHLORIDE INSULATED UNSHEATHED AND SHEATHED CABLES/CORDS WITH RIGID AND FLEXIBLE CONDUCTOR FOR RATED VOLTAGES UP TO AND INCLUDING 450/750 V

(*Fourth Revision*)

1 GENERAL

1.1 Scope

This standard covers general requirements of single and multicore cables/cords with rigid as well as flexible annealed bare/tinned copper and aluminium conductor, insulated and sheathed (if any) with polyvinyl chloride (PVC) for rated voltages up to and including 450/750 V ac, 50 Hz used in electric power and lighting including cables for outdoor and low temperature use. These cables may be used on dc systems for rated voltages up to and including 1 500 V to earth. This standard also includes cables with fire performance category in FR (Flame retardant) and category FR-LSH (Flame retardant low smoke and halogen) with conductor temperature not exceeding 70°C or 85°C. These cables require to qualify and comply the testing as specified in the respective category.

NOTES

1 The term cord is used for the flexible cables up to 5 cores covering the sizes up to 2.5 mm².

2 For cables for outdoor use, the cables shall meet requirements of additional ageing test given in Table 1.

3 The cables covered in this standard are suitable for use on ac single or three phase (earthed or unearthed) systems for rated voltages U_0/U up to and including 450 /750 V, 50 Hz. The cables may be used on dc system for rated voltages up to and including 1 500 V to earth.

4 The cables covered in this standard are suitable for use where the combination of ambient temperature and temperature rise due to load results in a continuous conductor temperature not exceeding 70°C or 85°C.

5 The following types of cables are not covered in this standard:

- a) Telephone cables,
- b) PVC data transmission cables,
- c) Instrumentation cables,
- d) PVC insulated screened communication cables (braid/wires/tapes), and
- e) Flexible power cord other than PVC insulated.

6 The tests specified in Sections 1, 2 and 3 shall meet the requirements specified in IS 8130 for conductors, IS 5831 for PVC insulation and sheath and tested as per the test methods given in relevant parts of IS 10810 series.

7 This standard covers the following categories of cables:

<i>Category Code</i>	<i>Environment Description</i>
01	Cables for indoor installation
02	Cables for outdoor installations
FR	Flame retardant
FR-LSH	Flame retardant low smoke and halogen

8 This standard does not cover the requirements of flame retardance test for bunched cables.

9 The specification is divided into following 3 sections, namely:

Section 1	General requirements
Section 2	Single core cables/cords for fixed and flexible wiring
Section 3	Sheathed single and multicore cables/cords for fixed and flexible wiring

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>
1885 (Part 32) :	Electrotechnical vocabulary: Part 32
1993/IEC 50-461 : 1984	Electric cables
4905 : 1968	Methods for random sampling
5831 : 1984	PVC insulation and sheath of electric cables
8130 : 1984	Conductors for insulated electric cables and flexible cords
10418 : 1982	Drums for electric cables
10810	Methods of test for cables:
(Part 0) : 1984	General
(Part 1) : 1984	Annealing test for wires used in conductors
(Part 2) : 1984	Tensile test for aluminium wires

<i>IS No.</i>	<i>Title</i>
(Part 3) : 1984	Wrapping test for aluminium wires
(Part 4) : 1984	Persulphate test of conductor
(Part 5) : 1984	Conductor resistance test
(Part 6) : 1984	Thickness of thermoplastic and elastomeric insulation and sheath
(Part 7) : 1984	Tensile strength and elongation at break of thermoplastic and elastomeric insulation and sheath
(Part 10) : 1984	Loss of mass test
(Part 11) : 1984	Thermal ageing in air
(Part 12) : 1984	Shrinkage test
(Part 14) : 1984	Heat shock test
(Part 15) : 1984	Hot deformation test
(Part 20) : 1984	Cold bend test
(Part 21) : 1984	Cold impact test
(Part 43) : 1984	Insulation resistance
(Part 44) : 1984	Spark test
(Part 45) : 1984	High voltage test
(Part 53) : 1984	Flammability test
(Part 58) : 1998	Oxygen index test
(Part 59) : 1988	Determination of the amount of halogen acid gas evolved during combustion of polymeric materials taken from cables
(Part 60) : 1988	Thermal stability of PVC insulation and sheath
(Part 64) : 2003	Measurement of temperature index

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 1885 (Part 32) and IS 10810 (Part 0) and the following shall apply.

3.1 Polyvinyl Chloride Compound (PVC) — Combination of materials suitably selected, proportioned and treated, of which the characteristic constituent is the plastomer polyvinyl chloride or one of its copolymers. The same term also designates compounds containing both polyvinyl chloride and certain of its polymers.

3.2 Type of Compound — The category in which a compound is placed according to its properties, as determined by specific tests. The type designation is not directly related to the composition of the compound.

3.3 Type Tests — Tests required to be made before supplying a type of cable covered by this standard on a general commercial basis in order to demonstrate satisfactory performance characteristics to meet the intended application. 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 or manufacturing process, which might change the performance characteristics.

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

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

3.6 Rated Voltage — The rated voltage of a cable is the reference voltage for which the cable is designed and which serves to define the electrical tests.

The rated voltage is expressed by the combination of two values U_0/U expressed in volts:

U_0 being the rms value between any insulated conductor and the earth.

U being the rms value between any two-phase conductors of multicore cable or of a system of single-core cables.

In an alternating current system, the rated voltage of a cable shall be at least equal to the nominal voltage of the system for which it is intended.

This condition apply both to the value U_0 and to the value U .

In direct current system the nominal voltage of the systems shall not be higher than 1.5 times the rated voltage of the cable.

3.7 Nominal Value — The value by which a quantity is designated and which is often used in tables. Usually, in this standard, nominal values give rise to values to be checked by measurements taking into account specified tolerances.

SECTION 1 GENERAL REQUIREMENTS

4 CONDUCTOR

4.1 Material

The conductors shall consist of annealed, bare or tinned of high conductivity copper wires complying with Class 1 or Class 2 or Class 5 as per IS 8130.

The conductor shall be composed of aluminium wires complying to IS 8130.

A separator tape made of suitable material may be applied over conductor at the discretion of the manufacturer. The aluminium conductors shall be of Class 1 or Class 2 as per IS 8130 for sizes up to and including 10 mm² and stranded type as per Class 2 of IS 8130 for the sizes above 10 mm².

4.2 Electrical Resistance

The resistance of each conductor at 20°C shall be in accordance with the requirements of IS 8130 for the given class of conductor.

Compliance shall be checked by the test given in Table 1, SI No. (i) (a).

The classes of the conductors relevant to the various types of cables are given in Section 2 and Section 3.

Conductors of cables for fixed installations shall be circular solid, circular stranded or compacted circular/shaped stranded conductors.

Nominal cross-sectional area of conductor of cables covered in this standard are given in respective tables.

In case of tinned copper conductor, the persulphate test shall be conducted as per IS 8130 and as per IS 10810 (Part 4).

5 INSULATION

5.1 Material

The insulation shall be of polyvinyl chloride compound of the type specified for each type of cable (*see also* Section 2 and Section 3):

- a) *Type A* — Cables for fixed installation
- b) *Type C* — Heat-resistant cables (HR)
- c) *Type D* — Flexible cables and cords

The PVC shall conform to IS 5831. The test requirements for this compound are as per IS 5831 and as mentioned in the respective sections.

The single core unsheathed cables (*see* Section 2) with fire performance for category FR and FR-LSH, the insulation shall satisfy the relevant special FR/FR-LSH properties. In case of sheathed cables with fire performance for category FR and FR-LSH (*see* Section 3), the insulation need not be with FR/FR-LSH properties.

