***भारतीय मानक Indian Standards***

**IS 7098 (Part 1): 2024**

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 *(दूसरा पुनरीक्षण)*

**Specification for Crosslinked Polyethylene Insulated**

**Thermoplastic Sheathed Cables**

**Part 1 for Working Voltages Up To and Including 1100 Volts**

*(Second Revision)*

 ICS 29.060.20

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**भारतीय मानक ब्यूरो**

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FOREWORD

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

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

Other two parts of this series of Indian Standards cover cross-linked polyethylene insulated thermoplastic sheathed cables of following grades:

Part 2 For working voltages from 3.3 kV up to and including 33 kV,

Part 3 For working voltages from 66 kV up to and including 220 kV

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

Attention is drawn to the fact that cables with Category C3 (*see* **Annex A**), which are sheathed with low smoke and halogen free (LSHF) compound are mechanically not comparable with other categories of cables. Such cables are not intended for outdoor installations and should also be handled and installed with sufficient care to protect them against mechanical damage, exposure to corrosive substances or solvents, UV radiations as well as excessive heat.

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

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 results of a test, shall be rounded off in accordance with IS 2: 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

***Indian Standard***

SPECIFICATION FOR

CROSS-LINKED POLYETHYLENE INSULATED THERMOPLASTIC SHEATHED CABLES

**PART 1 FOR WORKING VOLTAGES UP TO AND INCLUDING 1100 VOLTS**

(*Second Revision*)

**SECTION 1 GENERAL**

**1. SCOPE**

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

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

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

**1.3** Armoured cables specified in this standard are suitable for use in mines also. However, for such cables, additional requirements have been included wherever necessary (**4.1.1, 14.5.2** and **18.2**).

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

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

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

**2. REFERENCES**

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

|  |  |
| --- | --- |
| *IS No.* | *Title* |
| IS 1885 (Part 32) : 2019 | Electrotechnical Vocabulary Part 32 Electric Cables (*Second Revision*) |
| IS 3961 (Part 6): 2016 | Recommended Current Ratings for Cables Part 6 Crosslinked Polyethylene Insulated PVC Sheathed Cables |
| IS 3975:1999 | Low carbon galvanized steel wires, formed wires and tapes for armouring 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-  | Methods of test for cables |
| (Part 1):1984 | Methods of test for cables: Part 1 annealing test for wires used as conductors |
| (Part 2):1984 | Methods of test for cables: Part 2 tensile test for aluminium wires |
| (Part 3):1984 | Methods of test for cables: Part 3 wrapping test for aluminium wires |
| (Part 5):1984 | Methods of test for cables: Part 5 conductor resistance test |
| (Part 6):1984 | Methods of test for cables: Part 6 thickness of thermoplastic and elastomeric insulation and sheath |
| (Part 7):1984 | Methods of test for cables: Part 7 tensile strength and elongation at break of thermoplastic and elastomeric insulation and sheath |
| (Part 10):1984 | Methods of test for cables: Part 10 loss of mass test |
| (Part 11):1984 | Methods of test for cables: Part 11 thermal ageing in air |
| (Part 12):1984 | Methods of test for cables: Part 12 shrinkage test |
| (Part 14):1984 | Methods of test for cables: Part 14 heat shock test |
| (Part 15):1984 | Methods of test for cables: Part 15 hot deformation test |
| (Part 21):1984 | Methods of test for cables: Part 21 cold impact test |
| (Part 30):1984 | Methods of test for cables: Part 30 hot set test |
| (Part 32):1984 | Methods of test for cables: Part 32 carbon content test for polyethylene |
| (Part 36):1984 | Methods of test for cables: Part 36 dimensions of armouring material |
| (Part 37):1984 | Methods of test for cables: Part 37 tensile strength and elongation at break of armouring materials |
| (Part 45):1984 | Methods of test for cables: Part 45 high voltage test |
| (Part 53):1984 | Methods of test for cables: Part 53 flammability test |
| (Part 58):1998 | Method of tests for cables: Part 58 oxygen index test |
| (Part 59):1988 | Part 59 determination of the amount of halogen acid gas evolved during combustion of polymeric materials taken from cables |
| (Part 60):1988 | Methods of test for cables: Part 60 thermal stability of PVC insulation and sheath |
| (Part 62):1993 | Method of tests for cables: Part 62 flame retardance test for bunched cables |
| (Part 63):1993 | Method of tests for cables: Part 63 measurement of smoke density of electric cables under fire conditions |
| (Part 64):2003 | Methods of test for cables: Part 64 measurement of temperature index |
| IS 13360 (Part 6/Sec 9): 2001  | Plastics - Methods of testing: Part 6 Thermal properties Section 9 Determination of density of smoke from the burning or decomposition of plastics |
| IS 16269:2018 | Recommended Short Circuit Ratings of Electric Cables with Rated Voltage from 1.1 kV to 220 kV — Specification |
| IS 17505 (Part 1) : 2021 | Specification for Thermosetting Insulated Fire Survival Cables for Fixed Installation having Low Emission of Smoke and Corrosive Gases when Affected by Fire for Working Voltages upto and including 1 100 V ac and 1 500 V dc |

**3.** **TERMINOLOGY**

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

**3.1 Routine Test -** Tests 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 Test -** Tests intended to prove that the quality and design of a given type of cable are in accordance with the specifications.

NOTES

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

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

a) The same grade of insulation (ie, XLPE) and manufacturing process are used,

b) The conductor cross-sectional area is not larger 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 purchaser and supplier.

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

1. 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;
2. The neutral-point or the mid-point connection is not earthed but a protective device is installed which automatically cuts out any part of the system which accidently becomes earthed: or
3. In case of ac systems only, the neutral point is earthed through an arc suppression coil with arrangement for isolation within 1 h of occurrence of the fault for the non-radial field cables and within 8 h for radial cables provided that the total of such periods in a year does not exceed 125 h.

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

**SECTION 2 MATERIALS**

**4. CONDUCTOR**

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

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

NOTE— Tinned copper conductors can be used on agreement between manufacture and purchaser.

**5. INSULATION**

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

**Table 1**

 **Properties of XLPE Insulation**

*(Clause* 5.1*)*

|  |  |  |
| --- | --- | --- |
| **Sl No** | **Property** | **Requirement** |
| (1) | (2) | (3) |
|  | Tensile Strength | 12.5 N/mm2(Min) |
|  | Elongation at break | 200 % (Min) |
|  | Ageing in air oven  a) Treatment: -Temperature -Durationb) Variation in Tensile Strength, from that without ageingc) Variation in Elongation at break, from that without ageing | 135 + 3ºC7 days+ 25 % (Max)+ 25 % (Max) |
|  | Hot set a) Treatment:  -Temperature  -Time under load  -Mechanical Stressb) Elongation under loadc) Permanent elongation after cooling | 200 + 3ºC15 Minutes20 N/cm2175 % (Max) 15 % (Max) |
|  | Shrinkage a) Treatment:  -Temperature  -Durationb) Shrinkage | 130 + 3ºC1 h4.0 % (Max) |
|  | Water absorption (gravimetric) a) Treatment:  -Temperature  -Durationb) Water absorbed | 85 + 2ºC14 days1 mg/cm2 (Max) |
|  | Volume resistivity:a) at 270Cb) at 900C | 1x1014 ohm-cm (Min)1x1012 ohm-cm (Min) |

**6. FILLER AND INNER SHEATH**

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

1. Vulcanized or unvulcanized rubber, or
2. Thermoplastic materials

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

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

**7. ARMOURING**

**7.1** Armouring shall be of the following:

1. Galvanized round steel wire, or
2. Galvanized formed steel wire (strip), or
3. Any metallic non-magnetic wire / strip

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

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

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

**8. OUTER SHEATH**

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

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

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

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

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

**Table 1A**

 **Properties of PE sheathing compound**

***(****Clause*8.3*)*

|  |  |  |
| --- | --- | --- |
| **Sl No** | **Properties** | **Requirement** |
| (1) | (2) | (3) |
|  | Before aginga) Tensile Strengthb) Elongation at break | 12.5 N/mm2 (Min)300 % (Min)  |
|  | Ageing in air oven:a) Treatment  -Temperature -Durationb) Elongation at break | 110 + 20C7 days300 % (Min) |
|  | Hot Deformation Test -Temperature  -Duration -Depth of Indentation  | 110 ± 20C6 hours50 % (Max) |
|  | Carbon black content (For Black sheath only) | 2.5 + 0.5% |