5.2 Application to the Conductor

The insulation shall be so applied that it fits closely on the conductor. It shall be possible to remove it without damage to the insulation itself, to the conductor or to the tin coating, if any. Compliance shall be checked by inspection and by manual test.

5.3 Thickness

The mean value of the thickness of insulation shall be not less than the specified value for each type and size of cable shown in the relevant tables given in Section 2 and Section 3.

The smallest of the measured values of thickness of insulation (t_i) shall not fall below the nominal value (t_i) specified in the relevant table by more than $(0.1 \text{ mm} + 0.1 t_i)$.

5.4 Mechanical Properties before and after Ageing

The insulation shall have adequate mechanical strength

and elasticity within the temperature limits to which it may be exposed in normal use.

The compliance shall be checked by carrying out tensile strength and elongation test, for respective type of PVC, as per Table 1 of IS 5831. The applicable test values shall be obtained from Table 1 of IS 5831, for appropriate type of PVC.

6 FILLER

6.1 Material

The fillers shall be composed of one of the following or of any combination of the following:

- a) A compound based on unvulcanized rubber or plastics; or
- b) Natural or synthetic textiles; or
- c) Paper; or
- d) PVC

When the filler is composed of unvulcanized rubber, there shall be no harmful interactions between its constituents and the insulation and/or the sheath.

The filler material shall be suitable for operating temperature of the cable and compatible with other components of the cable. This shall not be harder than the PVC used for insulation and sheath.

6.2 Application

The fillers shall fill the spaces between the cores giving the assembly a practically circular shape. The fillers shall not adhere to be cores. The assembly of cores and fillers may be held together by a film or tape.

7 BINDER TAPE

Binder tape shall consist of plastic or proof textile material. This is optional and may be provided as per the agreement between the purchaser and the supplier.

8 SHEATH

8.1 Material

The sheath shall be polyvinyl chloride compound of the type specified for each type of cable (*see also* Section 3) as given below:

- a) *Type ST1* — cables for fixed installations
- b) *Type ST2* — cables sheathed with 85°C HRPVC compound
- c) *Type ST3* — flexible cables

The PVC shall conform to IS 5831. Test requirements for these compounds are as per Table 2 of IS 5831.

For the cables with fire performance category FR and FR-LSH, sheathing compound shall satisfy the relevant special FR/FR-LSH properties.

8.2 Application

The sheath shall be extruded in a single layer,

- a) on the core, in case of single-core cables; and
- b) on the assembly of cores and fillers or inner covering, if any, in case of other cables.

The sheath shall not adhere to the cores. A separator, consisting of a film or tape, or talcum powder may be placed under the sheath.

In certain cases, indicated in the particular specifications (*see* Section 3) the sheath may penetrate into the spaces between the cores, thus forming a filling.

8.3 Thickness

The mean value of the thickness shall not be less than the specified value for each type and size of cable shown in the tables of the Section 3. However, the thickness of PVC sheath determined by taking average of number of measurements, shall be not less than nominal value (t_s) specified in relevant tables and smallest of the measured value shall not fall below the nominal value (t_s) specified by more than $(0.1 \text{ mm} + 0.15 t_s)$.

Compliance shall be checked by testing the dimensional requirements specified in Section 3 and as per test method given in IS 10810 (Part 6).

8.4 Mechanical Properties Before and After Ageing

The sheath shall have adequate mechanical strength and elasticity within the temperature limits to which it may be exposed in normal use.

The compliance shall be checked by carrying out tensile strength and elongation test, and shall meet the requirements given in Table 2 of IS 5831, for respective type of PVC.

9 OVERALL DIMENSIONS

The mean overall dimensions of the cables shall be within the limits specified in the tables given in Section 2 and Section 3.

9.1 Ovality

The difference between maximum and minimum measured values of overall diameter of sheathed circular cables shall not exceed 15 percent of the maximum measured value at the same cross-section.

10 TESTS

The testing on the cables will be conducted as given in Table 1 for each category of the cable listed under scope.

10.1 High Voltage Test (Water Immersion Test)

The core shall be carefully removed from a sample approximately 3 m long from the finished multi core

cable. In case of single core cable, the cores should be selected from the coil. They shall be so immersed in a water bath at $60 \pm 3^\circ\text{C}$ that their ends protrude at least 200 mm above the water level. After 24 h, voltage of 3 kV (rms) shall be applied between conductors and water. This voltage shall be raised to 6 kV (rms) within 10 s and held constant at this value for 5 min. If the sample fails in this test, one more sample shall be subjected to this test, which should pass.

The cores which have passed the preliminary test given in 10.1 shall be subsequently tested with a dc voltage of 1.2 kV in the same water-bath at the same temperature.

The conductor shall be connected to the negative pole and water to the positive pole of dc supply by means of copper electrode. The core shall withstand this dc voltage test for total 240 h without breakdown.

10.2 High Voltage Test (at Room Temperature)

In case of multi core cables and cords, the same shall withstand without breakdown an ac voltage of 3 kV (rms) or a dc voltage of 7.2 kV applied for a period of 5 min for each test connection.

Single core cables shall be immersed in water at ambient temperature 1 h before the testing and the test voltage shall be applied between conductor and water for the specified period.

10.3 Spark Test

Spark test may be carried out as an alternate to high voltage as per IS 10810 (Part 44) on single core unsheathed cables. The voltage shall be as specified below:

<i>Thickness of Insulation</i> mm	<i>Test Voltage</i> kV (rms)
Up to and including 1.0	6
Above 1.0 and up to and including 1.5	10
Above 1.5 and up to and including 2.0	15
Above 2.0 and up to and including 2.5	20
Above 2.5	25

10.4 Flammability Test

The testing is conducted in accordance with IS 10810 (Part 53).

The period of burning after removal of flame shall not exceed 60 s and unaffected portion from the lower edge of the top clamp shall be at least 50 mm.

10.5 Oxygen Index Test

The test shall be conducted as per IS 10810 (Part 58) on samples at $27 \pm 2^\circ\text{C}$. The oxygen index shall not be less than 29 percent.

10.6 Test for Halogen Acid Gas Evolution

The test shall be conducted as per IS 10810 (Part 59). The level of halogen acid gas evolved shall not exceed 20 percent by weight.

10.7 Test for Temperature Index

The test shall be conducted as per IS 10810 (Part 64). The minimum measured value of temperature index shall be 21 percent at a temperature of 250°C

10.8 Smoke Density Rating

Under preparation.

10.9 Additional Ageing Test (for Cables for Outdoor Use)

These additional type tests shall be conducted on cables for outdoor use (Category 02 type).

10.9.1 Ageing of Sample

A sample, 6 m long, of the finished cable shall be suspended in a heating chamber and exposed to a temperature of $80 \pm 2^\circ\text{C}$ for a period of 168 h. Immediately after this, the sample shall be placed in a bath of boiling water for a period of 8 h and in a water-bath at $27 \pm 2^\circ\text{C}$ for 16 h. This procedure shall be repeated on 5 successive days. The ends of the sample shall always protrude at least 200 mm above the water level throughout the period and sequence of testing.

10.9.2 Testing and Evaluation

A sample, 5 m long, taken from the conditioned sample as stated above shall be tested for high voltage test in accordance with 10.2. The test has however, to be carried out on the finished cable and in a water batch at $60 \pm 3^\circ\text{C}$.

The remaining conditioned sample shall be submitted to cold bend or cold impact test as appropriate.

10.10 Flex Test

Under consideration

10.11 Persulphate Test

This test is conducted for the tinned copper conductor as per method specified in IS 10810 (Part 4) and the requirements are as per 6.1.1 of IS 8130.