**Table 1B**

 **Properties of LSHF sheathing compound**

***(****Clause*6.3, 8.4*)*

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl No** | **Properties** | **Type ST8 \*** | **Type ST12 \*** |
| **Requirement** | **Requirement** |
| (1) | (2) | (3) | (4) |
|  | Before ageing- Tensile Strength- Elongation at break | 9.0 N /mm2 (Min)125 % (Min) | 12.5 N /mm2 (Min)300 % (Min) |
|  | After ageing in air oven- Temperature- Duration- Tensile Strength- Variation in Tensile strength, from that without ageing- Elongation at break- Variation in Elongation at break, from that without ageing | 100 + 2 0C 7 days9.0 N /mm2 (Min) ± 40 % (Max)100 % (Min)  ± 40 % (Max) | 110 + 2 0C 10 days10.0 N /mm2 (Min) ± 30 % (Max)300 % (Min) - |
|  | Hot Deformation Test - Temperature  -Duration -Depth of Indentation  | 80 ± 20C4 hours50 % (Max) | 110 ± 20C4 hours50 % (Max) |
|  | Water absorption (Gravimetric method) -Temperature  -Duration - Increase in mass | 70 + 20C24 hours10 mg/cm2 (Max) | Not applicable |
|  | pH - Conductivity- HCL | 4.3 (Min)10 µS/mm (Max)0.5% (Max) | 4.3 (Min)10 µS/mm (Max)0.5% (Max) |
|  | Cold Bend Test  -Temperature  -Duration | No cracks-15 ± 20C3 hours | No cracks-15 ± 20C3 hours |
| Cold elongation -Temperature  -Duration  | 20% (Min)-15 ± 20C3 hours | 20% (Min)-15 ± 20C3 hours |
| Cold Impact test  - Temperature  - Duration  | No cracks-15 ± 20C3 hours | No cracks-15 ± 20C3 hours |
|  | Shrinkage Test-Temperature-Duration-Shrinkage | Not applicable | 80 ± 20C5 hours3% (Max) |

**SECTION 3 CONSTRUCTION**

**9. CONDUCTOR**

**9.1** The construction of the conductor shall be as follows:

|  |  |  |
| --- | --- | --- |
| **Nominal Cross section** | **Solid/****Stranded** | **Flexibility class (ref IS 8130)** |
| **Copper mm2** | **Aluminium mm2** |
| (1) | (2) | (3) | (4) |
| - | 1.5 | Solid | 1 |
| 1.5- 6 | 2.5 - 10 | Solid/Stranded | 1 for solid2 for stranded |
| 10 and above | 16 and above | Stranded | 2 |

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

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

**TABLE 2**

**CROSS SECTIONAL AREA OF REDUCED NEUTRAL CONDUCTORS**

(*Clause* 9.3 *and* 14.6)

|  |  |
| --- | --- |
| **Nominal Cross Sectional Area of Phase Conductor**  | **Cross Sectional Area of Reduced Neutral Conductor** |
| **mm2** | **mm2** |
| (1) | (2) |
| 25 | 16 |
| 35 | 16 |
| 50 | 25 |
| 70 | 35 |
| 95 | 50 |
| 120 | 70 |
| 150 | 70 |
| 185 | 95 |
| 240 | 120 |
| 300 | 150 |
| 400 | 185 |
| 500 | 240 |
| 630 | 300 |

**10. INSULATION**

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

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

**TABLE 3**

 **THICKNESS OF INSULATION**

***(****Clauses*10.2 *and* 10.3*)*

|  |  |
| --- | --- |
| **Nominal Area of conductor**  | **Nominal thickness of Insulation (ti)** |
| **Single-core armoured cables** | **Single-core armoured and Multi-core cables** |
| mm2 | mm | mm |
| (1) | (2) | (3) |
| 1.5 | 1.0 | 0.7 |
| 2.5 | 1.0 | 0.7 |
| 4 | 1.0 | 0.7 |
| 6 | 1.0 | 0.7 |
| 10 | 1.0 | 0.7 |
| 16 | 1.0 | 0.7 |
| 25 | 1.2 | 0.9 |
| 35 | 1.2 | 0.9 |
| 50 | 1.3 | 1.0 |
| 70 | 1.4 | 1.1 |
| 95 | 1.4 | 1.1 |
| 120 | 1.5 | 1.2 |
| 150 | 1.7 | 1.4 |
| 185 | 1.9 | 1.6 |
| 240 | 2.0 | 1.7 |
| 300 | 2.1 | 1.8 |
| 400 | 2.4 | 2.0 |
| 500 | 2.6 | 2.2 |
| 630 | 2.8 | 2.4 |
| 800 | 3.1 | 2.6 |
| 1 000 | 3.3 | 2.8 |