11 IDENTIFICATION

The manufacturer shall be identified throughout the length of the cable by manufacturers' name or trade-mark being printed, indented 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 the scheme to be approved

by Bureau of Indian Standards shall be employed. The printing, indentation or embossing shall be done on the insulation in case of unsheathed cables and on the sheath in case of sheathed cables. The distance between any two consecutive printing, indentation or embossing shall not be more than 1 m

11.1 Durability

In case of printed marking, it shall be durable and compliance with the requirements. The compliance with requirement shall be checked by trying to remove the marking of manufacturer's name or trade-mark and the colours of cores or numerals by rubbing lightly ten times with a piece of cotton wool or cloth soaked in water.

11.2 Legibility

All markings shall be clear and legible. The colours of the identification threads shall be easy to recognize or easily made recognizable, if necessary, by cleaning with petrol or other suitable solvent.

12 CORE IDENTIFICATION

Each core shall be identified as follows:

- In case of cables for fixed wiring upto and including four cores shall be identified as per Table 2.
- The flexible cables/cords having upto and including 25 cores shall be marked as per the colour scheme given in Table 2.
- Any other colour scheme agreed to between the purchaser and manufacturer.

12.1 General Requirements

Identification of the cores of a cable shall be achieved by the use of coloured insulation or other suitable method. The colouring with skin type is allowed provided it meets the desired testing as given in the standard.

The colours shall be clearly identifiable and durable. Durability shall be checked by the test given in 3.1.

12.1.1 Colour Combination Yellow and Green

In case of yellow-green cables used for earthing, the distribution of the colours shall comply with the following condition:

For every 15 mm length of core, one of these colours shall cover at least 30 percent and not more than 70 percent of the surface of the core, the other colour covering the remainder.

12.2 Core Identification by Numbers

In case of core identification with help of numbering

instead of colour identification following shall be applicable. The insulation of the cores shall be of the same colour and numbered sequentially, except for the core coloured green-and-yellow, if one is included. The yellow-green core, if any, shall comply with the requirement of 12.1.1 and shall be in the outer layer. The numbering shall start by number 1 in the inner layer. The numbers shall be printed in Arabic numerals on the outer surfaces 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.

12.2.1 Preferred Arrangement of Marking

The numbers shall be repeated, at regular intervals along the core, consecutive numbers being inverted in relation to each other.

When the number is a single numeral, a dash shall be placed underneath it. If the number consists of two numerals, these shall be disposed one below the other and a dash placed below the lower numeral. The spacing between consecutive numbers shall not exceed 50 mm.

The arrangement of the marks is shown in Fig. 1.

12.2.2 Durability

Printed numerals shall be durable. Compliance with this requirement shall be checked by the test given in 11.1.

13 CABLE CODE

The following code shall be used for designating the cable:

Constituent	Code Letter
Aluminium conductor	A
PVC insulation	Y
PVC sheath	Y
Suitable for outdoor use	OU
PVC with FR properties	FR
PVC with FR-LSH properties	FR-LSH

NOTES

1 No code letter is required when the conductor material is copper.

2 In case of copper single core unsheathed PVC cable with FR or FR-LSH properties, the abbreviation FR or FR-LSH to be used after the complete cable code that is for example, Y (FR) or Y (FR-LSH).

3 In case of copper multicore PVC insulated and sheathed cable with FR or FR-LSH properties, the abbreviation FR or FR-LSH to be used after the cable code, that is for example YY (FR) or YY (FR-LSH)

14 SAMPLING OF CABLES

See Annex A.

15 PACKING AND MARKING

15.1 The cable shall be either wound on drums (*see* IS 10418) or reels or supplied in coils packed.

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

- Reference to this Indian Standard, for example, *see* IS 694;
- Manufacturer's name, brand name or trade-mark;
- Type of cable and voltage grade;
- In cases of flame retardant PVC the word 'FR' and in case of flame retardant low smoke type the word 'FR-LSH' to be used;
- Number of cores;
- Nominal cross-sectional area of conductor;
- In case of tinned copper conductor the word 'ATC' to be used;
- Cable code;
- Colour of core (in case of single core cables);
- Length of cable on the reel, drum or coil;
- Number of lengths on the reel, drum or coil (if more than one);
- Direction of rotation of drum (by means of arrow) in case packed in wooden drums;

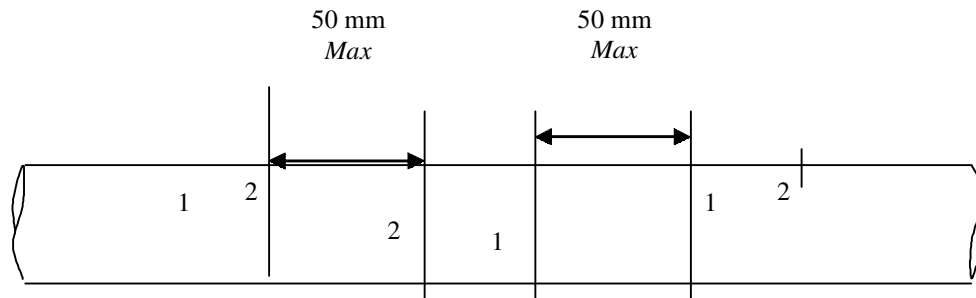


FIG. 1 PREFERRED ARRANGEMENT OF MARKING

Table 1 Tests
(Clauses 1.1, 4.2 and 10)