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

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

**11. CORE IDENTIFICATION**

**11.1** Cores shall beidentified as specified below:

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

1 Core : Red, black, yellow, blue or natural;

2 Core : Red and black;

3 Core : Red, yellow and blue;

4 Core : Red, yellow, blue and black;

5 Core : Red, yellow, blue, black and grey;

6 Core and above: Two adjacent cores (counting and direction core) in each layer, blue and yellow, remaining cores, grey; or

1. By numerals either by applying numbered strips or by printing on the cores as follows *(see* **NOTE 2**):

2 Core : 0 and 1

3 Core : 0,1 and 2

4 Core : 0,1,2 and 3

NOTES

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

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

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

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

**11.4** For reduced neutral conductors, the core shall have ‘0’ number.

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

**12. LAYING UP OF CORES**

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

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

**TABLE 4**

 **LAY UP OF CORES FOR CABLES**

**(***Clause*12.2)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No of cores** | **Lay-up** | **No of cores** | **Lay-up** | **No of cores** | **Lay-up** |
| (1) | (2) | (3) | (4) | (5) | (6) |
| 2 | 2 | 35 | 5-12-18 | 68 | 2-8-14-19-25 |
| 3 | 3 | 36 | 0-6-12-18 | 69 | 2-8-14-20-25 |
| 4 | 4 | 37 | 0-6-12-18 | 70 | 2-8-14-20-26 |
| 5 | 5 | 38 | 1-6-12-19 | 71 | 2-8-14-20-27 |
| 6 | 6 | 39 | 1-6-13-19 | 72 | 2-8-14-21-27 |
| 7 | 1-6 | 40 | 1-7-13-19 | 73 | 3-9-15-20-26 |
| 8 | 1-7 | 41 | 1-7-13-20 | 74 | 3-9-15-21-26 |
| 9 | 1-8 | 42 | 2-8-13-19 | 75 | 3-9-15-21-27 |
| 10 | 2-8 | 43 | 2-8-14-19 | 76 | 3-9-15-21-28 |
| 11 | 3-8 | 44 | 2-8-14-20 | 77 | 3-9-15-22-28 |
| 12 | 3-9 | 45 | 2-8-14-21 | 78 | 4-10-15-21-28 |
| 13 | 3-10 | 46 | 3-9-14-20 | 79 | 4-10-16-22-27 |
| 14 | 4-10 | 47 | 3-9-15-20 | 81 | 4-10-16-22-29 |
| 15 | 5-10 | 48 | 3-9-15-21 | 82 | 4-10-16-23-29 |
| 16 | 5-11 | 49 | 3-9-15-22 | 83 | 4-10-17-23-29 |
| 17 | 5-12 | 50 | 3-9-16-22 | 84 | 5-11-17-23-28 |
| 18 | 0-6-12 | 51 | 4-10-16-21 | 85 | 5-11-17-23-29 |
| 19 | 1-6-12 | 52 | 4-10-16-22 | 86 | 5-11-17-23-30 |
| 20 | 1-7-12 | 53 | 4-10-16-23 | 87 | 5-11-17-24-30 |
| 21 | 1-7-13 | 54 | 4-10-17-23 | 88 | 5-11-18-24-30 |
| 22 | 2-7-13 | 55 | 4-11-17-23 | 89 | 0-6-11-18-24-30 |
| 23 | 2-8-13 | 56 | 5-11-17-23 | 90 | 0-6-12-18-24-30 |
| 24 | 2-8-14 | 57 | 5-11-17-24 | 91 | 1-6-12-18-24-30 |
| 25 | 2-8-15 | 58 | 5-11-18-24 | 92 | 1-6-12-18-24-31 |
| 26 | 3-9-14 | 59 | 5-12-18-24 | 93 | 1-6-12-18-25-31 |
| 27 | 3-9-15 | 60 | 0-6-12-18-24 | 94 | 1-6-12-19-25-31 |
| 28 | 3-9-16 | 61 | 1-6-12-18-24 | 95 | 1-6-13-19-25-31 |
| 29 | 4-10-15 | 62 | 1-6-12-18-24 | 96 | 1-7-13-19-25-31 |
| 30 | 4-10-16 | 63 | 1-7-12-18-25 | 97 | 1-7-13-19-26-31 |
| 31 | 4-10-17 | 64 | 1-7-13-18-25 | 98 | 2-8-13-19-25-31 |
| 32 | 5-11-16 | 65 | 1-7-13-19-25 | 99 | 2-8-14-19-25-31 |
| 33 | 5-11-17 | 66 | 1-7-13-19-26 | 100 | 2-8-14-20-25-31 |
| 34 | 5-11-18 | 67 | 2-8-13-19-25 | - | - |

NOTES

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

2. This table is for guidance only.

3. Assembly co-efficient are as per IS 10462 (Part 1). In case of number of cores above 48, the assembly co-efficient (not available in IS 10462 (Part 1) shall be as agreed between purchaser and supplier.