Sl No.	Test	Category	Requirements, Ref to IS No./ Clause of this Standard	Method of Test, Ref to Part of IS 10810
(1)	(2)	(3)	(4)	(5)
i)	<i>Routine tests:</i>			
a)	Conductor resistance test	01, 02, FR and FR-LSH	IS 8130	5
b)	High voltage test or Spark test	01, 02, FR and FR-LSH	10.2 or 10.3	45 or 44
ii)	<i>Acceptance tests:</i>			
a)	Annealing test (for copper)	01, 02, FR and FR-LSH	IS 8130	1
b)	Tensile test (for aluminium)	01, 02, FR and FR-LSH	IS 8130	2
c)	Wrapping test (for aluminium)	01, 02, FR & FR-LSH	IS 8130	3
d)	Conductor resistance test	01, 02, FR and FR-LSH	IS 8130	5
e)	Test for thickness of insulation	01, 02, FR and FR-LSH	As per relevant tables- Tables 3 to 10	6
f)	Tensile strength and elongation at break of insulation	01, 02, FR and FR-LSH	IS 8130	7
g)	Insulation resistance test	01, 02, FR and FR-LSH	IS 8130	43
h)	High voltage test or spark test	01, 02, FR and FR-LSH	10.2 or 10.3	45 or 44
J)	Flammability test	01, 02, FR and FR-LSH	10.4	53
k)	Oxygen index test	FR and FR-LSH	10.5	58
m)	Test for temperature index	FR and FR-LSH	10.7	64
n)	Test for halogen acid gas evaluation	FR-LSH	10.6	59
p)	Test for smoke density rating	FR-LSH	10.8	Under preparation
q)	Persulphate test (for tinned copper conductor cable only)	01, 02, FR and FR-LSH	10.11	4
iii)	<i>Type tests:</i>			
a)	Tests on conductor:			
1)	Annealing test (for copper)	01, 02, FR and FR-LSH	IS 8130	1
2)	Tensile test (for aluminium)	01, 02, FR and FR-LSH	IS 8130	2
3)	Wrapping test (for aluminium)	01, 02, FR and FR-LSH	IS 8130	3
4)	Conductor resistance test	01, 02, FR and FR-LSH	IS 8130	5
5)	Persulphate test (for tinned copper conductor cable only)	01, 02, FR and FR-LSH	10.11 and 6.1.1 of IS 8130	4
b)	Test for overall dimensions and thickness of insulation /sheath		As per relevant tables— Tables 3 to 10	6
c)	Physical tests for insulation:			
1)	Tensile strength and elongation at break	01, 02, FR and FR-LSH	IS 5831	7
2)	Loss of mass test	01, 02, FR and FR-LSH	IS 5831	10
3)	Ageing in air oven	01, 02, FR and FR-LSH	IS 5831	11
4)	Shrinkage test	01, 02, FR and FR-LSH	IS 5831	12
5)	Heat shock test	01, 02, FR and FR-LSH	IS 5831	14
6)	Hot deformation	01, 02, FR and FR-LSH	IS 5831	15
7)	Thermal stability	01, 02, FR and FR-LSH	IS 5831	60
8)	Cold bend test	01, 02, FR and FR-LSH	IS 5831	20
9)	Cold impact test	01, 02, FR and FR-LSH	IS 5831	21
10)	Flammability test	01, 02, FR and FR-LSH	10.4	53
11)	Oxygen index test	FR and FR-LSH	10.5	58
12)	Test for temperature index	FR and FR-LSH	10.7	64
13)	Test for halogen acid gas evaluation	FR-LSH	10.6	59
14)	Test for smoke density	FR-LSH	10.8	Under preparation
d)	Physical tests for sheath (removed from the finished cable):			
1)	Tensile strength and elongation at break	01, 02, FR and FR-LSH	IS 5831	7
2)	Loss of mass test	01, 02, FR and FR-LSH	IS 5831	10
3)	Ageing in air oven	01, 02, FR and FR-LSH	IS 5831	11
4)	Shrinkage test	01, 02, FR and FR-LSH	IS 5831	12
5)	Heat shock test	01, 02, FR and FR-LSH	IS 5831	14
6)	Hot deformation	01, 02, FR and FR-LSH	IS 5831	15
7)	Thermal stability	01, 02, FR and FR-LSH	IS 5831	60
8)	Oxygen index test	FR and FR-LSH	10.5	58
9)	Test for temperature index	FR and FR-LSH	10.7	64
10)	Test for halogen acid gas evaluation	FR-LSH	10.6	59
11)	Test for smoke density	FR-LSH	10.8	Under preparation
e)	Test on completed cable:			
1)	High voltage test (water immersion test)	01, 02, FR and FR-LSH	10.1	45

Table 1 (Concluded)

Sl No.	Test	Category	Requirements, Ref to IS No./ Clause of this Standard	Method of Test, Ref to Part of IS 10810
(1)	(2)	(3)	(4)	(5)
2)	High voltage test or Spark test	01, 02, FR and FR-LSH	10.2 or 10.3	45 or 44
3)	Insulation resistance	01, 02, FR and FR-LSH	IS 5831	43
4)	High voltage test	01, 02, FR and FR-LSH	10.2	45
5)	Flammability test	01, 02, FR and FR-LSH	10.4	53
6)	Additional ageing test (OU cables only)	02, FR and FR-LSH	10.9	—
7)	Flex test (flexible cords for sizes limited to 5 cores with cross-sectional area of 2.5 mm ²)	01, 02, FR and FR-LSH	10.10	Under consideration

NOTE — The properties/testing for FR /FR-LSH cables as mentioned in this standard is applicable only for the cables covered in this standard.

Table 2 Core Identification
(Clause 12)

Sl No.	No. of Cores	Cables for Fixed Wiring and Cords	Flexible Cables
(1)	(2)	(3)	(4)
i)	1	Red, black, yellow, blue, white, grey	Red, black, yellow, blue, white, grey
ii)	2	Red and black	Red and black
iii)	3	Red, yellow and blue	Red, black and yellow-green or red, yellow and blue
iv)	4	Red, yellow, blue and black	Red, yellow, blue and yellow-green or red, yellow, blue and black
v)	5	—	Red, yellow, blue, black and grey or yellow, blue, green white and yellow-green
vi)	6	—	Red, yellow, blue, green, white and yellow-green Alternatively insulation cores shall be of the same colour either in black or grey or any other colour in agreement with purchaser and the manufacturer with number coded and with yellow/green in outer most layer as last core
vii)	7	—	Red, yellow, blue, green, white, black and yellow-green Alternatively insulation cores shall be of the same colour either in black or grey or any other colour in agreement with purchaser and manufacturer with number coded and with yellow/green in outer most layer as last core
viii)	8	—	Red, yellow, blue, green, white, black, grey and yellow-green Alternatively insulation cores shall be of the same colour either in black or grey or any other colour in agreement with purchaser and manufacturer with number coded and with yellow/green in outer most layer as last core
ix)	9	—	Red, yellow, blue, green, white, black, grey, orange and yellow-green Alternatively insulation cores shall be of the same colour either in black or grey or any other colour in agreement with the purchaser and the manufacturer or number coded and with yellow/green in outer most layer as last core
x)	10	—	Red, yellow, blue, green, white, black, grey, orange, brown and yellow-green Alternatively insulation cores shall be of the same colour either in black or grey or any other colour in agreement with the purchaser and the manufacturer or number coded and with yellow/green in outer most layer as last core
xi)	11	—	Red, yellow, blue, green, white, black, grey, orange, brown, pink and yellow-green Alternatively insulation cores shall be of the same colour either in black or grey or any other colour in agreement with the purchaser and the manufacturer with number coded and with yellow/green in outer most layer as last core
xii)	12	—	Red, yellow, blue, green, white, black, grey, orange, brown, pink, violet and yellow-green Alternatively insulation cores shall be of the same colour either in black or grey or any other colour in agreement with the purchaser and the manufacturer with number coded and with yellow/green in outer most layer as last core

Table 2 (Concluded)

Sl No. (1)	No. of Cores (2)	Cables for Fixed Wiring and Cords (3)	Flexible Cables (4)
xiii)	13 to 25 cores	—	Two adjacent cores in each layer blue and yellow (reference and direction core), and other remaining cores — Grey or alternatively insulation cores shall be of the same colour either in black or grey or any other colour in agreement with the purchaser and the manufacturer with number coded and with yellow/green in outer most layer as last core

NOTES

1 In case of single-core cables used for control wiring of switchgear, any colour other than the above shall be permissible as agreed to between the purchaser and the supplier.

2 The colour of insulation for parallel twin flexible cords may be red, black, yellow, blue, white or grey. The cores may be identified by a longitudinal rib on one core.

3 In case of single core cables and cords, manufacturers may provide one or two longitudinal ribs (stripes) of suitable colour applied by extrusion. The above-mentioned colours shall however be used as base colours. The base colour shall cover a majority of the surface, so as to facilitate easy visual identification of the same. In case two ribs (stripes) are provided, they shall be diametrically opposite to each other.

4 For cables and cords with more than five cores, as an alternative, it is permissible to have all cores of the same colour. In such case, the cores shall be numbered sequentially (Hindu-Arabic numerals printed on the surface of the cores), starting with '1' for the innermost layer. The gap between two successive printings shall not exceed 50 mm.

- p) Approximate gross mass;
- q) Country of manufacture;
- r) Year of manufacture; and
- s) The word suitable for outdoor use, wherever applicable.

- a) 0.5 to 10.0 mm² : Class 1 and 2
- b) 16 mm² and above : Class 2

16.1.2 Insulation

Insulation shall be polyvinyl chloride compound of Type A or Type C (HR) as per IS 5831, applied around the conductor. The insulation thickness shall comply with the specified values given in col 4 of Table 3. The standard also covers cables with fire performance categories FR and FR-LSH.

The smallest of the measured values of thickness of insulation shall not fall below the nominal value (t_i) specified in Table 3 by more than $(0.1 \text{ mm} + 0.1 t_i)$.

16.1.3 Overall Diameter

The maximum overall diameter shall not exceed the value given in col 5 of Table 3.

16.2 Tests

Compliance with the requirements of 16.1 shall be checked by inspection and by the tests given in Table 1.

15.2.1 BIS Certification Marking

The cable (packed coil, reel, drum or label) may also be marked with the Standard Mark.

15.2.1.1 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 details of conditions under which a licence for the use of the Standard Mark may be granted to the manufacturers or producers may be obtained from the Bureau of Indian Standards.

SECTION 2 SINGLE CORE CABLES/CORDS FOR FIXED AND FLEXIBLE WIRING**16 SINGLE CORE NON-SHEATHED CABLES WITH RIGID CONDUCTOR (CLASS 1 OR CLASS 2) FOR GENERAL PURPOSE (MAXIMUM CONDUCTOR TEMPERATURE 70°C OR 80°C)****16.1 Construction****16.1.1 Conductor**

16.1.1.1 The conductor shall comply with requirements of IS 8130 for Class 1 for solid and for Class 2 for stranded conductor. The sizes covered for the conductor are:

17 SINGLE CORE NON-SHEATHED CABLES WITH FLEXIBLE CONDUCTOR FOR GENERAL PURPOSE (MAXIMUM CONDUCTOR TEMPERATURE 70°C OR 85°C)**17.1 Construction****17.1.1 Conductor**

17.1.1.1 The conductor shall comply with the requirements given in IS 8130 for Class 5 conductors. The sizes covered are from 0.5 to 300 mm².

17.1.2 Insulation

The insulation shall be PVC compounds of Type D or Type C (HR) as per IS 5831, applied around the conductor. The standard also covers cables with fire performance categories FR and FR-LSH.

The insulation thickness shall comply with specified values given col 3 of Table 4. However FR/FR-LSH cables shall meet properties given in Table 2, wherever applicable pertaining to this type of cable.

The smallest of the measured values of thickness of insulation shall not fall below the nominal value (t_i) specified in Table 4 by more than $(0.1 \text{ mm} + 0.1 t_i)$.

17.1.3 Overall Diameter

The maximum overall diameter shall not exceed the value given in col 4 of Table 4.

17.2 Tests

Compliance with requirement of **17.1** shall be checked by inspection and by the test given in Table 1.

SECTION 3 SHEATHED SINGLE AND MULTICORE CABLES/CORDS FOR FIXED AND FLEXIBLE WIRING

18 SINGLE AND MULTICORE CIRCULAR PVC INSULATED AND SHEATHED CABLES WITH RIGID CONDUCTOR (CLASS 1 AND CLASS 2) FOR GENERAL PURPOSE) FOR MAXIMUM CONDUCTOR TEMPERATURE (70°C OR 85°C)

18.1 Construction**18.1.1 Conductor**

18.1.1.1 The conductor shall comply with requirements of IS 8130 Class 1 for solid and Class 2 for stranded conductor.

- a) No. of cores — 1, 2, 3, or 4
- b) Sizes — 1.0 to 120 mm²

18.1.2 Insulation

The insulation shall be of PVC of Type A or Type C

Table 3 Dimensions of Single Core Non-sheathed Cables with Rigid Conductor (Class 1 or Class 2) for General Purpose (Maximum Conductor Temperature 70°C or 85°C)
(Clauses 16.1.2 and 16.1.3)

Sl No.	Nominal Cross-Sectional Area of Conductor mm ²	Class of Conductor	Thickness of Insulation Nominal (t_i) mm	Maximum Overall Diameter mm
(1)	(2)	(3)	(4)	(5)
i)	0.5	1	0.6	2.3
ii)	0.75	1	0.6	2.5
iii)	1.0	1	0.6	2.7
iv)	1.5	1	0.7	3.2
v)	1.5	2	0.7	3.3
vi)	2.5	1	0.8	3.9
vii)	2.5	2	0.8	4.0
viii)	4.0	1	0.8	4.4
ix)	4.0	2	0.8	4.6
x)	6.0	1	0.8	5.0
xi)	6.0	2	0.8	5.2
xii)	10.0	1	1.0	6.4
xiii)	10.0	2	1.0	6.7
xiv)	16.0	2	1.0	7.8
xv)	25.0	2	1.2	9.7
xvi)	35.0	2	1.2	10.9
xvii)	50.0	2	1.4	12.8
xviii)	70.0	2	1.4	14.6
xix)	95.0	2	1.6	17.1
xx)	120.0	2	1.6	18.8
xxi)	150.0	2	1.8	20.9
xxii)	185.0	2	2.0	23.3
xxiii)	240.0	2	2.2	26.6
xxiv)	300.0	2	2.4	29.6
xxv)	400.0	2	2.6	33.2
xxvi)	500.0	2	2.8	37.5
xxvii)	630.0	2	3.0	42

Table 4 Single Core Non-sheathed Cable with Flexible Conductor for General Purpose (for Maximum Conductor Temperature 70°C or 85°C)
(Clause 17.1.2)

Sl No.	Nominal Cross-Sectional Area of Conductor	Thickness of Insulation Nominal (t_i)	Maximum Overall Diameter
(1)	mm ² (2)	mm (3)	mm (4)
i)	0.5	0.6	2.6
ii)	0.75	0.6	2.8
iii)	1.0	0.6	3.0
iv)	1.5	0.7	3.4
v)	2.5	0.8	4.1
vi)	4.0	0.8	4.8
vii)	6.0	0.8	5.3
viii)	10.0	1.0	7.0
ix)	16.0	1.0	8.1
x)	25.0	1.2	10.2
xi)	35.0	1.2	11.7
xii)	50.0	1.4	13.9
xiii)	70.0	1.4	16.0
xiv)	95.0	1.6	18.2
xv)	120.0	1.6	20.2
xvi)	150.0	1.8	22.5
xvii)	185.00	2.0	24.9
xviii)	240.0	2.2	28.4
xix)	300.0	2.4	31.0

(HR) as per IS 5831, applied around the conductor. The thickness shall comply with specified values given in Table 5.

The smallest of the measured values of thickness of insulation shall not fall below the nominal value (t_i) specified in the relevant table by more than $(0.1 \text{ mm} + 0.1 t_i)$.

18.1.3 Assembly of Cores

For cables with 2 cores and above, the cores shall be twisted together to form the core assembly.

18.1.4 Sheath

The sheath shall be PVC compound of Type ST1 in case of 70°C and ST2 (HR) in case of HR PVC type as per IS 5831, applied around the laid up cores. In case of cables with fire performance category FR and FR-LSH, the necessary care shall be taken for formulation to meet the additional special testing. The sheath shall fit closely and shall be capable of being removed without damage to the inner core. The sheath thickness shall comply with specified values given in Table 5.

The thickness of PVC sheath determined by taking average (t_s) of number of measurements, shall not be less than nominal value (t_s) specified in Table 5 and the smallest of the measured values shall not fall below nominal value specified in Table 5 by more than $0.1 \text{ mm} + 0.15 t_s$.

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

18.1.5 Ovality

The difference between maximum and minimum

measured values of overall diameter of sheathed circular cables shall not exceed 15 percent of the maximum measured values at the same cross-section.

18.1.6 Overall Dimensions

The mean overall dimensions shall be within the upper limit as given in Table 5.

18.2 Tests

The compliance with the requirement of 18.1 and shall be checked by inspection by test given in Table 1.