**13. INNER SHEATH (COMMON COVERING)**

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

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

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

**Table 5**

 **Thickness of Inner Sheath**

(*Clause* 13.3 *and* 15.3.1)

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

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

**14.** **ARMOURING**

**14.1 Application**

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

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

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

**14.1.4** A binder tape may be provided on the armour.

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

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

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

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

**Table 6**

 **Diameter of armour wires**

*(Clause* 14.3 *and* 14.6*)*

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

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

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

**14.5 Resistance**

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

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

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

1. The tensile strength of rounds steel wire / formed steel wire shall be not less than 250 N/mm2 and not more 580 N/mm2.
2. The elongation at break of round steel wire / formed steel wire shall be not less than 6 percent.
3. 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.
4. The zinc coating shall not show any cracks and shall not flake off on robbing by the bare finger when the formed steel wire is subjected to winding test.
5. The uniformity of zinc coating of round steel wire / formed steel wire shall comply with the requirements of IS 3975 subject to the following:

-The minimum number of dips shall be reduced by one half-minute dip.

-In case of formed wires dip test is applicable only for the face.

1. 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.

The mass of zinc coating of formed steel wire shall be not less than 95 percent of the mass specified in IS 3975.

1. The resistivity of the round steel wire / formed steel wire shall meet the requirements of IS 3975.

**15.** **OUTER SHEATH**

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

1. over the insulation in case of unarmoured single core cables;
2. Over the inner sheath in case of unarmoured twin, three and multicore cables; and
3. Over armouring in case of armoured cables.

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

**15.3** **Thickness of Outer Sheath**

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

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

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

**Table 7**

 **Thickness of Outer Sheath**

*(Clause* 15.3.1 and 15.3.2*)*

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

**SECTION 4 TESTS**

**16. Classification of Tests**

**16.1 Type Tests:** The following shall constitute type test:

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl.** | **Test** | **Ref of****Requirements** | **Ref of****Test Method of IS 10810** |
|  | a) Test 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 |
|  | b) Test for round steel wire / formed steel wire armour |  |  |
| 1) Dimensions  | **14.3** | 36 |
| 2) Physical tests on round wires / formed wires |  |  |
|  i) Tensile strength | **14.6** (a) | 37 |
|  ii) Elongation at break | **14.6** (b) | 37 |
|  iii) Torsion test for round wires | **14.6** (c) | 38 |
|  iv) Winding test for formed wires | **14.6** (d) | 39 |
|  v) Uniformity of zinc coating | **14.6** (e) | 40 |
|  vi) Mass of zinc coating | **14.6** (f) | 41 |
|  vii) Resistivity | **14.6** (g) | 42 |
|  | c)Test for thickness of insulation and sheath | **10,13** and **15,** Tables **3**,**5** and **7** | 6 |
|  | d) Physical tests for insulation |  |  |
|  1) Tensile strength and Elongation at break | Table 1 | 7 |
| 2) Ageing in air oven | Table 1 | 11 |
| 3) Hot set test | Table 1 | 30 |
| 4) Shrinkage Test | Table 1 | 12 |
| 5) Water absorption (gravimetric) | Table 1 | 33 |
|  | e) Physical tests for outer sheath |  |  |
| 1) PVC Sheath |  |  |
|  i) Tensile strength and Elongation at break | IS 5831 | 7 |
|  ii) Ageing in air oven | IS 5831 | 11 |
|  iii) Loss of mass in air oven | IS 5831 | 10 |
|  iv) Shrinkage test | IS 5831 | 12 |
|  v) Hot deformation test | IS 5831 | 15 |
|  vi) Heat shock test | IS 5831 | 14 |
|  vii) Thermal stability | IS 5831 | 60 |
| 2) PE Sheath |  |  |
|  i) Carbon black content | Table 1A | 32 |
|  ii) Tensile strength and elongation at break before and after ageing | Table 1A | 7 |
|  iii) Hot deformation | Table 1A | 15 |
|  iv) Shrinkage test | Table 1A | 12 |
| 3) LSHF Sheath |  |  |
|  i) Tensile strength and elongation at break before and after ageing | Table 1B | 7 |
|  |  ii) Hot deformation | Table 1B | 15 |
|  iii) Water absorption test (for Type ST8) | Table 1B | 33 |
|  iv) Shrinkage test (for Type ST12)  | Table 1B | 12 |
|  | f) Insulation resistance (volume resistivity test) | Table 1 | 43 |
|  | g) High Voltage Test | **17.2** | 45 |
|  | h) Flammability Test | **17.3** | 53 |
|  | j) Additional tests for cables with improved fire performance, as per categories in Annex A |  |  |
| Category C1 |  |  |
| 1) Oxygen index test | **17.4** | 58 |
| 2) Temperature index test | **17.9** | 64 |
| 3) Flame retardance test on single cable | **17.5** | 61 |
| 4) Flame retardance test on bunched cables | **17.6** | 62 |
| Category C2 |  |  |
| 1) Oxygen index test | **17.4** | 58 |
| 2) Temperature index test | **17.9** | 64 |
| 3) Flame retardance test on single cable | **17.5** | 61 |
| 4) Flame retardance test on bunched cables | **17.6** | 62 |
| 5) Smoke density test | **17.8** | IS 13360 (part 6/sec 9) |
| 6) Test for halogen acid evolution | **17.7** | 59 |
| Category C3 |  |  |
| 1) Oxygen index test | **17.4** | 58 |
| 2) Temperature index test | **17.9** | 64 |
| 3) Flame retardance test on single cable | **17.5** | 61 |
| 4) Flame retardance test on bunched cables | **17.6** | 62 |
| 5) Smoke density test | **17.8** | IS 13360 (part 6/sec 9) |
| 6) Test for halogen acid evolution | **17.7** | 59 |
| 7) Test for light transmission | **17.11** | 63 |
| 8) Test for pH and conductivity | **17.10** | **17.10** |

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

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl.** | **Test** | **Ref. of** **Requirements** | **Ref of****Test Method of IS 10810** |
|  | Annealing test (for copper) | IS 8130 | 1 |
|  | Tensile Test (for aluminium) | IS 8130 | 2 |
|  | Wrapping Test (for aluminium) | IS 8130 | 3 |
|  | Conductor Resistance Test | IS 8130 | 5 |
|  | Test for thickness of insulation and sheath | **9, 12** and **14**, Tables **2, 4** and **6** | 6 |
|  | Hot set test for insulation | Table 1 | 30 |
|  | Tensile strength and elongation at break test for insulation and sheath | Tables 1, 1A, 1B | 7 |
|  | High voltage test  | **17.2** | 45 |
|  | Insulation resistance (volume resistivity test) | Table 1 | 43 |
|  | Additional tests for cables with improved fire performance, as per categories in Annex A |  |  |
| ***Category C1*** |  |  |
| a) Oxygen index test | **17.4** | 58 |
| b) Flame retardance test on single cable | **17.5** | 61 |
| c) Flame retardance test on bunched cables | **17.6** | 62 |
| ***Category C2*** |  |  |
| a) Oxygen index test | **17.4** | 58 |
| b) Flame retardance test on single cable | **17.5** | 61 |
| c) Flame retardance test on bunched cables | **17.6** | 62 |
| d) Test for halogen acid evolution | **17.7** | 59 |
| e) Smoke density test | **17.8** | IS 13360 (part 6/sec 9) |
| ***Category C3*** |  |  |
| a) Oxygen index test | **17.4** | 58 |
| b) Flame retardance test on single cable | **17.5** | 61 |
| c) Flame retardance test on bunched cables | **17.6** | 62 |
| d) Test for halogen acid evolution | **17.7** | 59 |
| e) Test for light transmission | **17.11** | 63 |
| f) Test for pH and conductivity | **17.10** | **17.10** |

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

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

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl.** | **Test** | **Ref of** **Requirements** | **Ref of****Test Method of IS 10810** |
|  | Conductor resistance test | IS 8130 | 5 |
|  | High voltage test | **21.17** | 45 |
|  | Resistance test for armour (for mining cable only) | **21.9** | 42 |