19 SINGLE AND MULTICORE CIRCULAR PVC INSULATED AND SHEATHED CABLES/CORDS WITH FLEXIBLE CONDUCTOR (CLASS 5) FOR GENERAL PURPOSE (MAXIMUM CONDUCTOR TEMPERATURE 70°C OR 85°C)

19.1 Construction

19.1.1 Flexible Cable

19.1.1.1 The conductors shall comply with requirements given in IS 8130 for Class 5.

- Conductor material*— Annealed bare copper or annealed tinned copper
- No. of conductors* — 1, 2, 3, 4 and 5 core cable
- Sizes covered* — 4.00 to 300 mm²

NOTE — In general annealed tinned copper being used up to 16 mm² only.

19.1.2 Flexible Cords

19.1.2.1 The conductors shall comply with requirements given in IS 8130 for Class 5.

- a) *Conductor material* — Annealed bare copper or annealed tinned copper
- b) *No. of conductors* — 1, 2, 3, 4 and 5 core cords
- c) *Sizes covered* — 0.5 to 2.50 mm²

19.1.3 Insulation

The insulation shall be PVC compound Type D in case of general purpose and Type C (HR) in case of HR PVC type cable as per IS 5831, applied around each conductor. The insulation thickness shall comply with specified values given in Table 6 for flexible cable and Table 7 for flexible cords.

The smallest of the measured values of thickness of insulation shall not fall below the nominal value (t_i) specified in the relevant table by more than $(0.1 \text{ mm} + 0.1 t_i)$.

19.1.4 Assembly of Cores

In case of circular cables with 2 core and above, the cores shall be twisted together to form core assembly as recommended in Table 8.

19.1.5 Sheath

The sheath shall be PVC compound type PVC ST3 in case of general purpose and ST2 (HR) in case of HR PVC type as per IS 5831, applied around the cores. In case of cables with improved fire performance FR and FR-LSH, the necessary care shall be taken for formulation to meet the additional special testing. The sheath thickness shall comply with the specified values given in Table 6 for flexible cable and Table 7 for flexible cords.

The sheath may fill the space between cores thus forming a filling, but it shall not adhere to the cores. The assembly of cores may be surrounded by a separator, which shall not adhere to cores.

The assembly of circular cord shall have a practically circular cross-section.

The thickness of PVC sheath determined by taking average of number of measurements, shall not be less than nominal value (t_s) specified in Table 4 and the smallest of the measured values shall not fall below nominal value specified in Table 6 or Table 7 for flexible cables and flexible cords respectively by more than $0.1 \text{ mm} + 0.15 t_s$.

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

19.1.6 Ovality

The difference between maximum and minimum measured values of overall diameter of sheathed circular cables shall not exceed 15 percent of the maximum measured values at the same cross-section.

19.1.7 Overall Dimensions

The mean overall dimensions of circular cords shall be within the limits given in Table 6.

19.2 Tests

Compliance with the requirements of 19.1 shall be checked by inspection and by tests given in Table 1.

20 MULTICORE CIRCULAR PVC INSULATED AND SHEATHED CABLES WITH FLEXIBLE CONDUCTOR (CLASS 5) FOR GENERAL PURPOSE (FOR MAXIMUM CONDUCTOR TEMPERATURE 70°C OR 85°C)

20.1 Construction

20.1.1 Conductor

20.1.1.1 The conductor shall comply with the requirements given in IS 8130 for Class 5 conductor.

- a) *No. of conductor* — 6 to 25 cores
- b) *Sizes covered* — 0.5 to 2.5 mm²

20.1.2 Insulation

The insulation shall be PVC compound Type D in case of general purpose and Type C (HR) in case of HR PVC type as per IS 5831, applied around each conductor.

The insulation thickness shall comply with the specified value given in Table 9.

The smallest of the measured values of thickness of insulation (t_i) shall not fall below the nominal value (t_i) specified in the relevant table by more than $(0.1 \text{ mm} + 0.1 t_i)$.

20.1.3 Assembly of Cores and Fillers

The cores shall be twisted together, where appropriate, in several concentric layers, as the case may be. The recommended plan for lay of cores is given in Table 8.

Around each layer a tape may be applied as per the agreement between the purchaser and the supplier, which may cover cores fully or partially. The tape shall not adhere to the cores.

20.1.4 Sheath

For sheathed cable, the sheath shall be of PVC compound type ST3 in case of general PVC or ST2 (HR) type in case of HR PVC cables as per IS 5831, applied around the laid up cores. In case of cables with improved fire performance category FR and FR-LSH, the necessary care shall be taken for formulation to meet the additional special testing. An optional tape may be applied between the cores and outer sheath. The thickness (t_s) of PVC sheath determined by taking

average of number of measurements, shall not be less than nominal value (t_s) specified in Table 9 and the

smallest of the measured values shall not fall below nominal value by more than $0.1 \text{ mm} + 0.15 t_s$.

Table 5 PVC Insulated Circular Sheathed Cables for Fixed Wiring (Circular)
(Clauses 18.1.2, 18.1.4 and 18.1.6)

SI No.	Nominal Cross-Sectional Area of Conductor mm ²	Nominal Thickness of Insulation (t_i) mm	Nominal Thickness of Sheath (t_s)				Overall Dimensions, Max			
			Single Core	Two Core	Three Core	Four Core	Single Core	Two Core	Three Core	Four Core
(1)	(2)	(3)	mm (4)	mm (5)	mm (6)	mm (7)	mm (8)	mm (9)	mm (10)	mm (11)
i)	1.0 ¹⁾	0.6	0.8	0.9	0.9	0.9	4.7	8.2	8.6	9.2
ii)	1.5	0.6	0.8	0.9	0.9	0.9	5.0	8.8	9.2	10.0
iii)	2.5	0.7	0.8	1.0	1.0	1.0	5.8	10.5	11.0	12.0
iv)	4	0.8	0.9	1.0	1.1	1.1	6.8	12.0	13.0	14.0
v)	6	0.8	0.9	1.1	1.1	1.2	7.8	13.5	14.5	15.5
vi)	10	1.0	0.9	1.2	1.2	1.3	8.8	16.5	17.5	19.5
vii)	16	1.0	1.0	1.3	1.3	1.4	10.5	19.0	20.0	22.5
viii)	25	1.2	1.1	1.4	1.5	1.6	12.5	23.0	24.5	27.5
ix)	35	1.2	1.1	1.5	1.6	1.7	13.5	25.5	27.5	30.5
x)	50	1.4	1.2	1.6	1.7	1.8	15.5	29.5	31.5	35.0
xi)	70	1.4	2.4	2.4	2.5	2.8	17.5	35.0	37.0	41.4
xii)	95	1.6	1.5	2.7	2.9	3.1	21.0	40.5	43.2	48.1
xiii)	120	1.6	1.5	2.9	3.1	3.4	22.5	44.0	47.3	52.8

¹⁾ For copper conductor only.