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

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

**17. DETAIL OF TESTS**

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

**17.2 High Voltage Test**

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

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

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

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

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

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

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

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

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

**17.10 pH and conductivity of LSHF sheath-** As per Annex F of IS 17505 (Part 1).

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

**SECTION 5 IDENTIFICATION, PACKING AND MARKING**

**18. IDENTIFICATION**

**18.1 Manufacturer's Identification-** The manufacturer shall be identified throughout the length of the cable by means of a tape bearing, the manufacturer's name or trademark, or by manufacturer's name or trade mark being indented, printed or embossed on the cable. In case none of those methods can be employed, or if the purchaser so desires, colour identification threads in accordance with a scheme to be approved by the Bureau of Indian Standards (BIS) shall be employed. The indentation, printing, or embossing shall be done only on the outer sheath. The distance between any two consecutive printing, indentation or embossing shall not be more than 1 m.

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

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

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

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

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

|  |  |  |
| --- | --- | --- |
| **Sl No.** | **Constituent** | **Code Letter** |
|  | Aluminium conductor | A |
|  | XLPE insulation | 2X |
|  | Steel round wire armour | W |
|  | Non-magnetic round wire armour | Wa |
|  | Steel strip armour | F |
|  | Non-magnetic strip armour | Fa |
|  | Double steel strip armour | FF |
|  | Double steel round wire armour | WW |
|  | PVC outer sheath | Y |
|  | PE outer sheath | 2Y |
|  | LSHF outer sheath | Z |

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

**19. PACKING AND MARKING**

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

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

a) Reference to this Indian Standard, IS 7098 (Part 1);

b) Manufacturer's name or trade-mark;

c) Type of cable and voltage grade;

d) Number of cores;

e) Nominal cross-sectional area of conductor;

f) Cable code;

g) Length of cable on the drum;

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

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

k) Gross mass:

m) Country of manufacture; and

n) Year of manufacture.

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

**19.3 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**

(*Clause*1.5)

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

**ANNEX B**

**SAMPLING OF CABLES**

*(Clause* 16.2.1)

**B-1 LOT**

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

**B-2 SCALE OF SAMPLING**

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

**B-2.2** The number of drums (n) to be selected from the lot of drums (N) of consignment of cables shall be in accordance with col 2 and 1 of **Table 8** respectively. These samples shall be taken at random.

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

**B-3 NUMBER OF TESTS AND CRITERION FOR CONFORMITY**

**B-3.1** Suitable length of test sample shall be taken from each of the drums selected. These test samples shall be subjected to each of the acceptance tests (*see* **16.2**). A test sample is called defective if it fails in any of the acceptance tests. If the number of defectives is less than or equal to the corresponding permissible number (a) given in Col 3 of **Table 8** the lot shall be declared as conforming to the requirements of acceptance tests otherwise not.

**TABLE 8**

 **NUMBER OF DRUMS TO BE SELECTED FOR SAMPLING AND PERMISSIBLE NUMBER OF DEFECTIVES**

(*Clause* B-2.2 *and* B- 3.1)

|  |  |  |  |
| --- | --- | --- | --- |
| **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 above | 20 | 1 |
|  | 501 and above | 32 | 2 |

**ANNEX C**

(*Clause* 14.1.2, 16.1)

**ARMOUR COVERAGE PERCENTAGE**



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

where,

N = number of parallel wires,

d = diameter of wire / width of formed wires.

W = π x D x Cos α

D = diameter under armour

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

tan α = π x D/C, and

C = lay length of armouring wires / formed wires.

**ANNEX D**

( *Foreword* )