Table 6 Flexible PVC Insulated and Sheathed Cables (Circular)
(Clauses 19.1.3, 19.1.5 and 19.1.7)

SI No.	Nominal Cross-Sectional Area of Conductor mm ²	Nominal Thickness of Insulation (t_i) mm	Nominal Thickness of Sheath					Overall Diameter, Max				
			Single Core	Two Core	Three Core	Four Core	Five Core	Single Core	Two Core	Three Core	Four Core	Five Core
(1)	(2)	(3)	mm (4)	mm (5)	mm (6)	mm (7)	mm (8)	mm (9)	mm (10)	mm (11)	mm (12)	mm (13)
i)	4	0.8	1	1	1	1	1.1	6.8	11.6	12.4	13.6	15.3
ii)	6	0.8	1.1	1.1	1.2	1.2	—	7.5	13.0	13.8	15.47	—
iii)	10	1	1.3	1.3	1.4	1.4	—	9.4	16.5	17.69	19.5	—
iv)	16	1	1.4	1.4	1.4	1.4	—	10.9	19.4	20.6	23.0	—
v)	25	1.2	1.4	1.4	1.5	1.6	—	13.6	23.8	25.6	28.5	—
vi)	35	1.2	1.6	1.6	1.6	1.7	—	15.5	27.2	29.3	32.7	—
vii)	50	1.4	2.0	2.0	2.0	2.0	—	18.1	32.0	34.6	38.6	—
viii)	70	1.4	2.2	2.2	2.2	2.2	—	20.8	36.8	39.6	44.3	—
ix)	95	1.6	2.4	2.4	2.4	2.4	—	23.6	41.8	47.0	50.2	—
x)	120	1.6	2.5	2.5	2.5	2.5	—	26.0	46.2	51.0	55.7	—
xi)	150	1.8	—	—	2.6	2.6	—	—	—	54.8	62.1	—
xii)	185	2	—	—	2.8	2.8	—	—	—	61.2	68.5	—
xiii)	240	2.2	—	—	3.0	3.0	—	—	—	69.7	77.9	—
xiv)	300	2.4	—	—	3.2	3.2	—	—	—	75.7	84.7	—

Table 7 Dimensions of Flexible PVC Insulated and Sheathed Cords (Circular) and Flexible Twin Twisted and Twin Parallel Cable
(Clauses 19.1.3 and 19.1.5)

SI No.	Nominal Cross-Sectional Area of Conductor	Nominal Thickness of Insulation (t_i)	Nominal Sheathing Wall Thickness					Overall Dimension, Max						
			Single Core	Twin Core	Three Core	Four Core	Five Core	Single Core	Twin Core	Three Core	Four Core	Five Core	Parallel Twin	Twisted Twin
(1)	mm ² (2)	mm (3)	mm (4)	mm (5)	mm (6)	mm (7)	mm (8)	mm (9)	mm (10)	mm (11)	mm (12)	mm (13)	mm (14)	mm (15)
i)	0.5	0.6	0.9	0.9	0.9	0.9	0.9	4.3	6.9	7.3	8.0	8.7	2.6 × 5.2	5.2
ii)	0.75	0.6	0.9	0.9	0.9	0.9	0.9	4.5	7.3	7.7	8.4	9.2	2.8 × 5.6	5.6
iii)	1.0	0.6	0.9	0.9	0.9	0.9	1.0	4.7	7.6	8.1	8.8	9.6	3.0 × 6.0	6.0
iv)	1.5	0.6	0.9	0.9	0.9	1.0	1.0	5.4	8.9	9.4	10.4	11.4	3.3 × 6.6	6.6
v)	2.5	0.7	1.0	1.0	1.0	1.0	1.0	6.2	10.3	10.9	12.0	13.2	4.0 × 8.0	8.0
vi)	4	0.8	—	—	—	—	—	—	—	—	—	—	4.8 × 9.6	9.6

Table 8 Recommended Lay-up of Cores
(Clauses 19.1.4, 20.1.3 and 21.1.3)

Sl No. (1)	No. of Cores (2)	Lay-up (3)
i)	2	2
ii)	3	3
iii)	4	4
iv)	5	5
v)	6	6
vi)	7	1-6
vii)	8	1-7
viii)	9	1-8
ix)	10	2-8
x)	11	3-8
xi)	12	3-9
xii)	13	3-10
xiii)	14	4-10
xiv)	15	5-10
xv)	16	5-11
xvi)	17	5-12
xvii)	18	0-6-12
xviii)	19	1-6-12
xix)	20	1-7-12
xx)	21	1-7-13
xxi)	22	2-7-13
xxii)	23	2-8-13
xxiii)	24	2-8-14
xxiv)	25	2-8-15

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

The sheath shall be absent in case of unsheathed cable.

20.1.5 Ovality

The difference between maximum and minimum measured values of overall diameter of sheathed circular cables shall not exceed 15 percent of the maximum measured values at the same cross-section.

20.2 Tests

The compliance with the requirements of **20.1** above shall be checked by inspection and tests given in Table 1.

21 PARALLEL TWIN AND TWISTED TWIN FLEXIBLE PVC INSULATED UNSHEATHED CORDS (CLASS 5) FOR GENERAL PURPOSE (FOR MAXIMUM CONDUCTOR TEMPERATURE 70°C OR 85°C)

21.1 Construction

21.1.1 Conductor

21.1.1.1 The conductor shall comply with the requirements given in IS 8130 class 5 conductor.

- No. of conductor* — 2
- Sizes covered* — 0.5 to 4.0 mm²

21.1.2 Insulation

The insulation shall be PVC compound Type D in case

of general purpose and Type C (HR) in case of HR PVC type as per IS 5831, applied around each conductor. The insulation thickness shall comply with the specified value given in Table 10. The smallest of the measured values of thickness of insulation (t_i) shall not fall below the nominal value (t_i) specified in the relevant table by more than (0.1 mm + 0.1 t_i).

21.1.3 Assembly of Cores

The cores shall be twisted together for twin twisted cables with lay. For twin parallel cables, the cables shall be laid parallel to each other. The construction and dimensions shall be as given in Table 8.

21.2 Tests

The compliance with the requirements of **21.1** shall be checked by inspection and tests given in Table 1.

22 TWO AND THREE CORE FLAT CABLES WITH PVC INSULATION AND SHEATHED (CLASS 2 OR 5) FOR GENERAL PURPOSE (FOR MAXIMUM CONDUCTOR TEMPERATURE 70°C OR 85°C)

22.1 Construction

22.1.1 Conductor

22.1.1.1 The conductor shall comply with the requirements given in IS 8130.

- No. of conductors* — 2 and 3.
- For 1.5 and 2.5 mm² the conductor shall be

Table 9 Flexible PVC Insulated and Sheathed Cables (Circular)
(Clauses 20.1.2 and 20.1.4)