**COMMITTEE COMPOSITION**

Power Cables Sectional Committee- ETD 09

|  |  |
| --- | --- |
| *Organization* | *Representative(s)* |
| Central Power Research Institute, Bengaluru | SMT. MEENA K.P. ***(Chairperson)*** |
| 3 M Electro and Communication India Private Limited, Bengaluru | SHRI SANJAY JHA SHRI PERMEET SINGH *(Alternate I)* SHRI ASHISH AGARWAL *(Alternate II)* |
| Apar Industries Limited, Mumbai | SHRI AMIT KUMAR SAMANTA SHRI BHARAT PATEL *(Alternate)* |
| Bharat Heavy Electrical Limited, New Delhi | SMT. TI SANTHA  SHRI SAROJ KUMAR *(Alternate)* |
| Calcutta Electric Supply Corporation Limited, Kolkata | SHRI KIRIT RANA SHRI ARNAB GUHA *(Alternate)*  |
| Central Electricity Authority, New Delhi | SHRI BHANWAR SINGH MEENA SHRI MOHIT MUDGAL *(Alternate)* |
| Central Power Research Institute, Bengaluru | SMT R. ARUNJOTHI  SHRI THIRUMURTHY *(Alternate I)* DR. NEHA ADHIKARI *(Alternate II)* SHRI P.V.SATHEESH KUMAR *(Alternate III)* |
| Delhi Metro Rail Corporation Limited, Delhi | SHRI DEVINDER SINGH PARMAR SHRI ASHISH ARORA *(Alternate)* |
| Electrical Research and Development Association, Vadodara | SHRI SHEETAL PANCHAL  SHRI SHAILESH PATEL *(Alternate)* |
| Engineers India Limited, New Delhi | SHRI A. SAI  SHRI MEHUL BASU *(Alternate I)* SHRI VIRENDRA TIWARI *(Alternate II)* |
| Finolex Cables Limited, Pune | SHRI P.N. KHAIRNAR  SHRI BIPIN PATIL *(Alternate)* |
| Finolex J-Power Systems Limited, Pune | SHRI AVIJIT CHAKRABORTY SHRI HARSHAL TORIYA *(Alternate I)* SHRI NILESH BUTE *(Alternate II)* |
| Gujarat Energy Transmission Corporation Limited, Vadodara | SHRI A.A. JOSHI  SMT. DHARA D. BHATT *(Alternate)* |
| Indian Electrical and Electronics Manufacturers Association, New Delhi | SHRI VIVEK ARORA SHRI RISHABH JOSHI *(Alternate)* |
| International Copper Association India, Mumbai | SHRI AMOL KALSEKAR  SHRI AVINASH KHEMKA *(Alternate I)* SHRI JYOTISH PANDE *(Alternate II)* |
| KEC International Limited, Mumbai | SMT. RAJANI PANDE SHRI BHOOPENDRA SINGH *(Alternate)*  |
| LS Cable India Private Limited, Rewari | SHRI AJAY KUMAR MISHRA  SHRI DINESH KUMTHEKAR *(Alternate)* |
| Lapp India Private Limited, Jigani | SHRI KUMAR KRISHNA S.  |
| National Capital Region Transport Corporation, New Delhi | SHRI PAVAN KUMAR P. SHRI AFROZ ANSARI *(Alternate)* |
| National Hydroelectric Power Corporation, Faridabad | SHRI PANKAJ PRASOON  SMT. RASHMI SRASWAT *(Alternate)* |
| Nuclear Power Corporation of India Limited, Mumbai | SHRI ANANTHACHARI MANNEPALLI  SHRI SHASHANK SINGH *(Alternate)* |
| Paramount Communication Limited, Mumbai | SHRI ARUN SHARMA |
| Polycab Wires Private Limited, Mumabi | SHRI BHARAT SEHGAL  |
| RR Kabel Limited, Silvassa | SHRI JOSE THOMAS  SHRI RONAK BHATT *(Alternate I)* SHRI BALACHANDRAN DHARMAN *(Alternate II)* |
| Raychem RPG Private Limited, Chennai | SHRI R.S. ANEKAR  SHRI ABHIJIT DHAMALE *(Alternate)* |
| Shakun Polymers Limited, Vadodara | SHRI PRITEN SHAH SHRI PRATIK NAYAK *(Alternate)* |
| Sterlite Power Transmission Limited, New Delhi | SHRI RAJESH GULATI SHRI KAMAL KHANNA *(Alternate)* |
| Tata Consulting Engineers Limited, Navi Mumbai | SHRI K PRABHAKAR SHRI G.V. CHANDRA SHEKHAR *(Alternate)* |
| Tata Power Delhi Distribution Limited, New Delhi | SHRI SANJEEV ATRI SHRI KAPIL KUMAR *(Alternate)* |
| Universal Cables Limited, Satna | SHRI YOGENDRA SINGH TIWARI  SHRI C.S. MOHANTY *(Alternate)* |
| IN PERSONAL CAPACITY, Bengaluru | SHRI B. NAGESHWAR RAO  |
| IN PERSONAL CAPACITY, Bengaluru | SHRI SITARAMAN RAMA PRASATH |
| BIS Directorate General | SHRI ASIT KUMAR MAHARANA SCIENTIST ‘E’ AND HEAD (ETD) |

*Member Secretary*

MOHAMMAD ISRAFIL

 SCIENTIST ‘D’ (ETD), BIS