Sl No.	No. of Cores	0.50 mm ²				0.75 mm ²				1.00 mm ²				1.50 mm ²				2.50 mm ²			
		Nominal Thickness of Insulation	Nominal Sheathing	Overall Dimension <i>Max</i>		Nominal Thickness of Insulation	Nominal Sheathing	Overall Dimension <i>Max</i>		Nominal Thickness of Insulation	Nominal Sheathing	Overall Dimension <i>Max</i>		Nominal Thickness of Insulation	Nominal Sheathing	Overall Dimension <i>Max</i>		Nominal Thickness of Insulation	Nominal Sheathing	Overall Dimension <i>Max</i>	
(1)	(2)	mm (3)	mm (4)	mm (5)		mm (6)	mm (7)	mm (8)		mm (9)	mm (10)	mm (11)		mm (12)	mm (13)	mm (14)		mm (15)	mm (16)	mm (17)	
i)	6	0.6	0.9	9.5		0.6	1.0	10.0		0.6	1.0	10.5		0.6	1.0	12.4		0.7	1.1	14.5	
ii)	7	0.6	0.9	9.5		0.6	1.0	10.0		0.6	1.0	10.5		0.6	1.0	12.4		0.7	1.1	14.5	
iii)	8	0.6	1.0	11.1		0.6	1.0	11.8		0.6	1.0	12.4		0.6	1.1	14.7		0.7	1.2	17.3	
iv)	9	0.6	1.0	11.8		0.6	1.1	12.4		0.6	1.1	13.1		0.6	1.1	15.6		0.7	1.3	18.3	
v)	10	0.6	1.0	12.0		0.6	1.1	12.7		0.6	1.1	13.4		0.6	1.1	16.0		0.7	1.3	18.7	
vi)	11	0.6	1.0	12.0		0.6	1.1	12.7		0.6	1.1	13.4		0.6	1.1	16.0		0.7	1.3	18.7	
vii)	12	0.6	1.0	12.4		0.6	1.1	13.1		0.6	1.1	13.9		0.6	1.1	16.5		0.7	1.3	19.4	
viii)	13	0.6	1.0	13.1		0.6	1.1	13.8		0.6	1.1	14.6		0.6	1.2	17.4		0.7	1.3	20.5	
ix)	14	0.6	1.1	13.1		0.6	1.1	13.8		0.6	1.1	14.6		0.6	1.2	17.4		0.7	1.3	20.5	
x)	15	0.6	1.1	13.5		0.6	1.2	14.3		0.6	1.2	15.1		0.6	1.2	18.1		0.7	1.4	21.3	
xi)	16	0.6	1.1	13.8		0.6	1.2	14.6		0.6	1.2	15.4		0.6	1.2	18.4		0.7	1.4	21.7	
xii)	17	0.6	1.1	14.6		0.6	1.2	15.4		0.6	1.2	16.3		0.6	1.3	19.5		0.7	1.4	23.0	
xiii)	18	0.6	1.1	14.6		0.6	1.2	15.4		0.6	1.3	16.3		0.6	1.3	19.5		0.7	1.4	23.3	
xiv)	19	0.6	1.1	14.6		0.6	1.2	15.4		0.6	1.3	16.3		0.6	1.3	19.5		0.7	1.4	23.8	
xv)	20	0.6	1.2	15.4		0.6	1.3	16.3		0.6	1.4	17.3		0.6	1.4	20.7		0.7	1.5	24.4	
xvi)	21	0.6	1.2	15.4		0.6	1.3	16.3		0.6	1.4	17.3		0.6	1.4	20.7		0.7	1.5	25.0	
xvii)	22	0.6	1.2	16.3		0.6	1.3	17.3		0.6	1.4	18.2		0.6	1.4	21.9		0.7	1.5	25.8	
xviii)	23	0.6	1.2	16.3		0.6	1.3	17.3		0.6	1.4	18.2		0.6	1.4	21.9		0.7	1.5	26.3	
xix)	24	0.6	1.2	17.1		0.6	1.3	18.2		0.6	1.4	19.2		0.6	1.4	23.0		0.7	1.5	27.2	
xx)	25	0.6	1.2	17.1		0.6	1.3	19.0		0.6	1.4	19.2		0.6	1.4	23.0		0.7	1.5	27.9	

- either stranded (Class 2) or flexible (Class 5).
- c) For 0.50 mm², 0.75 mm², 1.00 mm², 4 mm² and above, the conductor shall be flexible (Class 5).
- d) Sizes covered are 0.5 to 95 mm² for 3 cores flat and 0.5 to 50 mm² for flat twin.

22.1.2 Insulation

The insulation shall be PVC compound Type A in case of general purpose or Type C (HR) in case of HR PVC type as per IS 5831, applied around each conductor.

The insulation thickness (t_i) shall comply with the specified value given in Table 10.

The smallest of the measured values of thickness of insulation (t_i) shall not fall below the nominal value (t_i) specified in the relevant table by more than $(0.1 \text{ mm} + 0.1 t_i)$.

22.1.3 Assembly of Cores

The cores shall be laid in the flat formation.

22.1.4 Sheath

The sheath shall be PVC compound type ST1 in case of general purpose PVC or ST2 (HR) type in case of HR PVC cables as per IS 5831, applied around the laid up cores. In case of cables with improved fire performance category FR and FR-LSH, the necessary care shall be taken for formulation to meet the additional special testing. An optional tape may be applied between the cores and outer sheath. The thickness (t_s) of PVC sheath determined by taking average of number of measurements, shall not be less than nominal value (t_s) specified in Table 10 and the smallest of the measured values shall not fall below nominal value by more than $0.1 \text{ mm} + 0.15 t_s$.

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

22.2 Tests

The compliance with the requirements of 22.1 above shall be checked by inspection and tests given in Table 1.

Table 10 Dimensions of Insulated and Sheathed Two and Three Core Flat Cables
(Clauses 21.1.2, 22.1.2 and 22.1.4)

Sl No.	Nominal Cross-Sectional Area of Conductor	Nominal Thickness of Insulation (t_i)	Nominal Thickness of Sheath (t_s)	Overall Dimensions, Max ($W \times H$)	
				2 Core	3 Core
(1)	mm ² (2)	mm (3)	mm (4)	mm (5)	mm (6)
i)	0.5	0.6	0.9	7.2 × 4.9	9.6 × 4.9
ii)	0.75	0.6	0.9	7.8 × 5.2	10.5 × 5.2
iii)	1.0	0.6	0.9	8.0 × 5.4	11.0 × 5.4
iv)	1.5	0.6	0.9	8.6 × 5.6	10.7 × 5.3
v)	2.5	0.7	1.0	10.5 × 6.6	13.0 × 6.2
vi)	4.0	0.8	1.0	12.0 × 7.4	15.3 × 7.1
vii)	6.0	0.8	1.1	13.0 × 8.0	19.2 × 8.4
viii)	10.0	1.0	1.4	16.0 × 9.6	24.2 × 10.4
ix)	16.0	1.0	1.4	18.5 × 11.0	29.0 × 12.4
x)	25.0	1.2	2.0	22.5 × 13.0	36.5 × 15.7
xi)	35.0	1.2	2.0	25.5 × 14.5	40.5 × 17.2
xii)	50.0	1.4	2.2	29.0 × 16.5	46.5 × 19.3
xiii)	70.0	1.4	2.2	—	52.0 × 21.0
xiv)	95.0	1.6	2.4	—	61.0 × 24.5

ANNEX A

(Clause 14)

SAMPLING OF CABLES**A-1 LOT**

In any consignment the cables of the same size and type 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 requirement of the specification.

A-2.2 The number of samples to be selected shall depend on col 1 and col 2 of table 11. These samples shall be taken at random.

A-2.2.1 In order to ensure the randomness of selection, procedure given in IS 4905 may be followed.

A-3 NUMBER OF TESTS AND CRITERION FOR CONFORMITY

From each of the drum/coils/reels selected according

to col 1 and col 2 of Table 11, suitable lengths of test samples shall be taken. These test samples shall be subjected to each of the acceptance tests. 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 of Table 11, the lot shall be declared as conforming to the requirements of the acceptance tests; otherwise not.

Table 11 Sampling of Cables

(Clauses A-2.2 and A-3)

Number of Drums/Coils/ Reels in the Lot	Number of Drums/Coils/Reels to be Taken as Sample	Permissible Number of Defectives
(N) (1)	(n) (2)	(a) (3)
Up to 50	3	0
51-100	5	0
101-300	8	0
301 and above	13	1

ANNEX B

(Foreword)

COMMITTEE COMPOSITION

Power Cables Sectional Committee, ETD 09

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Universal Cables Ltd, Satna	SHRI R. C. AGRAWAL
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Southern	: C.I.T. Campus, IV Cross Road, CHENNAI 600113	{ 2254 1216, 2254 1442 2254 2519, 2254 2315
Western	: Manakalaya, E9 MIDC, Marol, Andheri (East) MUMBAI 400093	{ 2832 9295, 2832 7858 2832 7891, 2832 7892

Branches: AHMEDABAD. BANGALORE. BHOPAL. BHUBANESHWAR. COIMBATORE. DEHRADUN. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. KANPUR. LUCKNOW. NAGPUR. PARWANOO. PATNA. PUNE. RAJKOT. THIRUVANANTHAPURAM. VISAKHAPATNAM.